DEC-12-UW5A-D
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NMRSIM(E)

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1.0 ABSTRACT

NMRSIM(E)[1] is designed to calculate theoretical spectra of compounds containing nuclei of spin one-half, including hydrogen, fluorine, and carbon-13. Chemical shifts for each nucleus and coupling constants between nuclei are input from the Teletype. Calculated line spectra are displayed on the VR12 scope. Twenty-five calibration points are displayed across the X axis. Output is to LINCtape and high- or low-speed paper tape punch, as well as to the Teletype. NMRSIM has options that allow varying all the parameters as well as offsets for enhancement of resolution. Chemical shifts and coupling constants may be adjusted continuously until the displayed theoretical spectrum is acceptable. Spectra may be read back and displayed from LINCtape or paper tape; several psectra may be merged in this mode of operation, thereby allowing the simulation of large spin systems or mixtures of compounds.

2.0 EQUIPMENT

A PDP-12A equipped with KW12A real time clock and MC12 4K Memory Extension is required.

3.0 OPERATING PROCEDURES

NMRSIM(E) is loaded from a LAP6-DIAL[2] tape containing the program by the command

→ LO NMRSIM(E),Ø ↵

Refer to the LAP6-DIAL Programmer's Manual, DEC-12-SE2B-D for further details.

The restarting procedure is as follows:

1) Press the STOP key on the PDP-12A.
2) Press I/O PRESET.
3) Press START.

NMRSIM then returns to the display mode.

---

[1] NMRSIME utilizes the EAE option for the PDP-12.

[2] LAP6-DIAL is hereafter referred to as DIAL.

4.0 SPECTRUM GENERATION

After the program is loaded, it prints a series of messages on the Teletype to specialize the parameters for the experiment. The user types a reply to each message and terminates the response by pressing the RETURN key. If an illegal response is typed, a ? is printed on the Teletype and the message is repeated. The RUBOUT key can be used to erase incorrectly typed characters before a terminator is typed. The messages are listed below with their acceptable responses. Refer to section 8.0 for a sample dialogue.

4.1 COMMENTS:

Any amount of commentary can be typed at this time using any of the Teletype keys. After entering appropriate titles, type CTRL/A to advance to the next message.

4.2 WANT PAPER TAPE I/O?

Only a response of Y or N is acceptable. A reply of N stores the position and intensity of all calculated transitions on LINCtape only. A reply of Y outputs the position and intensity of all calculated transitions on paper tape in addition to LINCtape. After a reply of Y, a second question is printed:

WANT HIGH SPEED READER-PUNCH?

Type Y to use the high-speed punch, type N to output to the Teletype punch.

4.3 NO. OF SPINS =

Enter the number of spins; values from 1 through 6 are acceptable.

4.4 OFFSET & WIDTH

These two parameters define the range of the X axis on the scope. OFFSET is the value in Hz of the first point displayed along the horizontal axis. WIDTH is the total range in Hz of the horizontal axis. It is important to keep in mind that the axis will be displayed from right to left corresponding to the standard display mode for NMR data.

4.5 CHEMICAL SHIFTS:

Enter the value in Hz of the CHEMICAL SHIFTS in order. Type a comma to separate values:

1, 2, . . . , n

4.6 COUPLING CONSTANTS

Enter the value in Hz of the coupling constants in order:

$J_{1\ 2}$, $J_{1\ 3}$, $J_{1\ 4}$, ..., J_{1n}, $J_{2\ 3}$, $J_{2\ 4}$, ..., J_{2n}, ..., $J_{(n-1)n}$

Specify every coupling constant required, even if the value is zero. Type a comma after each value.

4.7 BLOCK, U:

Type the starting block in octal notation, a comma, and the number of the LINCtape transport unit to be used to store the peak parameters of the calculated transitions. The number of blocks required is dependent upon the size of the spin system desired.

The computer now calculates the theoretical spectra and automatically stores the data on the LINCtape.

5.0 COMMANDS

When displaying a line spectrum the Teletype is active and can be used to issue commands defining the next task for the computer. Six options are available to the user at this time. Each of these commands is issued by typing the appropriate letter followed by a colon. The command may be changed by using the RUBOUT key before the colon has been typed. The display can be scaled with Right Switches 9, 1Ø and 11.

5.1 R (RESTAPT)

Restart prints the message COMMENTS (section 4.1) and restarts the program. It is used to calculate a complete set of new data. Note that paper tape status can not be changed after the initial responses to the messages.

5.2 C (COUPLING CONSTANTS)

Returns to section 4.6 and requests new parameters. Used for open loop iteration to find the best coupling constants.

5.3 O (OFFSET & WIDTH)

This command allows a new section of the X axis to be displayed on the scope so that any section of the calculated spectrum can be displayed on the scope. The OFFSET option is useful for resolution enhancement. To exercise this option, there must be NMR data on LINCtape or paper tape (prepared by the P: command). If paper tape was requested during initialization (section 4.2), the question

TAPE INPUT?

is asked. Type Y to read data from the high speed or Teletype reader and write it on LINCtape before display. Type N to read data from LINCtape.

5.4 D (DIAL)

Program returns control to the DIAL Operating System.

5.5 L (LIST)

The L command lists intensity and energy data on the Teletype in tabular format. After typing L, the message

MIN. INTENSITY:

is printed. Type an integer number between Ø and 1ØØØ. If the intensity of the transition is greater than the entered value, the transition will be in the output list. This question thus serves as a threshold on the intensities that are listed. A second question

DISPLAY LIST

is then printed. Type Y to output only the lines which are displayed on the scope. Type N to output all lines in the table. There are usually many more lines than are displayed on the scope because the scope cannot resolve closely adjacent lines.[1]

---

[1] If the Teletype punch is turned on during a List operation, a binary coded decimal paper tape is produced which may be used as input to CATACAL (DEC-12-UW1A-D) to produce a spectrum consisting of peaks instead of lines.

5.6 P (PUNCH)

The accumulated spectrum can be punched on the high-speed reader/punch by issuing the punch command.

6.0 OPERATING SUGGESTIONS

A useful starting point for many 6Ø MHz NMR (hydrogen) spectra of organic molecules is a sweep offset of Ø Hz and a sweep width of 5ØØ Hz. For best results, however, all peaks should eventually be examined at a considerably smaller sweep width, since rounding errors may give misleading scope displays with large sweep widths. It should be noted that increasing the sweep offset moves peaks to the right, and decreasing the sweep offset moves peaks to the left. Once the peaks are observed, the proper sweep offset and width can be determined from the 25 calibration marks placed across the X axis.

For purposes of estimating a logical minimum intensity, remember that the calibration on the scope on the Y axis is always Ø to 1ØØØ.

7.0 NMR BACKGROUND

The discussion below assumes that the nuclei being studied are hydrogen, fluorine, carbon-13 or other nuclei of spin 1/2.

Each nucleus in a molecule can be assigned a spin of either α or β. For a system containing n nuclei, there are 2^n spin states possible. Each of these states is called a basic product function. The energy of a basic product function can be calculated from equation 1 below where $s_i = -1/2$ for β spin and + 1/2 for α spin, υ_i is the frequency of absorption in Hz, T_{ij} = + 1/4 if i and j have the same spin and - 1/4 if i and j have opposite spin, and J_{ij} is the coupling constant between i and j in cps.

$$1 \qquad H_{uu} = \sum_{i=1}^{n} (s_i \upsilon_i + \sum_{j>i} T_{ij} J_{ij})$$

The energy of interaction between two basic product functions is Ø unless both have the same number of α and β spins. When this condition is fulfilled, the interaction energy is calculated from equation 2 where U=1 if the basic product functions differ only in the interchange of spins i and j (J_{ij} as defined above). Otherwise, U=Ø.

$$2 \qquad H_{uv} = 1/2UJ_{ij}$$

Thus, to calculate an NMR spectrum, one constructs all of the possible basic product functions and sorts them into groups, each member of a group containing the same number of α and β spins. The energy of each of them is determined and used as the diagnonal element in a square matrix. The off-diagonal elements of this matrix (H matrix) are energies of interaction between the members of the group. This matrix is diagonalized and these elements then contain the energies of the final spin functions. These final spin eigenfunctions are the columns of the matrix (U matrix) required to diagonalize the H matrix. Each element in a spin function represents the contribution of a basic product function to that spin function.

Before continuing, it is necessary to define the F_z value of a spin function, as shown in equation 3, where s_i is as previously defined.

$$3 \qquad F_z = \sum_{i=1}^{n} s_i$$

Now the peaks observed in NMR spectra are transitions from one spin function to another. These transition energies and their intensities can be calculated as outlined below. Transitions are allowed between spin functions whose F_z values differ only by 1. If this holds, the energy of the transition is the difference in energy of the final spin eigenfunctions, and the intensity of the transition is given by equation 4 where C_u is the uth element in one spin function, C'_v is the vth element in the other spin function, and A=1 if the basic product functions represented by C_u and C'_v differ by one spin. Otherwise, A=Ø.

$$4 \qquad I = \left(\sum_u \sum_v C_u C'_v A\right)^2$$

8.0 EXAMPLE

The following pages represent an actual printout. The spectra are representations of those displayed on the scope. The underlined data is that typed by the user.

```
LO NMRSIME,2

NMRSIM
COMMENTS:   DEMO 1

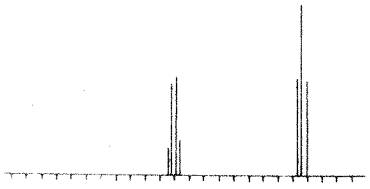
WANT PAPER TAPE I/O?Y
WANT HIGH SPEED READER-PUNCH?Y

NO. OF SPINS=  5

OFFSET & WIDTH:Ø,5ØØ

CHEMICAL SHIFTS: 9Ø,9Ø,9Ø,26Ø,26Ø

COUPLING CONSTANTS:  Ø,Ø,8,8,Ø,8,8,8,8,Ø,
BLOCK, U:   4ØØ,3
```



```
L:

MIN. INTENSITY:Ø

DISPLAY LIST?Y

  INTENSITY      ENERGY
     27.ØØ       272.ØØ
     9Ø.ØØ       264.ØØ
     99.ØØ       256.ØØ
     36.ØØ       248.ØØ
    1Ø4.ØØ        97.ØØ
    189.ØØ        9Ø.ØØ
     86.ØØ        81.ØØ
P:
O:
```

OFFSET & WIDTH:Ø,3ØØ

TAPE INPUT?Y

BLOCK, U: 42Ø,3,

MORE?N
P:

NMRSIM

COMMENTS: DEMO 1 CONT

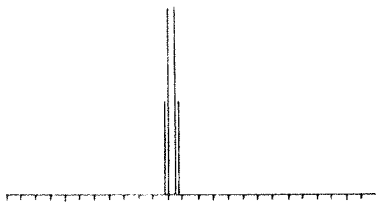
NO. OF SPINS= 2

OFFSET & WIDTH:Ø,5ØØ

CHEMICAL SHIFTS: 265,28Ø

COUPLING CONSTANTS: 5

BLOCK, U: 44Ø,3



C:

COUPLING CONSTANTS: 1Ø

BLOCK, U: 44Ø,3

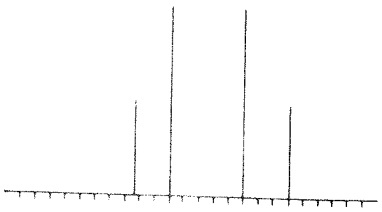
Q:

OFFSET & WIDTH:25Ø,5Ø

TAPE INPUT?N

BLOCK, U: 44Ø,3

MORE?N



D:

9.0 ASSEMBLING NMRSIM

The NMRSIM program is supplied to the user in both source and binary on the tape. To generate a new binary file if the source program is modified, use the following procedure.

1. Load a DIAL-MS tape on unit Ø. Load unit 1 with either a DIAL-V2 or DIAL-MS system tape. If another tape unit is available, mount the tape containing the CLEARSYM and NMRSIM source programs there. If only two tape units are available, place the source programs on unit Ø (with PIP if necessary), in order to reduce the assembly time.

2. Type →ZE↵ to clear the binary Working Area of unit 1.

3. Type →AS CLEARSYM↵ . CLEARSYM is a two word program which produces a clean symbol table.

```
ØØØØ
SAVSYM 1
```

4. Type →AS NMR2,Ø↵ . Error messages generated at this time should be ignored. Press the RETURN key to terminate the assembly after the errors have all been printed to suppress printing of the symbol table.

5. Type →ZE↵. This clears the binary Working Area on unit 1.

6. Type →LI NMR3,Ø↵. If no listing is desired, use the AS command. Any errors generated now are real and must be corrected.

7. Type →LI NMR2,Ø↵ . Because the symbol table produced is the same as the one generated in step 6, printing may be suppressed with the RETURN key after it has started to be printed.

8. Type →SB NMR23,Ø↵. This saves the binary output from the two previous assemblies

9. Type →ZE↵.

10. Two versions of the Floating Point Package are supplied. If the machine has the EAE option, NMR1E should be used in the following steps and NMRSIME will be generated. If the machine does nothave this option, NMR1 should be used to generate NMRSIM.

11. Type →AB NMR1,Ø ↵.

12. Type →AB NMR23,Ø↵.

13. Type →SB NMRSIM,ØP↵. A binary file of NMRSIM(E) has now been generated and the command →LO NMRSIM,Ø ↵ will cause load and execute.

10.0 INTERNAL DESCRIPTION

The complete program listings are contained at the back of the manual. The following is a brief outline of the program; capital letters below refer to variables.

1. Begins with text mode for input of commentary.
2. Enter the number of spins and store in N.
3. Set "switch" for punched output.
4. Set up basic produce functions (BPFs).
   A. Calculate NARRY array which contains relative addresses of the BPFs of different F_z value.
   B. Calculate NUSE array. This array actually contains the BPFs. They are stored in groups, each group having an F_z value one greater than the preceding group.
5. Get sweep offset and sweep width.
6. Get chemical shifts.
7. Get coupling constants.
8. Initialize SPEC array.
   A. This array eventually contains the displayed spectrum.
   B. It is initialized to Ø except for calibration points where it is set to $4ØØØ_8$.
9. Calculate first H and U matrices.
   A. First H matrix is always a 1 X 1 which does not require diagonalization.
   B. First U matrix is always a 1 X 1 with its only element equal to 1.
10. Set FLAG which is the negative of the number of times the loop from 11 to 17 must be executed.

11. Set N2, calculate EN and UOLD arrays.

    A. Copy the trace of the H matrix into the EN array.

    B. Copy the U matrix into the UOLD array.

    C. Set N2 equal to the size of the H matrix just copied.

12. Calculate the size of the next H matrix and put in into N1.

13. Determine which transitions will be allowed between the BPFs represented by UOLD and those that will be represented by U. This is stored in the array called TABLE.

14. Initialize H and U matrixes.

    A. Diagonal H elements are calculated by equation 1.

    B. Off-diagonal H elements are calculated by equation 2.

    C. The U matrix is initialized to all zeros except for ones on the diagonal.

15. Diagonalize the H matrix and calculate the U matrix by the Jacobi method.

16. Calculate transitions.

    A. Calculate transition energies by forming the differences between the elements of the trace of the H matrix and the elements in the EN array.

    B. Calculate transition intensities from equation 4.

    C. Store appropriate values in SPEC array.

17. Test FLAG to see if the loop is done.

    A. If loop is not done, go to 11.

    B. If loop is done, display spectrum.

18. If ALT MODE is typed, interpret mnemonic and execute option.

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```
0000                    *20
0001                            /NMR SPECTRAL SIMULATOR:
0002                            /ORIGINALLY IN DECUS LIBRARY AS    -194
0003                            /AS SUBMITTED BY D,F, JUERS, R,J, BOETTCHER, V,J, HULL
0004                            /AND H,E, ZIMMERMAN OF UNIV, OF WISC,, MADISON, WISC,
0005                            /MODIFICATIONS MADE BY G,W, DULANEY OF DEC, MAYNARD, MASS.
0006                            /TO ALLOW OPERATION ON THE PDP-12.
0007                            PMODE
0010                            LODSYM
0011                            LISTAP -1
0012                            FEXT=0000
0013                            FADD=1000
0014                            FSUB=2000
0015                            FMPY=3000
0016                            FDIV=4000
0017                            FGET=5000
0020                            FPUT=6000
0021                            FNOR=7000
0022                    SQUARE=1
0023                    SQROOT=2
0024                    FMPY2=3
0025                    FDIV2=4
0026                    NEGATE=5
0027                    FLOIN=6
0030                    EXP=44
0031                    HORD=45
0032                    LORD=46
0033                            *5
0034    0005    0760    INPUT,  FPINP
0035    0006    7200    OUTPUT, 7200
0036    0007    5600    INTERP, 5600
0037                            *20
0040                            PMODE
0041    0020    5421            JMP I .+1
0042    0021    0202            BEGIN
0043    0022    0354    HRED,   HIRED
0044    0023    0361    HPUN,   HIPUN
0045    0024    2145    TABLE,  TABL
0046    0025    0000    READ,   0
0047    0026    6031            KSF
0050    0027    5026            JMP     .-1
0051    0030    6036            KRB
0052    0031    5425            JMP I   READ
0053    0032    0000    TYPE,   0
0054    0033    6041            TSF
0055    0034    5033            JMP     .-1
0056    0035    6046            TLS
0057    0036    5432            JMP I   TYPE
0060                            *62
0061    0062    0010            10
0062                    DECIMAL
0063    0063    0020    IFZB,   16
0064    0064    0027    NUSEB,  23
0065    0065    0127    CPSB,   87
0066    0066    0151    CUPB,   105
0067    0067    1306    BOLD,   710
0070    0070    1212    ENB,    650
0071    0071    0226    SPECB,  150
0072    0072    3566    UB,     1910
0073    0073    6046    HB,     3110
0074                    OCTAL
0075    0074    2676    PRINT,  PRINTL
```

```
0076    0075  3600  DISPLAY,        STDIS
0077    0076  4103  TAPTRN, LNCTAP
0100    0077  0010  UNIT,   10
0101    0100  0110  STBLK,  110
0102    0101  0000  BLK1,   0
0103    0102  0000  INSWT,  0
0104    0103  3051  AREND,  -DATBUF+1-371
0105    0104  4336  CORBUF, DATBUF-1
0106    0105  0334  TPGT,   GTTP
0107    0106  0000  N,      0
0110    0107  0000  TEMP,   0
0111    0110  0000  LIMIT,  0
0112    0111  0000          0
0113    0112  0000          0
0114    0113  0000  ADD0,   0
0115    0114  0000  TEMP1,  0
0116    0115  0000  N1,     0
0117    0116  0000  A,      0
0120    0117  0000          0
0121    0120  0000          0
0122    0121  0000  B,      0
0123    0122  0000          0
0124    0123  0000          0
0125    0124  0000  FSIN,   0
0126    0125  0000          0
0127    0126  0000          0
0130    0127  0000  FCOS,   0
0131    0130  0000          0
0132    0131  0000          0
0133    0132  0000  N2,     0
0134    0133  0000  JTEMP,  0
0135    0134  0000  FACTOR, 0
0136    0135  0000          0
0137    0136  0000          0
0140    0137  0000  OFSET,  0
0141    0140  0000          0
0142    0141  0000          0
0143                        P0ND=.          /MARK END P0
0144                        *200
0145    0200  7200          CLA
0146    0201  3055          DCA 55
0147    0202  6032  BEGIN,  KCC             /SA OF PROGRAM
0150    0203  6046          TLS
0151    0204  6014          RFC
0152    0205  4474          JMS I   PRINT   /NMR SIMULATOR-COMMENTS:
0153    0206  3747          HD1
0154    0207  4025  OVERO,  JMS     READ    /ROUTINE ALLOWS USER TO TYPE ANY AMOUNT
0155    0210  4032          JMS     TYPE
0156    0211  1332          TAD     M2010   /OF COMMENTARY AT BEGINNING OF PROGRAM,
0157    0212  7640          SZA CLA         /EXIT IS ACHEIVED BY TYPING CTRL/A,
0160    0213  5207          JMP     OVERO   /GET MORE
0161    0214  4720          JMS I   INDIL   /GET HSR/P AND TAPE SETUP
0162    0215  3214          DCA     .-1     /RETURNED WITH SKP IN AC; NO FURTHER CALLS
0163    0216  5222          JMP     GTSPN
0164    0217  7200  ERROR0, CLA
0165    0220  1330          TAD     QUEST
0166    0221  4032          JMS     TYPE
0167    0222  4474  GTSPN,  JMS I   PRINT   /NO. OF SPINS=
0170    0223  3764          HD2
0171    0224  4405          JMS I   INPUT
0172          4712          JMS I   FIXM
0173    0226  7110          CLL RAR
```

```
0176    0231  7004          RAL
0177    0232  1331          TAD     M7      /NO
0200    0233  7500          SMA             /WAS IT >6?
0201    0234  5217          JMP     ERRORO  /YES, NO GOOD
0202    0235  1333          TAD     P7
0203    0236  3106          DCA     N       /STORE
0204    0237  4711          JMS I   INITO    /INITIALIZE NARRAY & NUSE
0205    0240  4715  NUDAT,  JMS I   ULIM    /GET UPPER SPECTRAL LIMIT
0206    0241  4474          JMS I   PRINT   /CHEM SHIFTS:
0207    0242  1744          HD5
0210    0243  4714          JMS I   W       /GET CHEMICAL SHIFTS
0211    0244  4474  NEWJ,   JMS I   PRINT   /COUPLING CONSTANTS:
0212    0245  1755          HD6
0213    0246  4716          JMS I   JO      /GET COUPLING CONSTANTS
0214    0247  4334          JMS     GTTP
0215    0250  4717          JMS I   INPEC   /INITIALIZE SPEC ARRAY
0216    0251  1100          TAD     STBLK
0217    0252  3101          DCA     BLK1    /RESET TAPE BLOCK
0220    0253  7201          CLA IAC
0221    0254  3133          DCA     JTEMP
0222    0255  7001          IAC
0223    0256  3115          DCA     N1      /READY TO INITIALIZE EN & BOLD
0224    0257  1106          TAD     N
0225    0260  7041          CIA
0226    0261  3326          DCA     FLAGO   /SET LOOP
0227    0262  1063          TAD     IFZB
0230    0263  3327          DCA     ADDRO   /SET UP TO FIND BPFS
0231    0264  4721          JMS I   HUGETO  /H(1,1) HAS EN(1) & U(1,1) HAS UOLD(1,1)
0232    0265  4723  RPTO,   JMS I   COPYO   /COPY TRACE OF H INTO EN & U INTO UOLD
0233    0266  1727          TAD I   ADDRO   /GET NEW JTEMP
0234    0267  3133          DCA     JTEMP
0235    0270  2327          ISZ     ADDRO   /SET TO GET NEW JTEMP
0236    0271  1133          TAD     JTEMP
0237    0272  7041          CIA
0240    0273  1727          TAD I   ADDRO
0241    0274  3115          DCA     N1      /NEW N1
0242    0275  4722          JMS I   ALLOWO
0243    0276  4721          JMS I   HUGETO  /INITIALIZE H & U MATRICES
0244    0277  4724          JMS I   JAKEO   /DIAGNALIZE
0245    0300  4725          JMS I   TRANSO  /CALCULATE TRANSITIONS
0246    0301  2326          ISZ     FLAGO   /DONE?
0247    0302  5265          JMP     RPTO    /NO, LOOP AGAIN
0250    0303  6201          CDF 0
0251    0304  7333          STL CLA IAC RTR /PUT TAG WORD IN CORE ARRAY
0252    0305  3411          DCA I   11
0253    0306  4476          JMS I   TAPTRN  /WRITE OUT LAST PART OF BUFFER
0254    0307  5475          JMP I   DISPLAY /DISPLAY SPECTRUM
0255    0310  2663  CARTN,  CRLFD
0256    0311  3400  INITO,  INITB
0257    0312  3127  FIXM,   FIX
0260    0313  4315  ASK,    ASKM
0261    0314  0600  W,      WC
0262    0315  3554  ULIM,   ULIMP
0263    0316  0610  JO,     JC
0264    0317  1121  INPEC,  INSPEC
0265    0320  4400  INDIL,  INDIAL
0266    0321  2200  HUGETO, HUGET
0267    0322  2000  ALLOWO, ALLOW
0270    0323  2320  COPYO,  COPY
0271    0324  1200  JAKEO,  JAKE
0272    0325  2400  TRANSO, TRANS
0273    0326  0000  FLAGO,  0
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0274    0327  0000  ADDRO,  0
0275    0330  0277  QUEST,  0277
0276    0331  7771  M7,     -7
0277    0332  7577  M2010,  -201
0300    0333  0007  P7,     7
0301    0334  0000  GTTP,   0
0302    0335  4474        JMS I   PRINT   /BLOCK, U:
0303    0336  1736        HD4
0304    0337  4753        JMS I   OCIN
0305    0340  5337        JMP     .-1     /ERROR RETURN
0306    0341  7450        SNA             /BLOCK 0 NOT ALLOWED
0307    0342  5337        JMP     .-3
0310    0343  3100        DCA     STBLK
0311    0344  4405        JMS I   INPUT
0312    0345  4712        JMS I   FIXM
0313    0346  0352        AND     MSK7
0314    0347  3077        DCA     UNIT
0315    0350  4710        JMS I   CARTN
0316    0351  5734        JMP I   GTTP
0317    0352  0007  MSK7,  7
0320    0353  4200  OCIN,  OCTIN
0321    0354  0000  HIRED,  0
0322    0355  6011        RSF
0323    0356  5355        JMP     .-1
0324    0357  6016        RRB RFC
0325    0360  5754        JMP I   HIRED
0326    0361  0000  HIPUN,  0
0327    0362  6026        PLS
0330    0363  6021        PSF
0331    0364  5363        JMP     .-1
0332    0365  5761        JMP I   HIPUN
0333                *400
0334    0400  0002        2               /PDP
0335    0401  6046        TLS
0336    0402  4717  OFFS,  JMS I   AULIM
0337    0403  4474        JMS I   PRINT   /TAPE INPUT?
0340    0404  1770        HD8
0341    0405  4713        JMS I   ASKMX
0342    0406  3102        DCA     INSWT
0343    0407  4505        JMS I   TPGT    /GET BLOCK AND UNIT
0344    0410  4716        JMS I   INSPA   /INIT, ARRAYS AND TAPE
0345    0411  1102        TAD     INSWT
0346    0412  7640        SZA CLA         /TAPE?
0347    0413  5222        JMP     GET     /NO
0350    0414  1100        TAD     STBLK
0351    0415  3101        DCA     BLK1    /RESET TAPE BLOCK
0352    0416  6014        RFC
0353    0417  4422        JMS I   HRED
0354    0420  7450        SNA             /IS DATA COMING?
0355    0421  5217        JMP     .-2     /NO, BLANK TAPE
0356    0422  4327  GET,   JMS     RDWD    /YES, READ A -CHEMICAL SHIFT
0357    0423  5267        JMP     DONIN   /GOT END MARK; CHECK FOR MORE INPUT
0360    0424  4407        JMS I   INTERP
0361    0425  1110        FADD    LIMIT
0362    0426  3134        FMPY    FACTOR  /SCALE
0363    0427  1320        FADD    HALFA
0364    0430  0000        FEXT
0365    0431  4723        JMS I   FIXA    /FIX IT
0366    0432  3324        DCA     SPECAD
0367    0433  4327        JMS     RDWD    /GET CORRESPONDING INTENSITY
0370      54  7402        HLT             /CAN ONLY GET HERE BY ERROR
0371    0435  4723        JMS I   FIXA    /FIX IT
0372    0436  3325        DCA     ARROR
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0373    0437  1324          TAD     SPECAD
0374    0440  7510          SPA                 /IN RIGHT RANG
0375    0441  5222          JMP     GET         /NO, LOOK AT NE  ONE
0376    0442  1326          TAD     M500        /MAYBE
0377    0443  7700          SMA CLA             /IN RIGHT RANGE?
0400    0444  5222          JMP     GET         /NO, LOOK NEXT CASE
0401    0445  1324          TAD     SPECAD
0402    0446  1071          TAD     SPECB       /YES, ADDRESS IN SPEC ARRAY
0403    0447  3324          DCA     SPECAD
0404    0450  6211          CDF 10
0405    0451  1724          TAD I   SPECAD
0406    0452  7004          RAL
0407    0453  7110          CLL RAR             /SET BIT 0 TO 0
0410    0454  1325          TAD     APROB
0411    0455  7700          SMA CLA             /OVERFLOW?
0412    0456  5264          JMP .+6             /NO
0413    0457  1724          TAD I   SPECAD      /YES, SET TO MAX
0414    0460  7004          RAL
0415    0461  7250          CLA CMA RAR
0416    0462  3724          DCA I   SPECAD      /STORE
0417    0463  5222          JMP     GET         /LOOK NEXT CASE
0420    0464  1724          TAD I   SPECAD
0421    0465  1325          TAD     APROB       /INCREMENT CURRENT VALUE
0422    0466  5262          JMP     .-4
0423    0467  4474  DONIN,  JMS I   PRINT       /MORE?
0424    0470  3761          HD3
0425    0471  4713          JMS I   ASKMX
0426    0472  7640          SZA CLA
0427    0473  5302          JMP     NMRE
0430    0474  1102          TAD     INSWT       /YES
0431    0475  7650          SNA CLA             /PAPER?
0432    0476  5216          JMP     GET-4       /YES
0433    0477  4505          JMS I   TPGT        /NO, LINCTAPE; GET BLOCK , UNIT
0434    0500  4715          JMS I   TPSTR       /INIT. TAPE AND BUFFER
0435    0501  5222          JMP     GET
0436    0502  4714  NMRE,   JMS I   CARLFD
0437    0503  1102          TAD     INSWT
0440    0504  7640          SZA CLA
0441    0505  5475          JMP I   DISPLAY
0442    0506  7133          STL IAC RTR         /INSERT TAG WORD
0443    0507  6201          CDF 0
0444    0510  3411          DCA I   11
0445    0511  4476          JMS I   TAPTRN      /WRITE OUT LAST BUFFER
0446    0512  5475          JMP I   DISPLAY
0447    0513  4315  ASKMX,  ASKM
0450    0514  2663  CARLFD, CRLFD
0451    0515  3317  TPSTR,  STRTP
0452    0516  1121  INSPA,  INSPEC
0453    0517  3554  AULIM,  ULIMP
0454    0520  0000  HALFA,  0
0455    0521  2000          2000
0456    0522  0000          0
0457    0523  3127  FIXA,   FIX
0460    0524  0000  SPECAD, 0
0461    0525  0000  APROB,  0
0462                DECIMAL
0463    0526  7014  M500,   -500
0464                OCTAL
0465    0527  0000  RDWD,   0
0466    0530  7200          CLA
0467    0531  6201          CDF 0
0470    0532  1102          TAD     INSWT
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0472    0534  5340          JMP     STPE
0473    0535  4773          JMS I   FACLOD
0474    0536  5366          JMP     RDEX    /NORMAL RETURN
0475    0537  5727          JMP I   RDWD
0476    0540  7346  STPE,   STA CLL RTL     /-3
0477    0541  3372          DCA     FLAGR   /INITIALIZE TO READ THREE WORDS
0500    0542  1370          TAD     P44
0501    0543  3113          DCA     ADD0
0502    0544  4771          JMS I   CKEND   /CHECK FOR END OF BUFFER
0503    0545  7300  BACKO,  CLA CLL
0504    0546  4422          JMS I   HRED
0505    0547  7006          RTL
0506    0550  7006          RTL             /SHIFT TO BITS 2-7
0507    0551  7004          RAL
0510    0552  7510          SPA             /IS THIS A STARTING MARK?
0511    0553  5345          JMP     BACKO   /YES
0512    0554  7430          SZL             /NO, IS IT AN END MARK?
0513    0555  5727          JMP I   RDWD    /YES, EXIT W/O INCRD RETURN
0514    0556  7004          RAL             /NO, SHIFT TO BITS 0-5
0515    0557  4422          JMS I   HRED
0516    0560  3513          DCA I   ADD0    /STORE COMPLETE WORD
0517    0561  1513          TAD I   ADD0
0520    0562  3411          DCA I   11      /STICK IT IN CORE BUFFER
0521    0563  2113          ISZ     ADD0
0522    0564  2372          ISZ     FLAGR   /IS WHOLE F.P.  READ?
0523    0565  5345          JMP     BACKO   /NO,READ NEXT WORD
0524    0566  2327  RDEX,   ISZ     RDWD    /NORMALLY INCR. RETURN
0525    0567  5727          JMP I   RDWD    /YES, RETURN
0526    0570  0044  P44,    0044
0527    0571  1161  CKEND,  ENDCHK
0530    0572  0000  FLAGR,  0
0531    0573  3250  FACLOD, LODFAC
0532                *600
0533    0600  0000  WC,     0               /INPUT OF CPS AND CUP
0534    0601  7200          CLA
0535    0602  1065          TAD     CPSB
0536    0603  3356          DCA     ADDRC   /START OF CPS ARRAY
0537    0604  1106          TAD     N
0540    0605  7041          CIA
0541    0606  3352          DCA     FLAGC   /SET  OF CHEMICAL SHIFTS
0542    0607  5226          JMP     RPTC    /GET CHEMICAL SHIFTS
0543    0610  0000  JC,     0
0544    0611  7200          CLA
0545    0612  1210          TAD     JC
0546    0613  3200          DCA     WC
0547    0614  1066          TAD     CUPB
0550    0615  3356          DCA     ADDRC   /START OF CUP ARRAY
0551    0616  1106          TAD     N
0552    0617  7041          CIA
0553    0620  7001          IAC
0554    0621  3352          DCA     FLAGC   /SET TO CALCULATE  OF JS
0555    0622  1352          TAD     FLAGC
0556    0623  2352          ISZ     FLAGC
0557    0624  5222          JMP     .-2
0560    0625  3352          DCA     FLAGC   /FLAGC CONTAINS -  OF JS
0561    0626  4405  RPTC,   JMS I   INPUT   /GET A VALUE
0562    0627  4407          JMS I   INTERP
0563    0630  0004          FDIV2
0564    0631  6756          FPUT I  ADDRC   /STORE
0565    0632  0000          FEXT
0566    0633  7325          CLA IAC STL RAL
0567    0634  1356          TAD     ADDRC
                            DCA     ADDRC   /INCREMENT ADDRS
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0571  0636  2352          ISZ     FLAGC   /DONE?
0572  0637  5226          JMP     RPTC    /NO; GET NEXT ELEMENT
0573  0640  6211          CDF 10
0574  0641  5600          JMP I   WC      /YES; RETURN
0575  0642  0000  DIAGC,  0
0576  0643  4751          JMS I   KLAEL   /CLEAR ADD0 (3 WORDS)
0577  0644  1065          TAD     CPSB
0600  0645  3356          DCA     ADDRC   /ADDRC INITIALIZED TO CPS
0601  0646  1066          TAD     CUPB
0602  0647  3357          DCA     ADDRC1  /ADDRC1 INITIALIZED TO CUP
0603  0650  1106          TAD     N
0604  0651  7041          CIA
0605  0652  3352          DCA     FLAGC   /SET CPS DO LOOP
0606  0653  1107          TAD     TEMP    /GET BPF
0607  0654  3354          DCA     TEMC    /STORE IN TEMC
0610  0655  7300  RPTC1,  CLA CLL
0611  0656  1354          TAD     TEMC
0612  0657  7010          RAR             /GET RIGHTMOST BIT
0613  0660  3354          DCA     TEMC    /STORE REDUCED BPF
0614  0661  1354          TAD     TEMC
0615  0662  3355          DCA     TEMC1   /STORE FOR J USE
0616  0663  7430  CASE2,  SZL             /ALPHA OR BETA?
0617  0664  5272          JMP     .+6     /ALPHA
0620  0665  1346          TAD     BETA    /BETA SPIN
0621  0666  3300          DCA     ORDER   /SET DIRECTIONS
0622  0667  1350          TAD     CASE1
0623  0670  3320          DCA     DIRC    /SET DIRECTIONS FOR JS
0624  0671  5276          JMP     .+5
0625  0672  1344          TAD     ALPHA
0626  0673  3300          DCA     ORDER   /SET DIRECTIONS
0627  0674  1263          TAD     CASE2
0630  0675  3320          DCA     DIRC    /SET DIRECTIONS
0631  0676  4407          JMS I   INTERP
0632  0677  5513          FGET I  ADD0
0633  0700  0000  ORDER,  0               /INCREMENT ELEMENT DEPENDING ON DIRECTIONS
0634  0701  6513          FPUT I  ADD0
0635  0702  0000          FEXT
0636  0703  7325          CLA IAC STL RAL
0637  0704  1356          TAD     ADDRC
0640  0705  3356          DCA     ADDRC   /INCREMENT ADDRC
0641  0706  2352          ISZ     FLAGC   /DONE?
0642  0707  5312          JMP     .+3     /NO; CONTINUE
0643  0710  6211          CDF 10
0644  0711  5642          JMP I   DIAGC   /YES; RETURN
0645  0712  1352          TAD     FLAGC
0646  0713  3353          DCA     FLAGC1  /SET J DO LOOP
0647  0714  7300  RPTC2,  CLA CLL
0650  0715  1355          TAD     TEMC1   /GET PARTIALLY ROTATED BPF
0651  0716  7010          RAR             /ROTATE
0652  0717  3355          DCA     TEMC1   /STORE ROTATED VALUE
0653  0720  0000  DIRC,   0               /DEPENDS ON SPIN
0654  0721  5325          JMP     .+4     /SAME AS REFERENCE
0655  0722  1347          TAD     BETA1   /DIFFERENT THAN REFERENCE
0656  0723  3332          DCA     CONTROL /SET INSTRUCTION
0657  0724  5327          JMP     .+3
0660  0725  1345          TAD     ALPH1
0661  0726  3332          DCA     CONTROL /SET INSTRUCTION
0662  0727  4407          JMS I   INTERP
0663  0730  5513          FGET I  ADD0
0664  0731  1513          FADD I  ADD0
0665  0732  0000  CONTROL,0               /DEPENDS ON SPIN
0666  0733  0004          FDIV2
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0670    0735  0000          FEXT
0671    0736  7325          CLA IAC STL RAL
0672    0737  1357          TAD     ADDRC1
0673    0740  3357          DCA     ADDRC1  /INCREMENT ADDRC1
0674    0741  2353          ISZ     FLAGC1  /DONE WITH J LOOP?
0675    0742  5314          JMP     RPTC2   /NO; REPEAT
0676    0743  5255          JMP     RPTC1   /CONTINUE CPS LOOP
0677    0744  1756  ALPHA,  FADD I  ADDRC
0700    0745  1757  ALPH1,  FADD I  ADDRC1
0701    0746  2756  BETA,   FSUB I  ADDRC
0702    0747  2757  BETA1,  FSUB I  ADDRC1
0703    0750  7420  CASE1,  SNL
0704    0751  1147  KLAEL,  CLAEL
0705    0752  0000  FLAGC,  0
0706    0753  0000  FLAGC1, 0
0707    0754  0000  TEMC,   0
0710    0755  0000  TEMC1,  0
0711    0756  0000  ADDRC,  0
0712    0757  0000  ADDRC1, 0
0713    0760  0000  FPINP,  0
0714    0761  6201          CDF 0
0715    0762  4767          JMS I   FLIN
0716    0763  1060          TAD     60
0717    0764  7650          SNA CLA
0720    0765  5362          JMP     .-3
0721    0766  5760          JMP I   FPINP
0722    0767  7400  FLIN,   7400
0723                *1000
0724    1000  0000  XTERM,  0
0725    1001  4347          JMS     CLAEL   /3 WORD CLEAR OF ADD0
0726    1002  7240          STA
0727    1003  3313          DCA     INDD1
0730    1004  3314          DCA     INDD2   /INITIALIZE VARIABLES
0731    1005  7346          CLL STA RTL
0732    1006  3312          DCA     CTRDD
0733    1007  1107          TAD     TEMP    /GET BPFS TO BE COMPARED
0734    1010  3315          DCA     TEM
0735    1011  1114          TAD     TEMP1
0736    1012  3316          DCA     TEM1
0737    1013  1106          TAD     N
0740    1014  7041          CIA
0741    1015  3320          DCA     FLAGD   /SET DO LOOP
0742    1016  7300  RPTD,   CLA CLL
0743    1017  1315          TAD     TEM     /EXAMINE 1ST BPF
0744    1020  7010          RAR
0745    1021  3315          DCA     TEM     /STORE REDUCED VALUE
0746    1022  7430  INSTD,  SZL             /TEST LINK
0747    1023  5227          JMP     .+4
0750    1024  1317          TAD     INSTD1  /DIRD SHOULD    BE SNL
0751    1025  3235          DCA     DIRD
0752    1026  5231          JMP     .+3
0753    1027  1222          TAD     INSTD   /DIRD SHOULD BE SZL
0754    1030  3235          DCA     DIRD
0755    1031  7100          CLL
0756    1032  1316          TAD     TEM1    /EXAMINE CORRESPONDING BIT OF OTHER BPF
0757    1033  7010          RAR
0760    1034  3316          DCA     TEM1    /STORE REDUCED VALUE
0761    1035  0000  DIRD,   0
0762    1036  5252          JMP     CONT    /SPINS THE SAME, ROTATE AGAIN
0763    1037  2312          ISZ     CTRDD   /HOW MANY DIFFERENCES?
0764    1     5243          JMP     .+3     /<3 CONTINUE
0765    1     6211  RET,    CDF 10          /TOO MANY, RETURN
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0767   1043  1106          TAD     N
0770   1044  1320          TAD     FLAGD   /POSITION OF T  DIFFERENCE
0771   1045  2313          ISZ     INDD1   /WHERE TO STORE
0772   1046  5251          JMP     .+3     /INDD1 HAS A VALUE, STORE INDD2
0773   1047  3313          DCA     INDD1   /STORE IN INDD1
0774   1050  5252          JMP     .+2
0775   1051  3314          DCA     INDD2
0776   1052  2320  CONT,   ISZ     FLAGD   /WHOLE BPF EXAMINED?
0777   1053  5216          JMP     RPTD    /NO, ROTATE AGAIN
1000   1054  1313          TAD     INDD1   /YES, GET ADDRESS OF RELEVANT J
1001   1055  7041          CIA
1002   1056  1314          TAD     INDD2
1003   1057  3314          DCA     INDD2
1004   1060  1313          TAD     INDD1
1005   1061  7041          CIA
1006   1062  3313          DCA     INDD1
1007   1063  7040          CMA
1010   1064  1106          TAD     N
1011   1065  7041          CIA
1012   1066  3320          DCA     FLAGD
1013   1067  2313          ISZ     INDD1
1014   1070  5272          JMP     .+2
1015   1071  5275          JMP     .+4
1016   1072  1320          TAD     FLAGD
1017   1073  2320          ISZ     FLAGD
1020   1074  5267          JMP     .-5
1021   1075  7041          CIA
1022   1076  1314          TAD     INDD2
1023   1077  3312          DCA     CTRDD
1024   1100  1312          TAD     CTRDD
1025   1101  1312          TAD     CTRDD
1026   1102  1312          TAD     CTRDD
1027   1103  1066          TAD     CUPB
1030   1104  3312          DCA     CTRDD   /CTRDD CONTAINS PROPER ADDRESS
1031   1105  4407          JMS I   INTERP
1032   1106  5712          FGET I  CTRDD   /GET J VALUE
1033   1107  6513          FPUT I  ADD0    /PUT IN H ARRAY
1034   1110  0000          FEXT
1035   1111  5241          JMP     RET     /RETURN
1036   1112  0000  CTRDD,   0
1037   1113  0000  INDD1,   0
1040   1114  0000  INDD2,   0
1041   1115  0000  TEM,     0
1042   1116  0000  TEM1,    0
1043   1117  7420  INSTD1,  SNL
1044   1120  0000  FLAGD,   0
1045   1121  0000  INSPEC,  0             /INITIALIZE SPEC ARRAY
1046   1122  6211          CDF 10
1047   1123  7240          STA
1050   1124  3315          DCA     TEM     /INITIALIZE CALIBRATION COUNTER
1051   1125  1346          TAD     M500D
1052   1126  3320          DCA     FLAGD
1053   1127  1071          TAD     SPECB
1054   1130  3312          DCA     CTRDD   /INITIALIZE ADDRESS
1055   1131  2315  AGAIN,  ISZ     TEM     /NEED A CALIBRATION?
1056   1132  5336          JMP     .+4     /NO, DEPOSIT A 0
1057   1133  1345          TAD     M20     /YES
1060   1134  3315          DCA     TEM     /REINITIALIZE CALIBRATION COUNTER
1061   1135  7130          STL RAR         /PUT IN CALIBRATION
1062   1136  3712          DCA I   CTRDD   /PUT VALUE IN SPEC ARRAY
1063   1137  2312          ISZ     CTRDD
1064   1140  2320          ISZ     FLAGD   /DONE?
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1066    1142  4744          JMS I   INTAP
1067    1143  5721          JMP I   INSPEC  /RETURN
1070    1144  3317  INTAP,  STRTP
1071    1145  7754  M20,    7754
1072    1146  7014  M500D,  7014
1073    1147  0000  CLAEL,  0
1074    1150  6211          CDF 10
1075    1151  7240          STA
1076    1152  1113          TAD     ADD0
1077    1153  3010          DCA     10
1100    1154  3410          DCA I   10
1101    1155  3410          DCA I   10
1102    1156  3410          DCA I   10
1103    1157  6201          CDF 0
1104    1160  5747          JMP I   CLAEL
1105    1161  0000  ENDCHK, 0
1106    1162  7300          CLA CLL
1107    1163  1011          TAD     11
1110    1164  1103          TAD     AREND
1111    1165  7710          SPA CLA         /REACHED END OF TAPE BUFFER?
1112    1166  5761          JMP I   ENDCHK  /NO
1113    1167  4476          JMS I   TAPTRN  /YES, WRITE OUT THE BUFFER
1114    1170  1104          TAD     CORBUF
1115    1171  3011          DCA     11
1116    1172  5761          JMP I   ENDCHK
1117                *1200
1120    1200  0000  JAKE,   0
1121    1201  7200  RPTE,   CLA
1122    1202  1115          TAD     N1
1123    1203  7041          CIA
1124    1204  3365          DCA     FLAGE   /SET DO LOOP
1125    1205  7040          CMA
1126    1206  1115          TAD     N1
1127    1207  3267          DCA     CTRE    /CTRE=N1-1
1130    1210  3270          DCA     IS      /IS=0
1131    1211  7200  RPTE1,  CLA
1132    1212  2365          ISZ     FLAGE   /LOOP DONE?
1133    1213  5220          JMP     .+5     /NO, CONTINUE
1134    1214  1270          TAD     IS      /YES
1135    1215  7450          SNA             /MATRIX DIAGONALIZED?
1136    1216  5600          JMP I   JAKE    /YES, RETURN
1137    1217  5201          JMP     RPTE    /NO, GO THROUGH AGAIN
1140    1220  1267          TAD     CTRE
1141    1221  7041          CIA
1142    1222  3265          DCA     FLAGE1  /SET INNER DO LOOP
1143    1223  1367          TAD     R2
1144    1224  3364          DCA     INSTE
1145    1225  2265  RPTE2,  ISZ     FLAGE1  /DONE WITH INNER LOOP?
1146    1226  5234          JMP     .+6     /NO, CONTINUE
1147    1227  7240          CLA     CMA     /YES,INCREMENT CTRE AND OUTER DO LOOP
1150    1230  1267          TAD     CTRE
1151    1231  3267          DCA     CTRE    /CTRE=CTRE-1
1152    1232  1366          TAD     R1
1153    1233  3364          DCA     INSTE
1154    1234  7200          CLA
1155    1235  1115          TAD     N1
1156    1236  1365          TAD     FLAGE
1157    1237  3107          DCA     TEMP
1160    1240  1115          TAD     N1
1161    1241  1265          TAD     FLAGE1
1162    1     3114          DCA     TEMP1   /TEMP AND TEMP1 HA  SUBSCRIPTS
1163    12    4273          JMS     HSUBE
1164    1244  1513          TAD I   ADD0    /GET EXPONENT OF RELEVANT ELEMENT
```

```
1165    1245  1266          TAD     TESTE   /ADD 13 TO EXPONENT
1166    1246  7510          SPA             /ELEMENT SMALL ENOUGH?
1167    1247  5764          JMP I   INSTE   /YES, LOOK FOR OTHER
1170    1250  2113          ISZ     ADDØ    /IS IT Ø?
1171    1251  7300          CLA CLL
1172    1252  1513          TAD I   ADDØ
1173    1253  7004          RAL
1174    1254  7450          SNA
1175    1255  5764          JMP I   INSTE   /ITS Ø
1176    1256  7240          STA             /RESTORE ADDØ
1177    1257  1113          TAD     ADDØ
1200    1260  3113          DCA     ADDØ
1201    1261  2270          ISZ     IS      /SHOW THAT A LARGE ELEMENT IS FOUND
1202    1262  4671          JMS I   TRIGE   /Ø THE ELEMENT
1203    1263  4672          JMS I   VALUE
1204    1264  5764          JMP I   INSTE   /CONTINUE
1205    1265  0000  FLAGE1, Ø
1206    1266  0015  TESTE,  15
1207    1267  0000  CTRE,   Ø
1210    1270  0000  IS,     Ø
1211    1271  1400  TRIGE,  TRIG
1212    1272  1600  VALUE,  VALUEG
1213    1273  0000  HSUBE,  Ø
1214    1274  7200          CLA             /FIND ADDRESS OF H ELEMENT
1215    1275  1107          TAD     TEMP
1216    1276  7041          CIA
1217    1277  1114          TAD     TEMP1   /TEMP1-TEMP
1220    1300  7500          SMA             /WHICH IS BIGGEST?
1221    1301  5310          JMP     .+7     /TEMP1
1222    1302  7041          CIA             /TEMP
1223    1303  3340          DCA     DIFF    / FROM DIAGONAL ELEMENT
1224    1304  1114          TAD     TEMP1
1225    1305  7041          CIA
1226    1306  3336          DCA     IND1    /SET DO LOOP
1227    1307  5314          JMP     .+5
1230    1310  3340          DCA     DIFF
1231    1311  1107          TAD     TEMP
1232    1312  7041          CIA
1233    1313  3336          DCA     IND1
1234    1314  1115          TAD     N1
1235    1315  7041          CIA
1236    1316  3337          DCA     IND2    /SET UP REGISTER
1237    1317  2336          ISZ     IND1    /ENOUGH ADDITIONS?
1240    1320  5322          JMP     .+2     /NO, CONTINUE
1241    1321  5325          JMP     .+4     /YES, GET OUT OF LOOP
1242    1322  1337          TAD     IND2
1243    1323  2337          ISZ     IND2
1244    1324  5317          JMP     .-5
1245    1325  7041          CIA             /AC CONTAINS  OF ELEMENTS IN SKIPPED ROWS
1246    1326  1340          TAD     DIFF    / OF ELEMENTS TO SKIP
1247    1327  3113          DCA     ADDØ
1250    1330  1113          TAD     ADDØ
1251    1331  1113          TAD     ADDØ
1252    1332  1113          TAD     ADDØ
1253    1333  1073          TAD     HB
1254    1334  3113          DCA     ADDØ    /ADDØ CONTAINS ADDRESS
1255    1335  5673          JMP I   HSUBE
1256    1336  0000  IND1,   Ø
1257    1337  0000  IND2,   Ø
1260    1340  0000  DIFF,   Ø
1261    1341  0000  USUB,   Ø               /GETS ADDRESS IN U MATRIX
1262    1342  7240          STA
```

```
1264    1344  7450            SNA             /IS THIS 0
1265    1345  5353            JMP     .+6     /YES
1266    1346  7041            CIA             /NO
1267    1347  3336            DCA     IND1    /SET DO LOOP
1270    1350  1115            TAD     N1
1271    1351  2336            ISZ     IND1    /DONE WITH LOOP?
1272    1352  5350            JMP     .-2     /NO CONTINUE
1273    1353  1107            TAD     TEMP    /AC CONTAINS  OF ELEMENTS TO BE SKIPPED
1274    1354  3113            DCA     ADD0
1275    1355  7346            CLL STA RTL
1276    1356  1113            TAD     ADD0
1277    1357  1113            TAD     ADD0
1300    1360  1113            TAD     ADD0
1301    1361  1072            TAD     UB      /ADD0 CONTAINS ADDRESS
1302    1362  3113            DCA     ADD0
1303    1363  5741            JMP I   USUB
1304    1364  0000  INSTE,    0
1305    1365  0000  FLAGE,    0
1306    1366  1211  R1,       RPTE1
1307    1367  1225  R2,       RPTE2
1310                *1400
1311    1400  0000  TRIG,     0
1312    1401  4407            JMS I   INTERP  /GET H(JF,K)
1313    1402  5513            FGET I  ADD0
1314    1403  6337            FPUT    HJK
1315    1404  0000            FEXT
1316    1405  1107            TAD     TEMP
1317    1406  3327            DCA     JF
1320    1407  1114            TAD     TEMP1
1321    1410  3330            DCA     KF
1322    1411  1327            TAD     JF
1323    1412  3114            DCA     TEMP1
1324    1413  4742            JMS I   HSUBF   /GET ADDRESS OF H(J,J)
1325    1414  4407            JMS I   INTERP
1326    1415  5513            FGET I  ADD0
1327    1416  6331            FPUT    HJJ     /HJJ=H(J,J)
1330    1417  0000            FEXT
1331    1420  1330            TAD     KF
1332    1421  3107            DCA     TEMP
1333    1422  1330            TAD     KF
1334    1423  3114            DCA     TEMP1
1335    1424  4742            JMS I   HSUBF   /GET ADDRESS OF H(K,K)
1336    1425  4407            JMS I   INTERP
1337    1426  5513            FGET I  ADD0
1340    1427  6334            FPUT    HKK     /HKK=H(K,K)
1341    1430  2331            FSUB    HJJ
1342    1431  6321            FPUT    Y       /Y=HKK-HJJ
1343    1432  3321            FMPY    Y
1344    1433  6324            FPUT    R       /R=Y**2
1345    1434  5337            FGET    HJK
1346    1435  0003            FMPY2
1347    1436  0003            FMPY2
1350    1437  3337            FMPY    HJK
1351    1440  1324            FADD    R
1352    1441  0002            SQROOT
1353    1442  6324            FPUT    R       /R=(Y**2+4*HJK**2)**.5
1354    1443  0000            FEXT
1355    1444  1322            TAD     Y1
1356    1445  7500            SMA             /IS Y NEGATIVE?
1357    1446  5253            JMP     TR1     /NO
1360    14    4407            JMS I   INTERP  /YES
1361    15    0005            NEGATE          /THEN SET R=-R
1362    1451  6324            FPUT    R
```

```
1363      1452  0000            FEXT
1364      1453  4407  TR1,      JMS I   INTERP
1365      1454  5321            FGET    Y
1366      1455  4324            FDIV    R
1367      1456  6321            FPUT    Y       /Y(FCOS2)=Y/R
1370      1457  5337            FGET    HJK
1371      1460  0003            FMPY2
1372      1461  4324            FDIV    R
1373      1462  6324            FPUT    R       /R(FSIN2)=2*HJK/R
1374      1463  5316            FGET    ONEF
1375      1464  1321            FADD    Y
1376      1465  0004            FDIV2
1377      1466  0002            SQROOT
1400      1467  6127            FPUT    FCOS    /FCOS=((1+FCOS2)/)**.5
1401      1470  5324            FGET    R
1402      1471  4127            FDIV    FCOS
1403      1472  0004            FDIV2
1404      1473  6124            FPUT    FSIN    /FSIN=FSIN2/FCOS/2
1405      1474  5331            FGET    HJJ
1406      1475  1334            FADD    HKK
1407      1476  0004            FDIV2
1410      1477  6116            FPUT    A       /A=(HJJ+HKK)/2
1411      1500  5337            FGET    HJK
1412      1501  3324            FMPY    R
1413      1502  6121            FPUT    B       /B=HJK*FSIN2
1414      1503  5331            FGET    HJJ
1415      1504  2334            FSUB    HKK
1416      1505  0004            FDIV2
1417      1506  3321            FMPY    Y
1420      1507  2121            FSUB    B
1421      1510  6121            FPUT    B       /B=(HJJ-HKK)*FCOS2/2-HJK*FSIN2
1422      1511  0000            FEXT
1423      1512  1327            TAD     JF      /RESTORE TEMP AND TEMP1
1424      1513  3107            DCA     TEMP
1425      1514  6211            CDF 10
1426      1515  5600            JMP I   TRIG    /RETURN
1427      1516  0001  ONEF,      1
1430      1517  2000            2000
1431      1520  0000            0
1432      1521  0000  Y,        0
1433      1522  0000  Y1,       0
1434      1523  0000            0
1435      1524  0000  R,        0
1436      1525  0000            0
1437      1526  0000            0
1440      1527  0000  JF,       0
1441      1530  0000  KF,       0
1442      1531  0000  HJJ,      0
1443      1532  0000            0
1444      1533  0000            0
1445      1534  0000  HKK,      0
1446      1535  0000            0
1447      1536  0000            0
1450      1537  0000  HJK,      0
1451      1540  0000            0
1452      1541  0000            0
1453      1542  1273  HSUBF,    HSUBE
1454      1543  0000  ONESET,   0
1455      1544  7240            STA
1456      1545  1113            TAD     ADD0
1457      1546  3010            DCA     10
1460      1547  6211            CDF 10
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1462    1551  3410          DCA I   10
1463    1552  7132          STL RTR
1464    1553  3410          DCA I   10
1465    1554  3410          DCA I   10
1466    1555  6201          CDF 0
1467    1556  5743          JMP I   ONESET
1470                        TEXT4=,         /TEXT4 LOADS
1471                *1600
1472    1600  0000  VALUEG,  0               /CHANGES H AND U MATRICES
1473    1601  7200          CLA
1474    1602  1107          TAD     TEMP
1475    1603  3262          DCA     JG
1476    1604  1114          TAD     TEMP1
1477    1605  3263          DCA     K       /STORE TEMP AND TEMP1
1500    1606  1115          TAD     N1
1501    1607  7041          CIA
1502    1610  3264          DCA     FLAGG   /SET UP DO LOOP
1503    1611  6201          CDF 0
1504    1612  7201  RPTG,   CLA IAC
1505    1613  1264          TAD     FLAGG
1506    1614  1115          TAD     N1
1507    1615  3107          DCA     TEMP    /L INDEX
1510    1616  1261          TAD     USUBG
1511    1617  3256          DCA     SUBG    /READY TO CHANGE U MATRIX
1512    1620  4273          JMS     EL      /DO IT
1513    1621  1260          TAD     HSUBG
1514    1622  3256          DCA     SUBG    /READY TO CHANGE H MATRIX
1515    1623  4273          JMS     EL      /DO IT
1516    1624  2264          ISZ     FLAGG   /ALL ELEMENTS CALCULATED?
1517    1625  5212          JMP     RPTG    /NO, CONTINUE
1520    1626  1263          TAD     K
1521    1627  3107          DCA     TEMP
1522    1630  4660          JMS I   HSUBG   /GET ADDRESS OF H(K,K)
1523    1631  4407          JMS I   INTERP
1524    1632  5116          FGET    A
1525    1633  2121          FSUB    B
1526    1634  6513          FPUT I  ADD0    /H(K,K)=A=B
1527    1635  0000          FEXT
1530    1636  1262          TAD     JG
1531    1637  3107          DCA     TEMP
1532    1640  1262          TAD     JG
1533    1641  3114          DCA     TEMP1
1534    1642  4660          JMS I   HSUBG   /GET ADDRESS OF H(J,J)
1535    1643  4407          JMS I   INTERP
1536    1644  5116          FGET    A
1537    1645  1121          FADD    B
1540    1646  6513          FPUT I  ADD0    /H(J,J)=A+B
1541    1647  0000          FEXT
1542    1650  1263          TAD     K
1543    1651  3114          DCA     TEMP1
1544    1652  4660          JMS I   HSUBG   /GET ADDRESS OF H(J,K)
1545    1653  4657          JMS I   KLREL
1546    1654  6211          CDF 10
1547    1655  5600          JMP I   VALUEG  /RETURN
1550    1656  0000  SUBG,   0
1551    1657  1147  KLREL,  CLAEL
1552    1660  1273  HSUBG,  HSUBE
1553    1661  1341  USUBG,  USUB
1554    1662  0000  JG,     0
1555    1663  0000  K,      0
1556    1664  0000  FLAGG,  0
1557    1665  0000  LK,     0
1560    1666  0000          0
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1561    1667  0000          0
1562    1670  0000  LJ,     0
1563    1671  0000          0
1564    1672  0000          0
1565    1673  0000  EL,     0
1566    1674  1263          TAD     K
1567    1675  3114          DCA     TEMP1
1570    1676  4656          JMS I   SUBG
1571    1677  4407          JMS I   INTERP
1572    1700  5513          FGET I  ADD0
1573    1701  6265          FPUT    LK      /LK=M(L,K)
1574    1702  0000          FEXT
1575    1703  1262          TAD     JG
1576    1704  3114          DCA     TEMP1   /GET ADDRESS OF M(L,J)
1577    1705  4656          JMS I   SUBG
1600    1706  4407          JMS I   INTERP
1601    1707  5513          FGET I  ADD0
1602    1710  6270          FPUT    LJ      /LJ=M(L,J)
1603    1711  5265          FGET    LK
1604    1712  3124          FMPY    FSIN
1605    1713  6513          FPUT I  ADD0    /M(L,J)=LK*FSIN
1606    1714  5270          FGET    LJ
1607    1715  3127          FMPY    FCOS
1610    1716  2513          FSUB I  ADD0
1611    1717  6513          FPUT I  ADD0    /M(L,J)=M(L,J)*FCOS-M(L,K)*FSIN
1612    1720  0000          FEXT
1613    1721  1263          TAD     K
1614    1722  3114          DCA     TEMP1
1615    1723  4656          JMS I   SUBG    /GET ADDRESS OF M(L,K)
1616    1724  4407          JMS I   INTERP
1617    1725  5265          FGET    LK
1620    1726  3127          FMPY    FCOS
1621    1727  6265          FPUT    LK      /LK=FCOS*LK
1622    1730  5270          FGET    LJ
1623    1731  3124          FMPY    FSIN
1624    1732  1265          FADD    LK
1625    1733  6513          FPUT I  ADD0    /M(L,K)=M(L,J)*FSIN+M(L,K)*FCOS
1626    1734  0000          FEXT
1627    1735  5673          JMP I   EL
1630                        TEXT2=,         /TEXT2 LOADS
1631                *2000
1632    2000  0000  ALLOW,  0
1633    2001  7201          CLA IAC
1634    2002  1132          TAD     N2
1635    2003  7041          CIA
1636    2004  1133          TAD     JTEMP   /JTEMP=N2=1
1637    2005  1064          TAD     NUSEB
1640    2006  3334          DCA     ADD2    /CONTAINS ADDRESS OF BPF2
1641    2007  1024          TAD     TABLE
1642    2010  3330          DCA     TABADH  /INITIALIZE TABADH
1643    2011  1331          TAD     M12H
1644    2012  3332          DCA     CTRH3   /INITIALIZE CTRH3
1645    2013  1132          TAD     N2
1646    2014  7041          CIA
1647    2015  3335          DCA     FLAGH   /SET OUTER LOOP
1650    2016  7240  RPTH,   STA
1651    2017  1133          TAD     JTEMP
1652    2020  1064          TAD     NUSEB
1653    2021  3333          DCA     ADD1    /ADDRESS OF BPF1
1654    2022  1115          TAD     N1
1655    2023  7041          CIA
1656    2024  3336          DCA     FLAGH1  /SET INNER LOOP
1657    2025  6211  RPTH1,  CDF 10
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1660   2026  1734          TAD I   ADD2
1661   2027  3340          DCA     BPF2    /GET BPF2
1662   2030  1733          TAD I   ADD1
1663   2031  3337          DCA     BPF1    /GET BPF1
1664   2032  6201          CDF Ø
1665   2033  2333          ISZ     ADD1
1666   2034  4257          JMS     TEST    /FIND OUT IF ALLOWED TRANSITION
1667   2035  2336          ISZ     FLAGH1  /DONE WITH INNER LOOP?
1670   2036  5225          JMP     RPTH1   /NO, CONTINUE
1671   2037  2335          ISZ     FLAGH   /YES, DONE WITH OUTER LOOP?
1672   2040  5255          JMP     INC     /NO, CONTINUE
1673   2041  1332          TAD     CTRH3   /IS LAST TABLE ENTRY NORMALIZED?
1674   2042  7041          CIA
1675   2043  1331          TAD     M12H
1676   2044  7650          SNA CLA
1677   2045  5253          JMP     RETH    /YES, RETURN
1700   2046  1730          TAD I   TABADH  /NO, NORMALIZE IT
1701   2047  7110          CLL RAR
1702   2050  2332          ISZ     CTRH3   /NORMALIZED?
1703   2051  5247          JMP     .-2     /NO, ROTATE AGAIN
1704   2052  3730          DCA I   TABADH  /YES, STORE IT
1705   2053  6211  RETH,   CDF 10
1706   2054  5600          JMP I   ALLOW   /RETURN
1707   2055  2334  INC,    ISZ     ADD2
1710   2056  5216          JMP     RPTH
1711   2057  0000  TEST,   Ø
1712   2060  1106          TAD     N
1713   2061  7041          CIA
1714   2062  3341          DCA     CTRH    /- OF ROTATIONS
1715   2063  7001          IAC
1716   2064  7040          CMA
1717   2065  3342          DCA     CTRH1   /INITIALIZED TO -2
1720   2066  7300  OVER,   CLA CLL
1721   2067  1337          TAD     BPF1
1722   2070  7010          RAR
1723   2071  3337          DCA     BPF1    /STORE ROTATED VALUE
1724   2072  7430  ŻLINK,  SZL             /TEST LINK AND SET UP LATER TEST
1725   2073  5277          JMP     .+4
1726   2074  1343          TAD     NLINK
1727   2075  3305          DCA     INSTH
1730   2076  5301          JMP     .+3
1731   2077  1272          TAD     ŻLINK
1732   2100  3305          DCA     INSTH
1733   2101  7100          CLL
1734   2102  1340          TAD     BPF2
1735   2103  7010          RAR
1736   2104  3340          DCA     BPF2    /STORE  ROTATED VALUE
1737   2105  0000  INSTH,  Ø
1740   2106  5313          JMP     .+5     /SPINS THE SAME
1741   2107  2342          ISZ     CTRH1   /DIFFERENT
1742   2110  5313          JMP     .+3
1743   2111  7300          CLA CLL         /TOO MANY DIFFERENCES
1744   2112  5317          JMP     .+5
1745   2113  2341          ISZ     CTRH    /DONE ROTATING?
1746   2114  5266          JMP     OVER    /NO, ROTATE AGAIN
1747   2115  7200          CLA             /YES, ALLOWED TRANSITION
1750   2116  7120          STL
1751   2117  1730          TAD I   TABADH  /STORES ALLOWEDNESS
1752   2120  7010          RAR
1753   2121  3730          DCA I   TABADH
1754   2122  2332          ISZ     CTRH3   /NEED TO INCREMEN'  ABAD?
1755   2123  5657          JMP I   TEST    /NO
1756   2124  2330          ISZ     TABADH
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1757    2125  1331          TAD M12H        /REINIT CTRH3
1760    2126  3332          DCA CTRH3
1761    2127  5657          JMP I TEST
1762    2130  0000  TABADH,  Ø
1763    2131  7764  M12H,    7764
1764    2132  0000  CTRH3,   Ø
1765    2133  0000  ADD1,    Ø
1766    2134  0000  ADD2,    Ø
1767    2135  0000  FLAGH,   Ø
1770    2136  0000  FLAGH1,  Ø
1771    2137  0000  BPF1,    Ø
1772    2140  0000  BPF2,    Ø
1773    2141  0000  CTRH,    Ø
1774    2142  0000  CTRH1,   Ø
1775    2143  7420  NLINK,   SNL
1776    2144  0000          Ø
1777    2145  0000  TABL,    Ø
2000                        SAVSYM 2
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0000                    *20
0001                    PMODE
0002                    LODSYM
0003                    LISTAP =1
0004                    *2200
0005    2200  0000  HUGET, 0
0006    2201  7240        STA
0007    2202  1133        TAD     JTEMP
0010    2203  1064        TAD     NUSEB
0011    2204  3247        DCA     ADDR0   /CONTAINS ADDRESS OF 1ST BPF
0012    2205  1073        TAD     HB
0013    2206  3113        DCA     ADD0    /ADDRESS IN H ARRAY
0014    2207  1115        TAD     N1
0015    2210  7041        CIA
0016    2211  3245        DCA     ICTRI   /SET DO LOOP
0017    2212  7201  RPTI,  CLA IAC
0020    2213  1247        TAD     ADDR0
0021    2214  3250        DCA     ADDR2   /ADDRESS OF 2ND BPF
0022    2215  1647        TAD I   ADDR0
0023    2216  3107        DCA     TEMP    /CONTAINS BPF
0024    2217  4651        JMS I   DIAGEL  /GET A DIAGONAL ELEMENT
0025    2220  2247        ISZ     ADDR0   /MOVE TO NEXT BPF
0026    2221  2113        ISZ     ADD0
0027    2222  2113        ISZ     ADD0
0030    2223  2113        ISZ     ADD0    /MOVE TO NEXT H ELEMENT
0031    2224  7201        CLA IAC
0032    2225  1245        TAD     ICTRI
0033    2226  7450        SNA             /WAS THIS THE LAST ELEMENT?
0034    2227  5253        JMP     UGET    /YES, GET U MATRIX
0035    2230  3246        DCA     CTRI    /NO, SET INNER LOOP
0036    2231  7200  RPTI2, CLA
0037    2232  1650        TAD I   ADDR2
0040    2233  3114        DCA     TEMP1   /SECONDARY BPF
0041    2234  4652        JMS I   XTERMI  /GET A CROSS TERM
0042    2235  2113        ISZ     ADD0
0043    2236  2113        ISZ     ADD0
0044    2237  2113        ISZ     ADD0
0045    2240  2250        ISZ     ADDR2   /MOVE TO NEXT SECONDARY BPF
0046    2241  2246        ISZ     CTRI    /DONE WITH THIS ROW?
0047    2242  5231        JMP     RPTI2   /NO, CONTINUE
0050    2243  2245        ISZ     ICTRI   /YES, INCREMENT LOOP
0051    2244  5212        JMP     RPTI
0052    2245  0000  ICTRI, 0
0053    2246  0000  CTRI,  0
0054    2247  0000  ADDR0, 0
0055    2250  0000  ADDR2, 0
0056    2251  0642  DIAGEL, DIAGC
0057    2252  1200  XTERMI, XTERM
0060    2253  7200  UGET,  CLA             /INITIALIZE     U MATRIX
0061    2254  1115        TAD     N1
0062    2255  7041        CIA
0063    2256  3246        DCA     CTRI    /SET LOOP
0064    2257  1115        TAD     N1
0065    2260  2246        ISZ     CTRI    /LOOP DONE?
0066    2261  5257        JMP     .-2     /NO
0067    2262  3246        DCA     CTRI    /YES, OF U ELEMENTS
0070    2263  1246        TAD     CTRI
0071    2264  1246        TAD     CTRI
0072    2265  1246        TAD     CTRI    / OF WORDS IN U MATRIX
0073    2266  7041        CIA
0074    2267  3246        DCA     CTRI    /SET LOOP
0075    2270  1072        TAD     UB
```

```
0076  2271  3113          DCA     ADD0    /ADDRESS IN U MATRIX
0077  2272  3513          DCA I   ADD0    /LOOP ZEROES A  OF U MATRIX
0100  2273  2113          ISZ     ADD0
0101  2274  2246          ISZ     CTRI    /LOOP DONE?
0102  2275  5272          JMP     .-3     /NO
0103  2276  1115          TAD     N1      /YES,   PUT 1S ON DIAGONAL
0104  2277  7041          CIA
0105  2300  3246          DCA     CTRI    /SET LOOP
0106  2301  6201          CDF 0
0107  2302  7201  OVERI,  CLA IAC
0110  2303  1246          TAD     CTRI
0111  2304  1115          TAD     N1
0112  2305  3107          DCA     TEMP
0113  2306  1107          TAD     TEMP
0114  2307  3114          DCA     TEMP1   /INDICES OF DIAGONAL U ELEMENT
0115  2310  4717          JMS I   USUBI   /GET ADDRESS OF DIAGONAL ELEMENT
0116  2311  4716          JMS I   SETONE
0117  2312  2246          ISZ     CTRI    /LOOP DONE?
0120  2313  5302          JMP     OVERI   /NO
0121  2314  6211          CDF 10          /YES
0122  2315  5600          JMP I   HUGET   /RETURN
0123  2316  1543  SETONE, ONESET
0124  2317  1341  USUBI,  USUB
0125  2320  0000  COPY,   0
0126  2321  7200          CLA             /COPY U MATRIX
0127  2322  1072          TAD     UB
0130  2323  3247          DCA     ADDR0
0131  2324  1067          TAD     BOLD
0132  2325  3072          DCA     UB
0133  2326  1247          TAD     ADDR0
0134  2327  3067          DCA     BOLD
0135  2330  6201          CDF 0           /YES, COPY DIAGONAL H ELEMENTS INTO EN
0136  2331  1115          TAD     N1
0137  2332  7041          CIA
0140  2333  3246          DCA     CTRI    /SET LOOP
0141  2334  1070          TAD     ENB
0142  2335  3247          DCA     ADDR0   /ADDRESS IN EN
0143  2336  7201  AGAINI, CLA IAC
0144  2337  1246          TAD     CTRI
0145  2340  1115          TAD     N1
0146  2341  3107          DCA     TEMP
0147  2342  1107          TAD     TEMP
0150  2343  3114          DCA     TEMP1   /INDICES OF DIAGONAL H ELEMENT
0151  2344  4763          JMS I   HSUBI   /ADDRESS OF DIAGONAL H ELEMENT
0152  2345  4407          JMS I   INTERP
0153  2346  5513          FGET I  ADD0    /GET H ELEMENT
0154  2347  6647          FPUT I  ADDR0   /STORE IT
0155  2350  0000          FEXT
0156  2351  2247          ISZ     ADDR0
0157  2352  2247          ISZ     ADDR0
0160  2353  2247          ISZ     ADDR0
0161  2354  2246          ISZ     CTRI    /DONE?
0162  2355  5336          JMP     AGAINI  /NO
0163  2356  7200          CLA
0164  2357  1115          TAD     N1
0165  2360  3132          DCA     N2      /SET N2=N1
0166  2361  6211          CDF 10
0167  2362  5720          JMP I   COPY    /RETURN
0170  2363  1273  HSUBI,  HSUBE
0171                *2400
0172  2400  0000  TRANS,  0
0173  2401  6201          CDF 0
```

```
0175    2403  1067          TAD     BOLD
0176    2404  3336          DCA     IN2ADD  /ADDRESS OF 1ST ELEMENT IN CURRENT OLD
0177    2405  1070          TAD     ENB     /EIGENVECTOR
0200    2406  3121          DCA     B       /ADDRESS OF OLD EIGENVALUE
0201    2407  1132          TAD     N2
0202    2410  7041          CIA
0203    2411  3337          DCA     FLAGJ1  /SET 1ST ORDER LOOP
0204    2412  5224          JMP     UP
0225    2413  7200  RPT1,   CLA
0206    2414  2121          ISZ     B       /INCREMENT ADDRESS IN EN
0207    2415  2121          ISZ     B
0210    2416  2121          ISZ     B
0211    2417  1132          TAD     N2
0212    2420  1132          TAD     N2
0213    2421  1132          TAD     N2
0214    2422  1336          TAD     IN2ADD  /INCREMENT IN2 ADD
0215    2423  3336          DCA     IN2ADD
0216    2424  1072  UP,     TAD     UB
0217    2425  3340          DCA     IN1ADD  /ADDRESS OF 1ST ELEMENT IN CURRENT
0220    2426  1115          TAD     N1      /NEW EIGENVECTOR
0221    2427  7041          CIA
0222    2430  3341          DCA     FLAGJ2  /SET 2ND ORDER LOOP
0223    2431  5240          JMP     .+7
0224    2432  7200  RPT2,   CLA
0225    2433  1115          TAD     N1
0226    2434  1115          TAD     N1
0227    2435  1115          TAD     N1
0230    2436  1340          TAD     IN1ADD
0231    2437  3340          DCA     IN1ADD  /INCREMENT IN1ADD
0232    2440  7001          IAC
0233    2441  1341          TAD     FLAGJ2
0234    2442  1115          TAD     N1
0235    2443  3107          DCA     TEMP
0236    2444  1107          TAD     TEMP
0237    2445  3114          DCA     TEMP1   /SET SUBSCRIPTS FOR NEW EIGENVALUE
0240    2446  3116          DCA     A
0241    2447  3117          DCA     A+1
0242    2450  3120          DCA     A+2     /INITIALIZE TRANSITION PROBABILITY
0243    2451  1336          TAD     IN2ADD
0244    2452  3342          DCA     N2ADD   /ADDRESS IN OLD EIGENVECTOR
0245    2453  7040          CMA
0246    2454  3343          DCA     CTR     /INITIALIZE CTR
0247    2455  7040          CMA
0250    2456  1024          TAD     TABLE
0251    2457  3344          DCA     TABAD   /ADDRESS OF CHECK WORD
0252    2460  1132          TAD     N2
0253    2461  7041          CIA
0254    2462  3345          DCA     FLAGJ3  /SET 3RD ORDER LOOP
0255    2463  4746          JMS I   CALC1   /CALCULATE TRANSITION ENERGY
0256    2464  7200  RPT3,   CLA
0257    2465  1340          TAD     IN1ADD
0260    2466  3347          DCA     N1ADD   /ADDRESS IN NEW EIGENVECTOR
0261    2467  1115          TAD     N1
0262    2470  7041          CIA
0263    2471  3350          DCA     FLAGJ4  /SET 4TH ORDER LOOP
0264    2472  7200  RPT4,   CLA
0265    2473  2343          ISZ     CTR     /NEED A NEW CHECK WORD?
0266    2474  5302          JMP     .+6     /NO, GO ON
0267    2475  2344          ISZ     TABAD   /YES, INCREMENT ADDRESS
0270    2476  1351          TAD     M12
0271    2477  3343          DCA     CTR     /REINITIALIZE CTR
0272    2500  1744          TAD I   TABAD
        2501  3353          DCA     CHECK   /GET AND STORE NEW CHECK WORD
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0274    2502  1352            TAD     CHECK   /GET CHECK WORD
0275    2503  7210            RAR             /PUT CURRENT BIT INTO LINK
0276    2504  3352            DCA     CHECK   /STORE BALANCE
0277    2505  7420            SNL             /ALLOWED TRANSITION?
0300    2506  5315            JMP     .+7     /NO, SKIP CALCULATION
0301    2507  4407            JMS I   INTERP  /YES,CALCULATE PROBABLITY
0302    2510  5742            FGET I  N2ADD
0303    2511  5747            FMPY I  N1ADD
0304    2512  1116            FADD    A       /INCREMENT PROBABILITY
0305    2513  6116            FPUT    A
0306    2514  0000            FEXT
0307    2515  2347            ISZ     N1ADD
0310    2516  2347            ISZ     N1ADD
0311    2517  2347            ISZ     N1ADD   /INCREMENT NEW EIGENFUNCTION
0312    2520  2350            ISZ     FLAGJ4  /4TH ORDER LOOP DONE?
0313    2521  5272            JMP     RPT4    /NO, CONTINUE
0314    2522  2342            ISZ     N2ADD   /YES
0315    2523  2342            ISZ     N2ADD
0316    2524  2342            ISZ     N2ADD   /INCREMENT OLD EIGEN FUNCTION
0317    2525  2345            ISZ     FLAGJ3  /3RD ORDER LOOP DONE?
0320    2526  5264            JMP     RPT3    /NO, CONTINUE
0321    2527  4753            JMS I   CALC2   /YES, COMPUTE TOTAL PROBABILITY
0322    2530  2341  ALTR,     ISZ     FLAGJ2  /2ND ORDER LOOP DONE?
0323    2531  5232            JMP     RPT2    /NO, CONTINUE
0324    2532  2337            ISZ     FLAGJ1  /1ST ORDER LOOP DONE?
0325    2533  5213            JMP     RPT1    /NO, CONTINUE
0326    2534  6211            CDF 10          /YES
0327    2535  5600            JMP I   TRANS   /RETURN
0330    2536  0000  IN2ADD,   0
0331    2537  0000  FLAGJ1,   0
0332    2540  0000  IN1ADD,   0
0333    2541  0000  FLAGJ2,   0
0334    2542  0000  N2ADD,    0
0335    2543  0000  CTR,      0
0336    2544  0000  TABAD,    0
0337    2545  0000  FLAGJ3,   0
0340    2546  3000  CALC1,    CALCM1
0341    2547  0000  N1ADD,    0
0342    2550  0000  FLAGJ4,   0
0343    2551  7764  M12,      -14
0344    2552  0000  CHECK,    0
0345    2553  3042  CALC2,    CALCM2
0346    2554  0000  ARRLD,    0
0347    2555  4765            JMS I   CHKEND  /CHECK FOR END OF TAPE BUFFER
0350    2556  1044            TAD     EXP
0351    2557  3411            DCA I   11
0352    2560  1045            TAD     HORD
0353    2561  3411            DCA I   11
0354    2562  1046            TAD     LORD
0355    2563  3411            DCA I   11
0356    2564  5754            JMP I   ARRLD
0357    2565  1161  CHKEND,   ENDCHK
0360                  *2600
0361    2600  6036  INTRUP,   KRB             /GET A CHARACTER
0362    2601  4032            JMS     TYPE
0363    2602  7041            CIA
0364    2603  3107            DCA     TEMP
0365    2604  3114            DCA     TEMP1
0366    2605  1244            TAD     CHTB
0367    2606  3010            DCA     10
0370    2607  4025  RDMOR,    JMS     READ
0371    2610  4032            JMS     TYPE
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0373    2612  7450          SNA
0374    2613  5221          JMP     LOKUP
0375    2614  1243          TAD     MR377
0376    2615  7640          SZA CLA
0377    2616  5207          JMP     RDMOR
0400    2617  4263          JMS     CRLFD
0401    2620  5641          JMP I   DSPL
0402    2621  6201  LOKUP,  CDF 0
0403    2622  1410          TAD I   10
0404    2623  7450          SNA
0405    2624  5217          JMP     LOKUP-2
0406    2625  2114          ISZ     TEMP1
0407    2626  1107          TAD     TEMP
0410    2627  7640          SZA CLA
0411    2630  5222          JMP     LOKUP+1
0412    2631  1114          TAD     TEMP1
0413    2632  1245          TAD     ADDRL
0414    2633  3107          DCA     TEMP
0415    2634  1507          TAD I   TEMP
0416    2635  3107          DCA     TEMP
0417    2636  6211          CDF 10
0420    2637  4263          JMS     CRLFD
0421    2640  5507          JMP I   TEMP
0422    2641  4001  DSPL,   START
0423    2642  7506  M272,   =272
0424    2643  7673  MR377,  272=377
0425    2644  2645  CHTB,   CHRTB=1
0426    2645  2654  ADDRL,  TABADL=1
0427    2646  0320  CHRTB,  320     /P-UNCH
0430    2647  0322          322     /R-ESTART
0431    2650  0303          303     /C-OUPLING CONSTANTS
0432    2651  0317          317     /O-FFSET
0433    2652  0304          304     /D-IAL EXIT
0434    2653  0314          314     /L-IST
0435    2654  0000          0
0436    2655  3330  TABADL, BPNCH
0437    2656  0205          BEGIN+3
0440    2657  0244          NEWJ
0441    2660  0402          OFFS
0442    2661  4011          DIALEX
0443    2662  3200          LISP
0444    2663  0000  CRLFD,  0
0445    2664  7200          CLA
0446    2665  1274          TAD     P215
0447    2666  4032          JMS     TYPE
0450    2667  7200          CLA
0451    2670  1275          TAD     LF
0452    2671  4032          JMS     TYPE
0453    2672  7200          CLA
0454    2673  5663          JMP I   CRLFD
0455    2674  0215  P215,   215
0456    2675  0212  LF,     212
0457    2676  0000  PRINTL, 0
0460    2677  6201          CDF 0
0461    2700  4263          JMS     CRLFD
0462    2701  4263          JMS     CRLFD
0463    2702  1676          TAD I   PRINTL  /GET MESSAGE ADDRESS
0464    2703  2276          ISZ     PRINTL
0465    2704  3343          DCA     JUMP    /STORE VALUE
0466    2705  7300  AGAINL, CLA CLL
0467          5  1743          TAD I   JUMP    /GET 6 BIT PAIR
0470    2    7  7012          RTR
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0472  2711  7012            RTR
0473  2712  4320            JMS     WRITE   /TYPE LEFT 6 BITS
0474  2713  7200            CLA
0475  2714  1743            TAD I   JUMP
0476  2715  2343            ISZ     JUMP
0477  2716  4320            JMS     WRITE   /TYPE RIGHT 6 BITS
0500  2717  5305            JMP     AGAINL
0501  2720  0000  WRITE,    0
0502  2721  0347            AND     MASK1   /MASK OUT LEFT 6 BITS
0503  2722  7450            SNA             /EITHER HALF =0?
0504  2723  5341            JMP     EXITT   /YES, EXIT
0505  2724  1344            TAD     M36     /NO
0506  2725  7550            SPA SNA         /200 OR 300 SERIES?
0507  2726  5332            JMP     .+4     /300 SERIES
0510  2727  1345            TAD     P236    /200 SERIES
0511  2730  4032            JMS     TYPE    /TYPE IT
0512  2731  5720            JMP I   WRITE
0513  2732  7440            SZA             /SPECIAL CODE 36?
0514  2733  5336            JMP     .+3     /NO
0515  2734  4263            JMS     CRLFD
0516  2735  5720            JMP I   WRITE
0517  2736  1346            TAD     P336
0520  2737  4032            JMS     TYPE    /TYPE IT
0521  2740  5720            JMP I   WRITE
0522  2741  6211  EXITT,    CDF 10
0523  2742  5676            JMP I   PRINTL
0524  2743  0000  JUMP,     0
0525  2744  7742  M36,      -36
0526  2745  0236  P236,     236
0527  2746  0336  P336,     336
0530  2747  0077  MASK1,    0077
0531                        TEXT3=.         /TEXT3 LOADS
0532                        *3000
0533  3000  0000  CALCM1,   0
0534  3001  4633            JMS I   HSUBM   /GET ADDRESS OF OLD EIGENVALUE
0535  3002  4407            JMS I   INTERP
0536  3003  5521            FGET I  B
0537  3004  2513            FSUB I  ADD0    /EN-HII
0540  3005  0000            FEXT
0541  3006  4632            JMS I   LDARR   /LOAD ARRAY W/ -CHEMICAL SHIFT
0542  3007  4407            JMS I   INTERP
0543  3010  1110            FADD    LIMIT   /LIMIT -CHEMICAL SHIFT
0544  3011  3134            FMPY    FACTOR
0545  3012  1234            FADD    HALFM   /SET TO FIX AND ROUND
0546  3013  0000            FEXT
0547  3014  4327            JMS     FIX     /FIX IT
0550  3015  7510            SPA             /IN RIGHT RANGE?
0551  3016  5226            JMP     AHEAD   /NO, TOO SMALL
0552  3017  1237            TAD     M500M   /MAYBE
0553  3020  7500            SMA             /IN RIGHT RANGE?
0554  3021  5226            JMP     AHEAD   /NO, TOO BIG
0555  3022  1240            TAD     P500M   /YES
0556  3023  1071            TAD     SPECB
0557  3024  3241            DCA     ADSPEC  /ADDRESS FOR STORING PROBABILITY
0560  3025  5600            JMP I   CALCM1
0561  3026  7300  AHEAD,    CLA CLL
0562  3027  1237            TAD     M500M
0563  3030  3241            DCA     ADSPEC
0564  3031  5600            JMP I   CALCM1
0565  3032  2554  LDARR,    ARRLD
0566  3033  1273  HSUBM,    HSUBE
0567  3034  0000  HALFM,    0
0570  3035  2000            2000
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0571    3036  0000          0
0572    3037  7014  M500M,  7014
0573    3040  0764  P500M,  0764
0574    3041  0000  ADSPEC, 0
0575    3042  0000  CALCM2, 0                 /SUBROUTINE INCREMENTS PROPER ELEMENT
0576    3043  6211          CDF 10            /IN SPEC ARRAY
0577    3044  7200          CLA
0600    3045  1641          TAD I   ADSPEC
0601    3046  0305          AND     MASKM     /ERASE CALIBRATION MARK
0602    3047  3304          DCA     SIGN      /STORE
0603    3050  4407          JMS I   INTERP
0604    3051  5116          FGET    A
0605    3052  5116          FMPY    A         /SQUARE TO GET PROBABILITY
0606    3053  0000          FEXT
0607    3054  1306          TAD     PL6       /SCREEN OUT LOW INTENSITIES
0610    3055  1044          TAD     EXP
0611    3056  3044          DCA     EXP
0612    3057  4632          JMS I   LDARR
0613    3060  4327          JMS     FIX       /FIX
0614    3061  3303          DCA     PROB      /STORE CURRENT PROBABILITY
0615    3062  1241          TAD     ADSPEC
0616    3063  7710          SPA CLA
0617    3064  5642          JMP I   CALCM2
0620    3065  6211          CDF 10
0621    3066  1303          TAD     PROB
0622    3067  1304          TAD     SIGN      /GET - AC IF SUM IS TOO BIG
0623    3070  7700          SMA CLA
0624    3071  5276          JMP     .+5       /NOT TOO BIG
0625    3072  1641          TAD I   ADSPEC    /TOO BIG, SET TO MAX
0626    3073  7004          RAL
0627    3074  7250          STA RAR
0630    3075  5300          JMP     .+3
0631    3076  1641          TAD I   ADSPEC    /GET OLD SPEC ELEMENT
0632    3077  1303          TAD     PROB      /INCREMENT IT
0633    3100  3641          DCA I   ADSPEC    /STORE IT
0634    3101  6201          CDF 0
0635    3102  5642          JMP I   CALCM2    /RETURN
0636    3103  0000  PROB,    0
0637    3104  0000  SIGN,    0
0640    3105  3777  MASKM,   3777
0641    3106  0006  PL6,     6
0642    3107  0000  SETUP,   0
0643    3110  3325          DCA     HOLD
0644    3111  1325          TAD     HOLD
0645    3112  7012          RTR
0646    3113  7012          RTR
0647    3114  7012          RTR
0650    3115  0326          AND     BLIND     /MASK OUT BITS 0-5
0651    3116  4423          JMS I   HPUN      /PUNCH FIRST 6 BITS
0652    3117  7200          CLA
0653    3120  1325          TAD     HOLD
0654    3121  0326          AND     BLIND     /PUNCH LST 6 BITS
0655    3122  4423          JMS I   HPUN
0656    3123  7200          CLA
0657    3124  5707          JMP I   SETUP     /RETURN
0660    3125  0000  HOLD,    0
0661    3126  0077  BLIND,   0077
0662    3127  0000  FIX,     0                 /ROUTINE FIXES A F, P.
0663    3130  7200          CLA
0664    3131  1044          TAD     EXP
0665    3132  7540          SMA SZA           /IS  <1
0666    3133  5336          JMP     .+3       /NO GO ON
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0670    3135  5727            JMP I   FIX     /RETURN
0671    3136  1361            TAD     M11
0672    3137  7440            SZA             /IS HORD ALREAD RIGHT?
0673    3140  5343            JMP     .+3     /NO
0674    3141  1045            TAD     HORD    /YES, GET HORD
0675    3142  5727            JMP I   FIX     /RETURN
0676    3143  7500            SMA             /IS  TOO BIG TO FIX?
0677    3144  5356            JMP     ERROR   /YES, SET TO 3777
0700    3145  3325            DCA     HOLD    /NO, SET FIXING LOOP
0701    3146  1045            TAD     HORD
0702    3147  7100            CLL             /ROTATE RIGHT FILLING WITH 1S IF NEG
0703    3150  7510            SPA             /OR 0S IF POS
0704    3151  7120            STL
0705    3152  7010            RAR
0706    3153  2325            ISZ     HOLD    /LOOP DONE?
0707    3154  5347            JMP     .-5     /NO
0710    3155  5727            JMP I   FIX     /YES RETURN
0711    3156  7200  ERROR,    CLA
0712    3157  1305            TAD     MASKM
0713    3160  5727            JMP I   FIX
0714    3161  7765  M11,      7765
0715                          *3200
0716    3200  4474  LISP,     JMS I   PRINT   /MIN INTENSITY=
0717    3201  2767            HD10
0720    3202  4405            JMS I   INPUT
0721    3203  4407            JMS I   INTERP
0722    3204  6116            FPUT    A
0723    3205  0000            FEXT
0724    3206  4474            JMS I   PRINT   /DISPLAY LISTING?
0725    3207  2760            HD9
0726    3210  4634            JMS I   ASKRX
0727    3211  7650            SNA CLA
0730    3212  5633            JMP I   DSLST   /YES
0731    3213  4317            JMS     STRTP   /INIT, TAPE READ
0732    3214  4474            JMS I   PRINT   /INTENSITY  ENERGY
0733    3215  1557            HD11
0734    3216  6201            CDF 0
0735    3217  4250  BACK,     JMS     LODFAC
0736    3220  7410            SKP             /NORMAL RETURN
0737    3221  5475            JMP I   DISPLAY /FOUND TERMINATOR
0740    3222  4407            JMS I   INTERP
0741    3223  0005            NEGATE
0742    3224  6124            FPUT    FSIN
0743    3225  0000            FEXT
0744    3226  4250            JMS     LODFAC  /GET CORRESPONDING INTENSITY
0745    3227  7410            SKP
0746    3230  7402            HLT             /GOT HERE ONLY BY BAD FILE!
0747    3231  4265            JMS     EIPRNT
0750    3232  5217            JMP     BACK
0751    3233  4246  DSLST,    DSLS
0752    3234  4315  ASKRX,    ASKM
0753    3235  0000  LDCHK,    0
0754    3236  7200            CLA
0755    3237  1011            TAD     11
0756    3240  1103            TAD     AREND
0757    3241  7710            SPA CLA         /NEED NEW BUFFER LOAD?
0760    3242  5635            JMP I   LDCHK   /NO
0761    3243  1104            TAD     CORBUF  /YES
0762    3244  3011            DCA     11
0763    3245  7001            IAC
0764    3246  4476            JMS I   TAPTRN
0765    3247  5635            JMP I   LDCHK
0766    3250  0000  LODFAC,    0
```

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0767    3251  4235          JMS     LDCHK
0770    3252  1411          TAD I   11
0771    3253  3044          DCA     EXP
0772    3254  7132          STL RTR
0773    3255  1044          TAD     EXP
0774    3256  7650          SNA CLA                 /GET 6000, I,E,, END WORD?
0775    3257  2250          ISZ     LODFAC  /YES, INCR, RETURN
0776    3260  1411          TAD I   11
0777    3261  3045          DCA     HORD
1000    3262  1411          TAD I   11
1001    3263  3046          DCA     LORD
1002    3264  5650          JMP I   LODFAC
1003    3265  0000  EIPRNT, 0
1004    3266  4407          JMS I   INTERP
1005    3267  6127          FPUT    FCOS
1006    3270  2116          FSUB    A
1007    3271  0000          FEXT
1010    3272  1045          TAD     HORD
1011    3273  7710          SPA CLA                 /INTENSITY TOO SMALL?
1012    3274  5665          JMP I   EIPRNT  /YES, GET NEXT VALUES
1013    3275  4407          JMS I   INTERP  /NO, OUTPUT
1014    3276  5127          FGET    FCOS
1015    3277  0000          FEXT
1016    3300  7105          CLL IAC RAL
1017    3301  4406          JMS I   OUTPUT  /OUTPUT INTENSITY
1020    3302  1316          TAD     SPACE
1021    3303  4032          JMS     TYPE
1022    3304  4032          JMS     TYPE
1023    3305  4407          JMS I   INTERP
1024    3306  5124          FGET    FSIN
1025    3307  0000          FEXT
1026    3310  7105          IAC CLL RAL
1027    3311  4406          JMS I   OUTPUT  /OUTPUT CHEM SHIFT
1030    3312  4714          JMS I   CARLF
1031    3313  5665          JMP I   EIPRNT
1032    3314  2663  CARLF,  CRLFD
1033    3315  4315  ASKN,   ASKM
1034    3316  0240  SPACE,  240
1035    3317  0000  STRTP,  0                       /INITIALIZE TO READ FROM TAPE
1036    3320  7200          CLA
1037    3321  1104          TAD     CORBUF
1040    3322  3011          DCA     11
1041    3323  1100          TAD     STBLK
1042    3324  3101          DCA     BLK1
1043    3325  7001          IAC
1044    3326  4476          JMS I   TAPTRN  /READ FIRST BLOCK
1045    3327  5717          JMP I   STRTP
1046    3330  4517  BPNCH,  JMS     STRTP
1047    3331  6201          CDF 0
1050    3332  4564          JMS     LEDR
1051    3333  1362          TAD     KK300
1052    3334  4423          JMS I   HPUN
1053    3335  4255  PNOUT,  JMS     LDCHK
1054    3336  1411          TAD I   11
1055    3337  3363          DCA     TTT
1056    3340  7132          STL RTR
1057    3341  1363          TAD     TTT
1060    3342  7650          SNA CLA                 /GET 6000 FOR END?
1061    3343  5353          JMP     PEX     /YES
1062    3344  1363          TAD     TTT
1063       5  4757          JMS I   BPUN
1064    3346  1411          TAD I   11
```

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1066   3350  1411          TAD I   11
1067   3351  4757          JMS I   BPUN
1070   3352  5335          JMP     PNOUT
1071   3353  1361  PEX,    TAD     KK200
1072   3354  4423          JMS I   HPUN
1073   3355  4564          JMS     LEDR
1074   3356  5475          JMP I   DISPLAY
1075   3357  3107  BPUN,   SETUP
1076   3360  7700  LCT,    -100
1077   3361  0200  KK200,  200
1100   3362  0300  KK300,  300
1101   3363  0000  TTT,    0
1102   3364  0000  LEDR,   0
1103   3365  7200          CLA
1104   3366  1360          TAD     LCT
1105   3367  3363          DCA     TTT
1106   3370  4423          JMS I   HPUN
1107   3371  2363          ISZ     TTT
1110   3372  5370          JMP     .-2
1111   3373  5764          JMP I   LEDR
1112         *3400
1113   3400  0000  INITB,  0
1114   3401  7200          CLA                 /GET  OF BASIC PRODUCT FUNCTIONS
1115   3402  6211          CDF 10
1116   3403  1106          TAD     N
1117   3404  7041          CIA
1120   3405  3334          DCA     FLAGB
1121   3406  7201          CLA     IAC
1122   3407  7104          CLL RAL
1123   3410  2334          ISZ     FLAGB
1124   3411  5207          JMP     .-2
1125   3412  3336          DCA     NTOT
1126   3413  1063          TAD     IFZB        /INITIALIZE NARRAY
1127   3414  3333          DCA     ADDRB
1130   3415  7001          IAC
1131   3416  3733          DCA I   ADDRB
1132   3417  2333          ISZ     ADDRB
1133   3420  7105          CLL IAC RAL
1134   3421  3733          DCA I   ADDRB
1135   3422  2333          ISZ     ADDRB
1136   3423  7105          CLL IAC RAL
1137   3424  1106          TAD     N
1140   3425  3733          DCA I   ADDRB
1141   3426  2333          ISZ     ADDRB       /FIRST 3 INITIALIZED
1142   3427  7346          CLL STA RTL
1143   3430  1106          TAD     N           /N-3 IN AC
1144   3431  7510          SPA
1145   3432  5267          JMP     CONT3       /DONE INITIALIZING
1146   3433  7550          SPA SNA
1147   3434  5264          JMP     CONT4       /JUST ONE TO CALCULATE
1150   3435  7041          CIA                 /3-N IN AC
1151   3436  7001          IAC
1152   3437  7001          IAC                 /5-N IN AC
1153   3440  7540          SMA SZA
1154   3441  5256          JMP     CONT2       /JUST TWO TO CALCULATE
1155   3442  7650          SNA CLA
1156   3443  5253          JMP     CONT1       /3 TO CALCULATE
1157   3444  1340          TAD     P23         /4 TO GO
1160   3445  3733          DCA I   ADDRB
1161   3446  2333          ISZ     ADDRB
1162   3447  1341          TAD     P43
1163   3450  3733          DCA I   ADDRB
1164   3451  2333          ISZ     ADDRB
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1165    3452  5256          JMP     CONT2   /FOR N=6, 4 & 5 DONE
1166    3453  1637  CONT1,  TAD     P17
1167    3454  3733          DCA I   ADDRB
1170    3455  2333          ISZ     ADDRB   /FOR N=5, 4 DONE
1171    3456  7200  CONT2,  CLA
1172    3457  1106          TAD     N
1173    3460  7041          CIA
1174    3461  1336          TAD     NTOT
1175    3462  3733          DCA I   ADDRB   /2ND LAST ELEMENT=NTOT-N
1176    3463  2333          ISZ     ADDRB
1177    3464  7200  CONT4,  CLA             /CALCULATE FINAL ELEMENT
1200    3465  1336          TAD     NTOT
1201    3466  3733          DCA I   ADDRB
1202    3467  7200  CONT3,  CLA             /INITIALIZE NUSE
1203    3470  1336          TAD     NTOT
1204    3471  7041          CIA
1205    3472  3334          DCA     FLAGB   /-NTOT IN FLAGB
1206    3473  7200  RPTB1,  CLA
1207    3474  3342          DCA     CTRB
1210    3475  1106          TAD     N
1211    3476  7041          CIA
1212    3477  3335          DCA     INDEX   /-N IN INDEX
1213    3500  7001          IAC
1214    3501  1334          TAD     FLAGB
1215    3502  7041          CIA             /BPF TO BE TESTED IN AC
1216    3503  7100          CLL
1217    3504  7010  RPTB2,  RAR             /EXAMINE BIT BY BIT
1220    3505  7430          SZL
1221    3506  2342          ISZ     CTRB    /INCREMENT CTRB ON NON-ZERO LINK
1222    3507  2335          ISZ     INDEX   /DONE WITH THIS BPF?
1223    3510  5304          JMP     RPTB2   /NO; ROTATE AGAIN
1224    3511  7200          CLA             /YES; PUT IN PROPER IN NUSE ARRAY
1225    3512  1342          TAD     CTRB
1226    3513  1063          TAD     IFZB
1227    3514  3333          DCA     ADDRB
1230    3515  1733          TAD I   ADDRB
1231    3516  3107          DCA     TEMP    /TEMP CONTAINS REL, ADDRESS
1232    3517  2733          ISZ I   ADDRB   /INCREMENT NARRAY ELEMENT
1233    3520  7240          STA
1234    3521  1107          TAD     TEMP
1235    3522  1064          TAD     NUSEB
1236    3523  3333          DCA     ADDRB   /ADDRB CONTAINS LOCATION IN NUSE
1237    3524  7001          IAC
1240    3525  1334          TAD     FLAGB
1241    3526  7041          CIA
1242    3527  3733          DCA I   ADDRB   /VALUE IN NUSE
1243    3530  2334          ISZ     FLAGB   /DONE?
1244    3531  5273          JMP     RPTB1   /NO; GET NEXT NUMBER
1245    3532  5603          JMP I   INITB   /YES; RETURN
1246    3533  0000  ADDRB,  0
1247    3534  0000  FLAGB,  0
1250    3535  0000  INDEX,  0
1251    3536  0002  NTOT,   0
1252    3537  0021  P17,    21
1253    3540  0027  P23,    27
1254    3541  0053  P43,    53
1255    3542  0000  CTRB,   0
1256    3543  0000  MLPY2,  0
1257    3544  2044          ISZ     EXP
1260    3545  5743          JMP I   MLPY2
1261    3546  5743          JMP I   MLPY2
1262    3547  0000  DIVD2,  0
1263    3550  7240          STA
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1264    3551  1044          TAD EXP
1265    3552  3044          DCA EXP
1266    3553  5747          JMP I   DIVD2
1267    3554  0000  ULIMP,  0
1270    3555  4474          JMS I   PRINT   /SWEEP OFFSET AND WIDTH:
1271    3556  2750          HD7
1272    3557  4405          JMS I   INPUT
1273    3560  4407          JMS I   INTERP
1274    3561  6137          FPUT    OFSET
1275    3562  6110          FPUT    LIMIT
1276    3563  0006          FLOIN
1277    3564  6134          FPUT    FACTOR
1300    3565  1110          FADD    LIMIT
1301    3566  6110          FPUT    LIMIT
1302    3567  5375          FGET    P500
1303    3570  4134          FDIV    FACTOR
1304    3571  6134          FPUT    FACTOR
1305    3572  0000          FEXT
1306    3573  6211          CDF 10
1307    3574  5754          JMP I   ULIMP
1310    3575  0011  P500,   0011
1311    3576  3720          3720
1312    3577  0000          0000
1313                        /NMR DISPLAY ROUTINE PART A
1314                *3600
1315    3600  7200  STDIS,  CLA
1316    3601  6211          CDF 10
1317    3602  4526          JMS     INITK
1320    3603  1741  NEXTK,  TAD I   YK      /ROUTINE TO COMBINE ADJACENT
1321    3604  0334          AND     K3777   /ELEMENTS IN THE SPECB ARRAY
1322    3605  7450          SNA             /CHECK FOR NON-ZERO ELEMENT
1323    3606  5237          JMP     NINCR
1324    3607  3344          DCA     HOLDK
1325    3610  2341          ISZ     YK
1326    3611  2342          ISZ     XCTRK
1327    3612  5214          JMP     .+2
1330    3613  5242          JMP     ENDCOM
1331    3614  1741          TAD I   YK      /GET NEXT ELEMENT
1332    3615  0334          AND     K3777
1333    3616  7450          SNA
1334    3617  5237          JMP     NINCR
1335    3620  1344          TAD     HOLDK   /COMBINE ELEMENTS
1336    3621  0334          AND     K3777
1337    3622  3344          DCA     HOLDK
1340    3623  1741          TAD I   YK      /SAVE CALIBRATION MARK
1341    3624  0335          AND     K4000
1342    3625  1344          TAD     HOLDK
1343    3626  3741          DCA I   YK
1344    3627  7040          CMA
1345    3630  1341          TAD     YK
1346    3631  3341          DCA     YK
1347    3632  1741          TAD I   YK      /ERASE PREVIOUS ELEMENT
1350    3633  0335          AND     K4000
1351    3634  3741          DCA I   YK
1352    3635  2341          ISZ     YK
1353    3636  5203          JMP     NEXTK
1354    3637  2341  NINCR,  ISZ     YK      /GO ON TO NEXT ELEMENT
1355    3640  2342          ISZ     XCTRK
1356    3641  5203          JMP     NEXTK
1357    3642  4526  ENDCOM, JMS     INITK
1360    3643  1741          TAD I   YK      /ROUTINE TO FIND LARGEST ELEMENT
1361    3644  0334          AND     K3777   /IN ARRAY
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1363   3646  3340          DCA      HGT
1364   3647  2341  NEXTKV, ISZ      YK
1365   3650  2342          ISZ      XCTRK
1366   3651  5253          JMP      .+2
1367   3652  5261          JMP      ROTATE
1370   3653  1741          TAD I    YK
1371   3654  0334          AND      K3777
1372   3655  1340          TAD      HGT
1373   3656  7710          SPA CLA
1374   3657  5247          JMP      NEXTKV
1375   3660  5243          JMP      ENDCOM+1
1376   3661  4326  ROTATE, JMS      INITK    /ROUTINE TO CHECK FOR OVERSIZED
1377   3662  3343          DCA      FLAGK    /ELEMENT AND COMPUTE NUMBER OF
1400   3663  1340          TAD      HGT      /ROTATIONS REQUIRED TO PREVENT
1401   3664  7041          CIA               /DISPLAY BUFFER OVERFLOW
1402   3665  3340          DCA      HGT
1403   3666  1340  AGAINK, TAD      HGT
1404   3667  0336          AND      K3400
1405   3670  7650          SNA CLA
1406   3671  5300          JMP      OK
1407   3672  1340          TAD      HGT
1410   3673  0334          AND      K3777
1411   3674  7010          RAR
1412   3675  3340          DCA      HGT
1413   3676  2343          ISZ      FLAGK
1414   3677  5266          JMP      AGAINK
1415   3700  1343  OK,     TAD      FLAGK    /ROTATE ALL ELEMENTS IN ARRAY
1416   3701  7450          SNA               /ANY ROTATIONS NEEDED?
1417   3702  5746          JMP I    XSTART   /NO, EXIT TO DISPLAY
1420   3703  7041          CIA
1421   3704  3343          DCA      FLAGK
1422   3705  1343  NEXTY,  TAD      FLAGK
1423   3706  3345          DCA      FLGR
1424   3707  1741          TAD I    YK
1425   3710  0334          AND      K3777
1426   3711  7010  INSTK,  RAR
1427   3712  0334          AND      K3777
1430   3713  2345          ISZ      FLGR
1431   3714  5311          JMP      INSTK
1432   3715  3344          DCA      HOLDK
1433   3716  1741          TAD I    YK       /SAVE CALIBRATION MARK
1434   3717  0335          AND      K4000
1435   3720  1344          TAD      HOLDK
1436   3721  3741          DCA I    YK
1437   3722  2341          ISZ      YK
1440   3723  2342          ISZ      XCTRK
1441   3724  5305          JMP      NEXTY
1442   3725  5746          JMP I    XSTART
1443   3726  0000  INITK,  0
1444   3727  1337          TAD      ARRLIK
1445   3730  3342          DCA      XCTRK
1446   3731  1671          TAD      SPECB
1447   3732  3341          DCA      YK
1450   3733  5726          JMP I    INITK
1451   3734  3777  K3777,  3777
1452   3735  4000  K4000,  4000
1453   3736  3400  K3400,  3400
1454   3737  7014  ARRLIK, -764            /NUMBER OF ELEMENTS IN ARRAY
1455   3740  0000  HGT,    0
1456   3741  0000  YK,     0
1457   3742  0000  XCTRK,  0
1460   3743  0000  FLAGK,  0
1461   3744  0000  HOLDK,  0
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1462    3745  0000  FLGR,   0
1463    3746  4001  XSTART, START
1464                        TEXT1=,          /TEXT1 LOADS
1465                        *4000
1466                  /NMR DISPLAY ROUTINE PART B
1467    4000  0000  X,      0                /OPEN FOR X VALUE FOR LINC DISPLAY
1470    4001  6211  START,  CDF 10
1471    4002  6031          KSF              /KEYBOARD INTERRUPT
1472    4003  7610          SKP CLA
1473    4004  5702          JMP I    IRRPT
1474    4005  3200          DCA      X
1475    4006  1071          TAD      SPECB
1476    4007  3300          DCA      YP
1477    4010  5220          JMP      RPX-2
1500                  /THE FOLLOWING 7 WORD KLUDGE BOOTSTRAPS DIAL INTO CORE:
1501    4011  6141  DIALEX, LINC
1502                        LMODE
1503    0012  1020          1020             /LDA I 0
1504    0013  0020          20
1505    0014  0004          4                /ESF TO GET I/O PRESET
1506    0015  0643          643              /SET LINC DF=3
1507    0016  0701          701              /READ TAPE GROUP
1510    0017  7300          7300             /MUST BE IN LOCN 4017!
1511                        PMODE
1512    4020  1273          TAD      ARRLIM
1513    4021  3277          DCA      XCTR
1514    4022  1700  RPX,    TAD I    YP       /GET ELEMENT FROM ARRAY
1515    4023  7440          SZA               /CHECK FOR ZERO ELEMENT
1516    4024  5233          JMP      AFMRK-2
1517    4025  1274          TAD      M377
1520    4026  6141          LINC
1521                        LMODE
1522    0027  0140          DIS 0
1523    0030  0002          PDP
1524                        PMODE
1525    4031  7200          CLA
1526    4032  5252          JMP      INCR
1527    4033  7510          SPA              /CHECK FOR CALIBRATION MARK
1530    4034  5257          JMP      MRKR
1531    4035  7041  AFMRK,  CIA
1532    4036  3301          DCA      HGTP
1533    4037  1274          TAD      M377
1534    4040  1276  RPY,    TAD      INKY     /DISPLAY PEAKS
1535    4041  6141          LINC
1536                        LMODE
1537    0042  0140          DIS 0
1540    0043  0002          PDP
1541                        PMODE
1542    4044  2301          ISZ      HGTP
1543    4045  5240          JMP      RPY
1544    4046  7604          LAS              /GET Y INCREMENT
1545    4047  0275          AND      KK7
1546    4050  7001          IAC
1547    4051  3276          DCA      INKY
1550    4052  2200  INCR,   ISZ      X
1551    4053  2300          ISZ      YP
1552    4054  2277          ISZ      XCTR
1553    4055  5222          JMP      RPX
1554    4056  5202          JMP      START+1
1555    4057  7346   MRKR,  CLL STA RTL      /DISPLAY CALIBRATION MARK
1556    4060  1274          TAD      M377
1557    4061  6141          LINC
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1561   0062  0140          DIS Ø
1562   0063  0002          PDP
1563                       PMODE
1564   4064  7200          CLA
1565   4065  1700          TAD I    YP
1566   4066  0272          AND      K3777P
1567   4067  7450          SNA
1570   4070  5252          JMP      INCR
1571   4071  5235          JMP      AFMRK
1572   4072  3777  K3777P, 3777
1573   4073  7014  ARRLIM, -764
1574   4074  7404  M377,   -374
1575   4075  0007  KK7,    7
1576   4076  0000  INKY,   Ø
1577   4077  0000  XCTR,   Ø
1600   4100  0000  YP,     Ø
1601   4101  0000  HGTP,   Ø
1602   4102  2600  IRRPT,  INTRUP
1603   4103  0000  LNCTAP, Ø                /GENERAL LINC TAPE I/O SUBR,
1604   4104  7640          SZA CLA          /IF AC=Ø, WRITE; IF NOT, READ
1605   4105  1342          TAD      CRDC
1606   4106  1343          TAD      CWRC
1607   4107  3332          DCA      RWTI
1610   4110  1101          TAD      BLK1
1611   4111  3333          DCA      RWTI+1
1612   4112  2101          ISZ      BLK1
1613   4113  1077          TAD      UNIT
1614   4114  7110          CLL RAR
1615   4115  1344          TAD      CXOB
1616   4116  3330          DCA      XOBL
1617   4117  7006          RTL
1620   4120  7006          RTL
1621   4121  1332          TAD      RWTI
1622   4122  3332          DCA      RWTI
1623   4123  7001          IAC
1624   4124  1104          TAD      CORBUF
1625   4125  6141          LINC
1626                       LMODE
1627   0126  0023          23       /TMA
1630   0127  1020          1020     /LDA I Ø
1631   0130  0020  XOBL,   20
1632   0131  0001          1        /AXO
1633   0132  0000  RWTI,   Ø
1634   0133  0000          Ø
1635   0134  0003          3        /TAC
1636   0135  0002          PDP
1637                       PMODE
1640   4136  7001          IAC
1641   4137  7440          SZA                /TRANSFER OK?
1642   4140  7402          HLT                /NO!!
1643   4141  5703          JMP I    LNCTAP
1644   4142  7774  CRDC,   7774
1645   4143  0704  CWRC,   724
1646   4144  0020  CXOB,   20
1647                       *4200
1650   4200  0000  OCTIN,  Ø
1651   4201  7200          CLA                /OCTAL INPUT ROUTINE
1652   4202  3243          DCA VALU           /ANY NON OCTAL CHAR TERMINATES
1653   4203  4025  GTCHR,  JMS READ           /GET A CHARACTER
1654   4204  4032          JMS TYPE
1655   4205  3245          DCA LSCHR
1656   4206  1245          TAD LSCHR
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2052      4445  2005
2052      4446  2240
2052      4447  2401
2052      4450  2005
2052      4451  4011
2052      4452  5717
2052      4453  7700
2052                    IHD1,   TEXT \↑WANT PAPER TAPE I/O?\
2053      4454  2701
2053      4455  1624
2053      4456  4010
2053      4457  1107
2053      4460  1040
2053      4461  2320
2053      4462  0505
2053      4463  0440
2053      4464  2205
2053      4465  0104
2053      4466  0522
2053      4467  5520
2053      4470  2516
2053      4471  0310
2053      4472  7700
2053                    IHD2,   TEXT /WANT HIGH SPEED READER=PUNCH?/
2054                            *TEXT1
2055      3747  3616
2055      3750  1522
2055      3751  2311
2055      3752  1536
2055      3753  3603
2055      3754  1715
2055      3755  1505
2055      3756  1624
2055      3757  2372
2055      3760  4000
2055                    HD1,    TEXT /↑NMRSIM↑↑COMMENTS: /
2056      3761  1517
2056      3762  2205
2056      3763  7700
2056                    HD3,    TEXT /MORE?/
2057      3764  1617
2057      3765  5640
2057      3766  1706
2057      3767  4023
2057      3770  2011
2057      3771  1623
2057      3772  7540
2057      3773  4000
2057                    HD2,    TEXT /NO. OF SPINS=  /
2060                            *TEXT2
2061      1736  0214
2061      1737  1703
2061      1740  1354
2061      1741  4025
2061      1742  7240
2061      1743  4000
2061                    HD4,    TEXT /BLOCK, U:  /
2062      1744  0310
2062      1745  0515
2062      1746  1103
2062      1747  0114
2062      1750  4023
```

```
2062      1752  0024
2062      1753  2372
2062      1754  4000
2062                    HD5,    TEXT /CHEMICAL SHIFTS: /
2063      1755  0317
2063      1756  2520
2063      1757  1411
2063      1760  1607
2063      1761  4003
2063      1762  1716
2063      1763  2324
2063      1764  0116
2063      1765  2423
2063      1766  7240
2063      1767  4000
2063                    HD6,    TEXT /COUPLING CONSTANTS:  /
2064      1770  2401
2064      1771  2005
2064      1772  4011
2064      1773  1620
2064      1774  2524
2064      1775  7700
2064                    HD8,    TEXT /TAPE INPUT?/
2065                            *TEXT3
2066      2750  1706
2066      2751  0623
2066      2752  0524
2066      2753  4046
2066      2754  4027
2066      2755  1104
2066      2756  2410
2066      2757  7200
2066                    HD7,    TEXT /OFFSET & WIDTH:/
2067      2760  0411
2067      2761  2320
2067      2762  1401
2067      2763  3140
2067      2764  1411
2067      2765  2324
2067      2766  7700
2067                    HD9,    TEXT /DISPLAY LIST?/
2070      2767  1511
2070      2770  1656
2070      2771  4011
2070      2772  1624
2070      2773  0516
2070      2774  2311
2070      2775  2431
2070      2776  7200
2070                    HD10,   TEXT /MIN. INTENSITY:/
2071                            *TEXT4
2072      1557  3640
2072      1560  4011
2072      1561  1624
2072      1562  0516
2072      1563  2311
2072      1564  2431
2072      1565  4040
2072      1566  4040
2072      1567  4005
2072         0  1605
2072      1571  2207
2072      1572  3140
```

```
2071      1573  5000
2072                    HD11,   TEXT /*  INTENSITY     ENERGY */
2073                    /OVERLAY OF FLOATING POINT PACKAGE II
2074                    /MUST BE LOADED INTO FIELD Ø AND DATA FIELD MUST BE Ø
2075                    /WHEN ENTERING PACKAGE, ALL INDIRECT FLOATING COMMANDS ASSUME
2076                    /THE DATA IS IN FIELD 1,
2077                            *PØND
2100      0142  0000    INDIR,  Ø
2101      0143  5550            DCA I   LOC     /ROUTINE SETS DF=1 FOR GETTING
2102      0144  6211    DF,     CDF 10          /DATA ON INDIRECT INSTRUCTIONS
2103      0145  1144            TAD     DF      /JMS TO THIS ROUTINE FROM 5626
2104      0146  3157            DCA     CONTPR
2105      0147  5542            JMP I   INDIR
2106      0150  5656    LOC,    5656
2107      0151  0000    RESET,  Ø               /ROUTINE SETS DF=Ø AFTER
2110      0152  7006            RTL             /LOADING FAC
2111      0153  6201            CDF Ø
2112      0154  5551            JMP I   RESET
2113      0155  0000    STORE,  Ø               /ROUTINE SETS DF FOR FPUT
2114      0156  1044            TAD     EXP
2115      0157  0000    CONTPR, Ø
2116      0160  5555            JMP I   STORE
2117      0161  0000    NEXT,   Ø
2120      0162  7300            CLA CLL
2121      0163  6201            CDF Ø           /ROUTINE SETS DF=Ø BEFORE
2122      0164  5561            JMP I   NEXT    /GETTING NEXT INSTRUCTION
2123      0165  1163    DIR,    TAD     NEXT+2  /SETS DF=Ø FOR STORAGE
2124      0166  3157            DCA     CONTPR
2125      0167  5570            JMP I   .+1
2126      0170  5627            5627
2127                    *5624
2130      5624  5165            JMP     DIR
2131                    *5626
2132      5626  4142            JMS     INDIR
2133                    *5644
2134      5644  4151            JMS     RESET
2135                    *5705
2136      5705  4155            JMS     STORE
2137                    *5601
2140      5601  4161            JMS     NEXT
2141                    *7255
2142      7255  3172            FMPY    172
2143                    *172
2144      0172  0004            0004
2145      0173  2400            2400
2146      0174  0000            0000
2147                    *7463
2150      7463  3175            FMPY    175
2151                    *175
2152      0175  7775            7775
2153      0176  3146            3146
2154      0177  3147            3147
2155                            *7327
2156      7327  0240            240
2157      7330  0015            255-240
2160                            *6547
2161      6547  3543            MLPY2
2162      6550  3547            DIVD2
2163      6551  6000            6000
2164      6552  0760            FPINP
2165                    /MODIFIED DECUS 8-44:
2166                    /CHANGES TO FLOATING POINT OUTPUT ROUTINE
2167                    /TO ALLOW OPTIONAL FIXED POINT OUTPUT
```

```
                        /IF (62)=0, OUTPUT FLOATING
                        /OTHERWISE C(62) = NUMBER OF DIGITS
                        /C(AC) = NUMBER OF DECIMAL PLACES
                        /C(15) LOST DURING EXECUTION
                                *55
0055  0000              0
                        *7200
7200  0000  FOUT,       0
7201  3775              DCA I SCAD /SAVE C(AC)
7202  1045              TAD HORDER
7203  7710              SPA CLA
7204  1330              TAD SMINUS
7205  1327              TAD SPLUS
7206  4344              JMS ASCOUT /PRINT "SPACE" OR "-"
7207  1376              TAD BFRST
7210  3015              DCA 15     /INITIALIZE AUTO-INDEX
7211  5234              JMP 7234   /CONVERT MANTISSA AND BUFFER THE DIGITS
7212  1324  RETN,       TAD BEXP
7213  3044              DCA 44     /STORE DECIMAL EXPONENT
7214  4777              JMS I FXAD /GO TO OUTPUT THE NUMBER
7215  5223              JMP CRLF   /FIXED POINT RETURN
7216  1343              TAD CHE    /FLOATING POINT RETURN
7217  4344              JMS ASCOUT /PRINT "E"
7220  7000              NOP
7221  7000              NOP
7222  4737              JMS I EXPT /GO TO OUTPUT EXPONENT
7223  1055  CRLF,       TAD SWIT1
7224  7650              SNA CLA    /PRINT CR-LF?
7225  5600              JMP I FOUT /NO, EXIT
7226  1341              TAD CARRTN /YES
7227  4344              JMS ASCOUT
7230  1342              TAD LNFEED
7231  4344              JMS ASCOUT
7232  5600              JMP I FOUT /EXIT
                        *7375
7375  5565  SCAD,       SAC
7376  5566  BFRST,      BUFFER-1
7377  5400  FXAD,       FIXX
                        *7301
7301  3415              DCA I 15
                        *7305
7305  3415              DCA I 15
                        *7310
7310  5212              JMP RETN
                        HORDER=45
                        SMINUS=7330
                        SPLUS=7327
                        BEXP=7324
                        CHE=7343
                        EXPT=7337
                        ASCOUT=7344
                        SWIT1=55
                        CARRTN=7341
                        LNFEED=7342
                        /IN THE COMMENTS BELOW;-
                        /   F = NUMBER OF DIGITS TO BE OUTPUT
                        /   D = NUMBER OF DECIMAL PLACES
                        /   E = DECIMAL EXPONENT
                        /   P = NUMBER OF PLACES REMAINING TO BE
                        /       PRINTED BEFORE DECIMAL POINT
                        *5400
5400  0000  FIXX,       0
```

```
2267    5402  7450          SNA           /FLOATING OUTPUT?
2270    5403  5225          JMP R6        /YES, ROUND OFF TO 6 PLACES
2271    5404  7041          CIA
2272    5405  1365          TAD SAC
2273    5406  7510          SPA           /   F-D > 0 ?
2274    5407  5214          JMP .+5       /YES
2275    5410  7240          CLA CMA
2276    5411  1062          TAD 62
2277    5412  3365          DCA SAC       /MAKE D = F-1
2300    5413  7040          CMA
2301    5414  1044          TAD 44
2302    5415  7500          SMA           /   F-D > E ?
2303    5416  7200          CLA           /NO, ROUND OFF TO F PLACES
2304    5417  1062          TAD 62        /YES
2305    5420  7510          SPA           /   D+E < 0 ?
2306    5421  5250          JMP PRNT+1    /YES, NO ROUNDING NEEDED, GO TO PRINT
2307    5422  1354          TAD M6        /NO, ROUND TO D+E PLACES,
2310    5423  7500          SMA           /TO A MAXIMUM OF 6 PLACES
2311    5424  7200          CLA
2312    5425  1353  R6,     TAD K7
2313    5426  3364          DCA TEMPX     /SAVE NUMBER+1 OF PLACES TO ROUND TO
2314    5427  1356          TAD BUFST
2315    5430  1364          TAD TEMPX     /SET UP BUFFER ADDRESS AT WHICH
2316    5431  3366          DCA PLCE      /ROUNDING OFF SHOULD START
2317    5432  1364          TAD TEMPX
2320    5433  7041          CIA           /SET UP COUNT OF MAXIMUM NUMBER
2321    5434  3364          DCA TEMPX     /OF CARRIES ALLOWABLE
2322    5435  7107          CLL IAC RTL     /*4
2323    5436  2766  RETX,   ISZ I PLCE    /ADD 1 TO DIGIT AT CURRENT POSITION
2324    5437  1766          TAD I PLCE
2325    5440  1355          TAD M10
2326    5441  7710          SPA CLA       /CARRY REQUIRED?
2327    5442  5251          JMP PRNT      /NO, GO TO OUTPUT
2330    5443  3766          DCA I PLCE    /YES, MAKE CURRENT DIGIT A ZERO
2331    5444  2364          ISZ TEMPX     /BEGINNING OF BUFFER REACHED?
2332    5445  5313          JMP DECR      /NO, DECREMENT BUFFER ADDRESS AND REPEAT
2333    5446  2766          ISZ I PLCE    /YES, SET MANTISSA TO 0,1
2334    5447  2044          ISZ 44        /COMPENSATE BY INCREMENTING EXPONENT
2335    5450  7200          CLA
2336    5451  1356  PRNT,   TAD BUFST
2337    5452  3015          DCA 15        /SET AUTO-INDEX REGISTER
2340    5453  1062          TAD 62
2341    5454  7450          SNA           /   F = 0 ?
2342    5455  5342          JMP FLOP      /YES, OUTPUT AS FLOATING NUMBER
2343    5456  7041          CIA           /NO,
2344    5457  3366          DCA FCOUNT    /SET UP COUNT TO PRINT F PLACES
2345    5460  1366          TAD FCOUNT
2346    5461  1044          TAD 44
2347    5462  7540          SMA SZA       /   E > F ?
2350    5463  5317          JMP XXX       /YES, PRINT XS
2351    5464  1365          TAD SAC
2352    5465  7500          SMA           /   E < F-D ?
2353    5466  7200          CLA           /NO, TAKE P = E
2354    5467  7041          CIA           /YES, TAKE P = F-D
2355    5470  1044          TAD 44
2356    5471  7041          CIA
2357    5472  3364          DCA TEMPX     /SET UP MINUS P
2360    5473  1361          TAD M7X
2361    5474  3365          DCA SCOUNT    /SET COUNT OF MAX. NO. OF SIG. FIGS.
2362    5475  1044  BACKX,  TAD 44
2363    5476  1364          TAD TEMPX
2364    5477  7650          SNA CLA       /   P = E ?
2365    5500  5330          JMP DIG       /YES, PRINT DIGIT
```

```
2366    5501  1364          TAD TEMPX  /NO,
2367    5502  7001          IAC
2370    5503  7710          SPA CLA    /   P > 1 ?
2371    5504  1360          TAD SPACX  /YES, TAKE SPACE; OTHERWISE 0
2372    5505  4323  IN,     JMS OUTX   /PRINT CHARACTER
2373    5506  2364          ISZ TEMPX  /P CHARACTERS PRINTED?
2374    5507  5275          JMP BACKX   /NO
2375    5510  1362          TAD POINT  /YES,
2376    5511  4757          JMS I OPUT /PRINT DECIMAL POINT
2377    5512  5275          JMP BACKX
2400    5513  7040  DECR,   CMA
2401    5514  1366          TAD PLCE
2402    5515  3366          DCA PLCE
2403    5516  5236          JMP RETX
2404    5517  7200  XXX,    CLA
2405    5520  1363          TAD CHX
2406    5521  4323          JMS OUTX   /PRINT "X"
2407    5522  5320          JMP .-2    /AND REPEAT
2410    5523  0000  OUTX,   0
2411    5524  4757          JMS I OPUT /PRINT CHARACTER
2412    5525  2366          ISZ FCOUNT /F CHARACTERS PRINTED?
2413    5526  5723          JMP I OUTX /NO, RETURN
2414    5527  5600          JMP I FIXX /YES, NUMBER FINISHED
2415    5530  7040  DIG,    CMA
2416    5531  1044          TAD 44     /REDUCE E BY 1
2417    5532  3044          DCA 44
2420    5533  2365          ISZ SCOUNT /6 SIG. FIGS. PRINTED?
2421    5534  5340          JMP .+4    /NO
2422    5535  7040          CMA        /YES,
2423    5536  3365          DCA SCOUNT /RESET COUNT TO -1
2424    5537  5305          JMP IN     /AND LEAVE C(AC) = 0
2425    5540  1415          TAD I 15   /TAKE NEXT DIGIT FROM BUFFER
2426    5541  5305          JMP IN
2427    5542  1354  FLOP,   TAD M6     /SET COUNT TO PRINT
2430    5543  3366          DCA FCOUNT /6 DIGITS AFTER DECIMAL POINT
2431    5544  4757          JMS I OPUT /PRINT "0"
2432    5545  1362          TAD POINT
2433    5546  4757          JMS I OPUT /PRINT "."
2434    5547  2200          ISZ FIXX   /INCREMENT RETURN ADDRESS
2435    5550  1415          TAD I 15   /TAKE NEXT DIGIT FROM BUFFER
2436    5551  4323          JMS OUTX   /PRINT IT
2437    5552  5350          JMP .-2    /AND REPEAT
2440    5553  0007  K7,     7
2441    5554  7772  M6,     -6
2442    5555  7766  M10,    -12
2443    5556  5566  BUFST,  BUFFER-1
2444    5557  7352  OPUT,   7352
2445    5560  7760  SPACX,  240-260
2446    5561  7771  M7X,    -7
2447    5562  7776  POINT,  256-260
2450    5563  0050  CHX,    330-260
2451    5564  0000  TEMPX,  0
2452    5565  0020  SCOUNT, 0
2453    5566  0000  FCOUNT, 0
2454    5567  0002  BUFFER, 2
2455                PLCE=FCOUNT
2456                SAC=SCOUNT
2457                SAVSYM 2
```

NO ERRORS

```
A       0116
ADDRB   3533
```

```
ADDRC   0756
ADDRC1  0757
ADDRL   0755
ADDRO   0027
ADDRØ   2247
ADDR2   2250
AUDØ    0113
ADD1    2133
AUD2    2134
ADSPEC  3041
AFMRK   4035
AGAIN   1131
AGAINI  2336
AGAINK  3666
AGAINL  2705
AHEAD   3026
ALLOW   2000
ALLOWO  0322
ALPHA   0744
ALPH1   0745
ALTR    2530
APROB   0525
AREND   0103
ARRLD   2554
ARRLIK  3737
ARRLIM  4073
ASCOUT  7344
ASK     0313
ASKI    4440
ASKM    4315
ASKMX   0513
ASKN    3315
ASKRX   3234
AULIM   0517
B       0121
BACK    3217
BACKO   0545
BACKX   5475
BEGIN   0202
BETA    0746
BETA1   0747
BEXP    7324
BFRST   7376
BLIND   3126
BLK1    0101
BOLD    0067
BPF1    2137
BPF2    2140
BPNCH   3330
BPUN    3357
BUFFER  5567
BUFST   5556
CALCM1  3000
CALCM2  3042
CALC1   2546
CALC2   2553
CARLF   3314
CARLFD  0514
CARRTN  7341
CARTN   0310
CASE1   0750
CASE2   0663
CHF     7343
```

CHECK 2552
CHKEND 2565
CHRTB 2646
CHTB 2644
CHX 5563
CKEND 0571
CLAEL 1147
CLAIAC 4433
CONT 1052
CONTPR 0157
CONTRO 0732
CONT1 3453
CONT2 3456
CONT3 3467
CONT4 3464
COPY 2320
COPYO 0323
CORBUF 0104
CPSB 0065
CRDC 4142
CRLF 7223
CRLFD 2663
CRRTL 4437
CTR 2543
CTRB 3542
CTRDD 1112
CTRE 1267
CTRH 2141
CTRH1 2142
CTRH3 2132
CTRI 2246
CUPB 0066
CWRC 4143
CXOB 4144
DATBUF 4337
DECR 5513
DF 0144
DIAGC 0642
DIAGEL 2251
DIALEX 4011
DIFF 1340
DIG 5530
DIR 0165
DIRC 0723
DIRD 1035
DISPLA 0075
DIV32 3547
DNOM 4313
DONIN 0467
DSLS 4246
DSLST 3233
DSPL 2641
DTEM 4244
EIPRNT 3265
EL 1673
ENB 0070
ENDCHK 1161
ENDCOM 3642
ERROR 3156
ERRORO 0217
EXITT 2741
EXP 0044
EXPT 7337

```
FACLOD 0373
FACTOR 0134
FADD    00
FCOS   0127
FCOUNT 5566
FDIV   4000
FDIV2  0004
FEXT   0000
FGET   5000
FIX    5127
FIXA   0523
FIXM   0312
FIXX   5400
FLAGB  3534
FLAGC  0752
FLAGC1 0753
FLAGD  1120
FLAGE  1365
FLAGE1 1265
FLAGG  1664
FLAGH  2135
FLAGH1 2136
FLAGJ1 2537
FLAGJ2 2541
FLAGJ3 2545
FLAGJ4 2550
FLAGK  3743
FLAGO  0326
FLAGR  0572
FLGR   3745
FLIN   0767
FLOIN  0006
FLOP   5542
FLOTR  4303
FMPY   3000
FMPY2  0003
FNISH  4224
FNOR   7000
FOUT   7200
FPINP  0760
FPUT   6000
FSIN   0124
FSUB   2000
FXAD   7377
GET    0422
GTCHR  4203
GTSPN  0222
GTTP   0334
HALFA  0520
HALFM  3034
HB     0073
HD1    3747
HD10   2767
HD11   1557
HD2    3764
HD3    3761
HD4    1736
HD5    1744
HD6    1755
HD7    2750
HD8    1770
HD9    2760
HGT    3740
```

```
HGTP    4101
HIPUN   0361
HIRED   0354
HJJ     1531
HJK     1537
HKK     1534
HOLD    3125
HOLDK   3744
HORD    0045
HORDER  0045
HPUN    0023
HRED    0022
HSRP    4416
HSUBE   1273
HSUBF   1542
HSUBG   1660
HSUBI   2363
HSUBM   3033
HUGET   2200
HUGETO  0321
ICTRI   2245
IEPRNT  4302
IFZB    0063
IHD1    4441
IHD2    4454
IN      5505
INC     2055
INCR    4052
INDD1   1113
INDD2   1114
INDEX   3535
INDIAL  4400
INDIL   0320
INDIR   0142
IND1    1336
IND2    1337
INITB   3400
INITK   3726
INITO   0311
INKY    4076
INPEC   0317
INPUT   0005
INSPA   0516
INSPEC  1121
INSTD   1022
INSTD1  1117
INSTE   1364
INSTH   2105
INSTK   3711
INSWT   0102
INTAP   1144
INTERP  0207
INTRUP  2600
IN1ADD  2540
IN2ADD  2536
IRRPT   4102
IS      1270
JAKE    1200
JAKEO   0324
JC      0610
JF      152
JG      1662
```

```
JTEMP   0133
JUMP    0003
K       0003
KF      1530
KK200   3361
KK300   3362
KK7     4075
KLAEL   0751
KLREL   1657
K3400   3736
K3777   3734
K3777P  4072
K4000   3735
K7      5553
LCT     3360
LDARR   3032
LDCHK   3235
LEDR    3364
LF      2675
LIMIT   0110
LISP    3200
LJ      1670
LK      1665
LNCTAP  4103
LNFEED  7342
LOC     0150
LODFAC  3250
LOKUP   2621
LORD    0046
LONT    4423
LRD     4434
LSCHR   4245
LTP     4435
MASKM   3105
MASK1   2747
MLPY2   3543
MN      4335
MN500   4301
MN7     4240
MRBT    4242
MRKR    4057
MRSRC   4255
MR377   2643
MSK7    0352
MY      4334
M1J     5555
M11     3161
M12     2551
M12H    2131
M2J     1145
M2010   0332
M272    2642
M36     2744
M377    4074
M500    0526
M5J0D   1146
M5J0M   3037
M6      5554
M7      0331
M7X     5561
N       0106
NEGATE  0005
```

```
NEXT    0161
NEXTK   3603
NEXTKV  3647
NEXTY   3705
NINCR   3637
NLINK   2143
NMRE    0502
NOLN    4276
NTOT    3536
NUDAT   0240
NUSEB   0064
N1      0115
N1ADD   2547
N2      0132
N2ADD   2542
OCIN    0353
OCTIN   4200
OFFS    0402
OFSC    4432
OFSET   0137
OK      3700
ONEF    1516
ONESET  1543
OPUT    5557
ORDER   0700
OUTPUT  0006
OUTX    5523
OVER    2066
OVERI   2302
OVERO   0207
PEX     3353
PL3E    5566
PL13    4314
PL6     3106
PNOUT   3335
POINT   5562
PRINT   0074
PRINTL  2676
PRNT    5451
PROB    3103
PUND    0142
P17     3537
P215    2674
P23     3540
P236    2745
P336    2746
P43     3541
P44     0570
P500    3575
P500M   3040
P7      0333
P7M0    4241
QUERR   4336
QUEST   0330
R       1524
RDEX    0566
RDMOR   2607
RDWD    0527
READ    0025
RESET   015
REI     10
RETH    2053
```

```
RETX    5436
ROTATE    61
RPTB1     73
RPTB2   3504
RPTC    0626
RPTC1   0655
RPTC2   0714
RPTD    1016
RPTE    1201
RPTE1   1211
RPTE2   1225
RPTG    1612
RPTH    2016
RPTH1   2025
RPTI    2212
RPTI2   2231
RPTJ    0265
RPT1    2413
RPT2    2432
RPT3    2464
RPT4    2472
RPX     4022
RPY     4040
RRTI    4132
R1      1366
R2      1367
R6      5425
SAC     5565
SCAD    7375
SCOUNT  5565
SETONE  2316
SETUP   3107
SIGN    3104
SKPP    4436
SMINUS  7330
SPACE   3316
SPACX   5560
SPECAD  0524
SPECB   0071
SPLUS   7327
SQROOT  0002
SQUARE  0001
START   4001
STBLK   0100
STOIS   3600
STORE   0155
STPE    0540
STRIP   3317
SUBG    1656
SWITI   0055
TABAD   2544
TABADH  2132
TABADL  2655
TABL    2145
TABLE   0024
TAPERN  0076
TEM     1115
TEMC    0754
TEMC1   0755
TEMP    0107
TEMPX   5564
TEMP1   0114
```

```
TEST    2057
TESTE   1266
TEXT1   3747
TEXT2   1736
TEXT3   2754
TEXT4   1557
TPST    2105
TESTR   0515
TRANS   2430
TRANSO  0325
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