COMPUTER PROGRAMS

IN

EARTHQUAKE SEISMOLOGY

VOLUME 1: GENERAL PROGRAMS

EDITED BY

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16. Abstract (Limit: 200 words)

This volume contains eleven documented copies of computer programs on spectral analysis and general purpose routines for use in earthquake seismology. Presently operating on a Honeywell 6023 Computer, the programs are free of machine dependent peculiarities with a few exceptions which are noted in the introduction. Although most programs require an offline CALCOMP drum plotter, in more recent programs plotting calls are performed in modular subroutine units to facilitate conversion to other plotting systems. The CALCOMP subroutines are listed. Most of the programs consist of a statement of purpose, input/output, program units, theory, or description, the actual program, sample data, and sample output. The program titles are: EXSPEC, SPSPEC, DATAPLT, FILTER, FPDPLT, EDABAC, LISTER, PLTSEIS, HILBERT, HASKELL, and SEISDIS.

17. Document Analysis a. Descriptors

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DATAPLT
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EDAPAC
LISTER
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HASKELL
SEISDIS

c. COSATI Field/Group

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Introduction to Volume 1

The purpose of this volume is to provide documented copies of computer programs which are useful in earthquake seismology. This volume contains spectral analysis programs and general purpose routines. Many programs have been designed with consistent input-output formats so that they can interface easily with other programs of Volume 1 and Volume 2.

The author has had programming experience with an IBM 1620, a CDC 3300, a CDC 6400, and most recently with a Honeywell 6023 computer on which the programs are presently operating. The programs should be free of machine dependent peculiarities with a few exceptions:

1. there are six alphanumeric characters to a word;
2. a floating or fixed point number occupies one word;
3. the largest and smallest floating point numbers on a Honeywell 6023 are about 1.0 E + 39 and 1.0 E - 39, respectively;
4. there is no PROGRAM statement;
5. the arcsine and arccosine functions are ARSIN and ARCOS respectively;
6. multiple files can be used for input or output.

Most programs contain calls for an offline CALCOMP drum plotter. In the more recent programs, plotting calls are performed in modular subroutine units so that conversion to other plotting systems can be facilitated. The CALCOMP subroutines used are the following:

PLOTS	initiates plot tape
PLOT	move pen
FACTOR	used to scale entire plot
SYMBOL	plots character string and special symbols
NUMBER	plots decimal equivalent of floating point number
SCALE	determines starting value and scale for an array of data to be plotted on a graph
AXIS	draws an annotated axis line for a graph
LINE	scales and plots a set of data points defined by X and Y coordinate arrays

The author is interested in any comments, corrections or improvements to the programs. The computer programs hopefully will be of use to other researchers. An acknowledgment of their source is all that is requested.

I. EXSPEC

PROGRAMMER: R. B. HERRMANN / July 1972

PURPOSE:

This program performs Fourier spectral analysis on time series consisting of up to 2048 equally spaced observations. Input data consist of either Y-amplitude values for equally spaced time intervals, or (X,Y) coordinates of the digitized trace which are then linearly interpolated to generate an evenly spaced time series. There are options for plotting the digitized seismogram, for removing DC and/or linear trends, and for saving the Fourier transform results for later analysis on FILE 01. The instrument response of various types of seismographs can be removed. If horizontal component data are read in, formation of the radial and transverse components of the ground motion spectral densities is performed in the frequency domain. The spectra are corrected for geometrical spreading on a sphere to a reference distance of 9° (1000 km). If this correction is not desired, enter 9.0 for the variable DEG.

The option IPRNT.GE.0 lists values of the amplitude and phase spectrum at selected periods which are suitable for logarithmic period axis plots. The program has been designed so that the tape or disk file on FILE 01 can be used as a master library and added to later. For initiating a new file on FILE 01, set INDEX = 0.

INPUT/OUTPUT

Input is through FILE 60 and is usually on punched cards. Printer output is through FILE 61. FILE 10 is used for the CALCOMP tape. FILE 01 contains the positive frequency spectral data. This format of data written on this file is such that it can be read directly by the programs DATAPLT and FILTER.

PROGRAM UNITS

PROGRAM EXSPEC: This is the main control link. The data are read in, corrected for digitizing trends and instrument effects. If desired, the horizontal spectra components are rotated to form the radial and transverse components of the ground motion spectra. The spectra are corrected for the effect of geometrical spreading on a sphere. An M point Fast Fourier Transform is used.

SUBROUTINE FOUR2 : This is a relatively slow but very compact expression for the Fast Fourier Transform. It was developed by Brenner (1967) as FOUR1.

SUBROUTINE TAPEWR: This subroutine writes a basic Fourier Transform block on tape. The block consists of a header which gives information for the identification and later use of the spectra information as well as the real and complex components of the Fourier transform of the ground motion for positive frequencies.

SUBROUTINE TREND: This subroutine can do one of three different operations. First it can do nothing to the digitized seismogram. Second it can remove a DC offset from the seismogram by adjusting the origin of the Y-axis coordinate system so that the area under the seismogram is zero. Third it can remove both the linear trend and DC offset from the seismogram.

SUBROUTINE TAPEIN: When the tape on FILE 01 is used for master storage of spectra, TAPEIN is used to skip previously written spectra on the tape in order to update it. If the tape used is new, INDEX is set to zero, and the spectra written by TAPEWR take up the first and succeeding positions on the tape.

SUBROUTINE PHASE: Given the arguments X and Y, this subroutine determines the phase PHI = arctan (Y/X) where PHI is specified as fractions of a circle between 0.0 and 1.0.

SUBROUTINE PRIN: Since the spectra are computed at 1024 frequencies, it would be a waste of computer time to list all the spectral amplitudes and phases. So this subroutine finds the spectral amplitude and phase in the data whose period is closest to 100.0 seconds, 90.0 seconds, etc. The resulting list is then printed on the printer.

SUBROUTINE INSTRM: This is the main control link for removing instrumental response from the spectra. Because the spectral values corresponding to negative frequencies are redundant because the original seismogram was a real quantity, only the positive frequency components have instrument effects removed. The option corresponding to ICONTRL = 6 means that no instrumental effects are removed. In all cases except ICONTRL = 4 both the amplitude and phase characteristics of the seismograph system are taken into account. The phase responses are such that an impulsive upward ground motion yields an initial upward movement on the seismogram.

SUBROUTINE SEISM1: This is the response of a 15-100 WWSSN seismograph system with peak magnifications of 375, 750, 1500, 3000 and 6000. To avoid the effects of dividing by very small instrument responses at very

high and very short periods, the instrument responses are removed only for data with periods between 1.0 and 200.0 seconds.

SUBROUTINE SEISM2: This is the response of a 30-100 WWSSN long period seismograph system with peak magnifications of 375, 750, 1500, 3000, and 6000. Again the instrument response is removed only in the period range of 1.0 through 200.0 seconds.

SUBROUTINE SEISM3: This is the response of the LRSM long period system with filter 6824-2. The response of this system has a 12 db per octave rolloff at short periods.

SUBROUTINE SEISM4: This reads in tabulated displacement or velocity sensitivity curves, short period values first followed by longer period values. If the velocity sensitivity is read in, it is converted to displacement sensitivity. When this routine is used, no correction for instrumental phase response can be made and hence the instrument corrected spectra cannot be used for phase or group velocity studies which require consideration of instrumental phase or group delay.

SUBROUTINE SEISM5: This is the instrument response, displacement sensitivity, of the standard Wood-Anderson torsion seismometer, 0.8 critical damping and magnification of PEAK.

SUBROUTINE SEISM7: This is the response of the LRSM long period system with filter 6824-13. The response of this system has a 6 db per octave rolloff at short periods.

SUBROUTINE SEISM8: This subroutine reads the constants of an electromagnetic seismometer-galvanometer system which are then used to correct the data for instrument response.

SUBROUTINE CARDIN: This subroutine reads in the digitized seismogram. The seismogram may be either a series of Y amplitudes taken at equally spaced data points, or a series of X-Y coordinate pairs of the digitized seismogram which are to be linearly interpolated to form a new evenly spaced time series of Y values. Since the digitizer used when designing these programs put out a $\pm$ sign and a series of 4 digits corresponding to each X and Y value, care must be taken for very long seismograms or those with very large amplitudes. In the case of very long seismograms, the plot of X(K) vs K would represent a sawtooth type of trace. The program recognizes this sawtooth and corrects for it (this is the meaning of the XJUMP parameters).

REFERENCES

Brenner, N. M. (1967). Three Fortran Programs that perform the Cooley-Tukey Fourier Transform, Technical Note 1967-2. Lincoln Laboratory.

Chandra, U. (1970). Analysis of body-wave spectra for earthquake energy determination, Bull. Seism. Soc. Am. 60, 539-563. (WWSSN instrument response).

Geotechnical Corporation (1963). "Test Report, LRSM Seismograph Calibration Study," Technical Report No. 63-55, Geotechnical Corporation, Garland, Texas.

Hagiwara, T. (1958). A note on the theory of the electromagnetic seismograph, Bull. Earthq. Res. Inst., Tokyo 36, 139-164.

INPUT DATA

Card Sequence	Column	Name	Format	Explanation
A.	1-5	IPLOT	I5	LT.0 Seismogram not plotted GE.0 Seismogram plotted
	6-10	M	I5	Number of points of Fast Fourier Transform, power of 2. M = 0 defaults to M = 1024; M = 2048 is maximum allowed.
B.	1-5	INDEX	I5	Number of spectra on output tape to be skipped before adding new spectra on FILE 01. INDEX = 0 for initializing new tape.
C.	1-5	ICONTRL	I5	Instrument response options 0 or negative - terminate program 1 15-100 WWSSN system 2 30-100 WWSSN system 3 LRSM LP with 12db filter #6824-2 4 Use tabulated displacement or velocity sensitivity 5 Wood-Anderson torsion seismometer 6 No instrument correction 7 LRSM LP with 6db filter #6824-13 8 Read in constants for Hagiwara's equation
	6-10	IDATA	I5	1 one component read in 2 EW read first then NS, E and N are positive displacements on seismogram. W and S are negative. The UT and UR spectra are formed. Both must have same TO and DT. UT is positive clockwise about source; UR is positive away from source.

Card Sequence	Column	Name	Format	Explanation
	11-15	ITAPE	I5	LT 0 no spectra written on 01 GE 0 write spectra on FILE 01
	16-20	IPRNT	I5	LT 0 do not print selected spectral values GE 0 print selected spectral values
	21-25	ITREND	I5	0 or neg bypass TREND 1 DC offset removed 2 DC offset and linear trend removed
	26-30	INTYP	I5	NE 2 Y values entered for evenly spaced time increments. Terminated by a +9999 punch after last data value. EQ 2 array of X,Y pairs which will be evenly spaced at interval of DT by CARDIN. First pair must be +0000+0000. Data set terminated by -9999-9999 pair.
D.			79H	Identification card. A 1 punch in Column 1 will cause the printer to skip a page.
E.	1-4	STA	A4	Station identifier
	5-8	COMP	A4	Component identifier
	11-20	DIST	F10.5	Station distance from epicenter in kilometers
	21-30	DEG	F10.5	Station distance from epicenter in degrees

Card Sequence	Column	Name	Format	Explanation
	31-40	BACKAZ	F10.5	Azimuth from station to epicenter, measured clockwise from north.
	41-50	TO	F10.5	Time digitizing began in seconds after origin time
	51-60	DT	F10.5	Digitizing interval used or desired.
	61-70	CPMM	F10.5	Counts of digitizer per millimeter on original record (counts per minute/ millimeters per minute)
	71-80	PEAK	F10.5	Peak response of instrument (has no meaning for ICONTRL = 4 or 6
F.	1-12	IDATE(3)	3A4	Date of event
	16-25	SLOPE	F10.5	Trend of record trace below true zero line in counts per DT unit. Can be ignored, if ITREND = 2 is used e.g. SLOPE = 0.0
	26-35	TMAX	F10.5	When INTYP = 2, total length for desired evenly spaced seismogram. Note TMAX must be less than M DT.
	36-45	CPM	F10.5	Counts per minute. Used for plotting 1-1 representation of original seismogram

Card Sequence	Column	Name	Format	Explanation
G. Digitized Data				
INTYP.NE.2		DUMMY(I)	12(F5.0, 1X)	Digitized trace for equispaced time values. End of trace signified by +9999
INTYP.EQ.2		X(I),Y(I)	16F5.0	X,Y pairs. These will be linearly interpolated to form a trace of amplitudes for equispaced time values of length TMAX and spacing DT. First pair must be +0000+0000, and last -9999-9999
H. Instrument response options.				
1. If ICONTRL = 4 the following instrument response data are read immediately following the digitized data of each trace.				
a.	1-5	N	I5	LT.0-velocity sensitivity read in ABS(N) values GT.0 displacement sensitivity values read in (N values)
b.(N/4) cards		(PER(I),RESP(I))	8F10.5	PER = period listed in order of increasing period RESP = velocity or displacement sensitivity
2. If ICONTRL = 8 the following parameters of Hagiwara's equation are read immediately following the digitized data:				
	1-10	TS	F10.5	Seismometer natural period
	11-20	HS	F10.5	Seismometer damping factor, HS=1 for critical damping

Card Sequence	Column	Name	Format	Explanation
	21-30	TG	F10.5	Galvanometer natural period
	31-40	HG	F10.5	Galvanometer damping factor
	41-50	SIGMA	F10.5	Coupling factor σ^2

At this point the program will go back to Point D if IDATA.EQ.2 in order to read in both the EW and NS seismograms, or to Point C if IDATA.EQ.1 or if both EW and NS seismograms have been read in.

Comments:

PEAK has the following meanings. For ICONTRL = 1 or 2, PEAK is the peak response of the WWSSN system as listed on the seismogram, e.g. 1500, 3000. For ICONTRL = 3, PEAK is the response of the LRSM system at a period of 23 seconds. For ICONTRL = 4, PEAK has no meaning. For ICONTRL = 5, PEAK equals 1400 or 2800 for the standard Wood-Anderson Torsion seismometer. For ICONTRL = 6, PEAK has no meaning. For ICONTRL = 7, PEAK is the response of the LRSM system at a period of 20.0 seconds. For ICONTRL = 8, PEAK is the peak response.

When horizontal data are processed, the order of the components on Unit 01 is UT (tangential) followed by UR (radial) spectra. For example given a sequence of data SLM Z, SLM E, SLM N, FLO E, FLO N, the resultant spectra on Unit 01 would be SLM UZ, SLM UT, SLM UR, FLO UT, FLO UR, in order.

```
C       PROGRAM EXSPEC
        CHARACTER STA,COMP,LABEL,IDATE,ICOMP
        COMMON/DTA/DATA(4096)
        DIMENSION IBUF(1026),IDATE(3),DUMMY(2050),DATUM(2048)
        DIMENSION LABEL(4)
        READ(60,63) IPLOT,M
C       IPLOT .GE. 0 CALCOMP PLOT PREPARED
C       M = NUMBER OF POINTS OF FOURIER TRANSFORM.  POWER OF 2
        IF(M.EQ.0) N = 1024
        DO 1 I = 1,11
        NN = 2**I
        NM = NN * 2
        IF(M.GE.NN.AND.M.LT.NM) N = NN
    1   CONTINUE
        IF(N.GT.2048) N = 2048
        N2 = N*2
        N02 = N/2
        N08 = N/8
        IF(IPLOT.LT.0) GO TO 62
        CALL PLOTS(IBUF,1026,10)
        CALL PLOT(0.0,-11.0,-3)
        CALL PLOT(0.0,3.0,-3)
   62   CONTINUE
        READ(60,63) INDEX
C       INDEX IS THE NUMBER OF SETS OF DATA ON TAPE TO BE SKIPPED BEFORE
C       WRITING
        CALL TAPEIN(INDEX,1)
        INDEX = INDEX + 1
        NWRITE = INDEX
  303   READ(60,63) ICONTRL,IDATA,ITAPE,IPRNT,ITREND,INTYP
        WRITE(61,63)ICONTRL,IDATA,ITAPE,IPRNT,ITREND,INTYP
   63   FORMAT(615)
        IF(ICONTRL.LE.0) GO TO 1000
C       ICONTRL PICKS PROPER MAGNIFICATION ROUTINE. SEE INSTRM
C       IDATA = 1 ONE COMPONENT ANALYZED
C       IDATA = 3 TWO COMPONENTS ARE READ IN EW FIRST THEN NS WITH THE
C       CONVENTION THAT POSITIVE DISPLACEMENTS ARE EAST AND NORTH
C       RESPECTIVELY
C       Z = DOWN  CPMM CAN BE MADE NEGATIVE TO CHANGE SENSE OF
C       DISPLACEMENT
C       ITAPE . GE . 0    WRITE POSITIVE FREQUENCIES OF SPECTRA ON TAPE
C       IPRINT . GE . 0    PRINT CERTAIN VALUES OF SPECTRA WITH PHASE AND
C       AMP
C       ITREND  = 1  REMOVE DC COMPONENT  = 2 REMOVE DC + LINEAR TREND
C       FROM DATA
C       INTYP.NE.2  EVENLY SPACED Y VALUES , DATA SET ENDED BY 9999
C       INTYP.EQ.2  ARRAY OF X, Y VALUES. ENDED BY -9999-9999 IF FIELD OF
C       X EXCEEDS 9999 AND NEXT COUNT IS 0001 PROGRAM ADJUSTS TO 10001,
C       HENCE X CAN HAVE RANGE OF 19999 CTS. NOTE FIRST X MUST BE 0000
        DO 100 ITYPE = 1,IDATA
```

```
      READ(60,2)
      WRITE(61,2)
      READ(60,10) STA,COMP,DIST,DEG,BACKAZ,TO,DT,CPMM,PEAK
C     STA = IDENTIFICATION OF STATION
C     COMP = IDENTIFICATION OF COMPONENT
C     DIST = DISTANCE IN KILOMETERS
C     DEG = DISTANCE FROM EPICENTER TO STATION IN DEGREES
C     BACKAZ = BACK AZIMUTH FROM STATION TO EPICENTER MEASURED CLOCKWISE
C     FROM N
C     TO = TIME WHEN DIGITIZING BEGAN IN SECONDS AFTER ORIGIN TIME OF
C     EVENT
C     DT = TIME INTERVAL BETWEEN DIGITIZING POINTS IN SECONDS
C     CPMM = COUNTS PER MILLIMETER OF ORIGINAL RECORD
C     PEAK = PEAK MAGNIFICATION OF INSTRUMENT RESPONSE
   10 FORMAT(2A4,2X,7F10.5)
      READ(60,11) IDATE(1),IDATE(2),IDATE(3),SLOPE,TMAX,CPM
C     SLOPE IS THE TREND OF THE RECORD TRACE BELOW THE ZERO LINE PER
C     UNIT DT
C     IF OPTION INTYP = 2  TMAX = TOTAL LENGTH DESIRED OF DIGITIZED
C     RECORD
C     CPM = COUNTS PER MINUTE
      CPS = CPM/60.
   11 FORMAT(3A4,3X,3F10.5)
      WRITE(61,6)
      WRITE(61,7) STA,COMP,DIST,DEG,BACKAZ,TO,DT,CPMM,PEAK
    6 FORMAT(1H ,20H STA    COMP    DIST KM    DEG    BACKAZ    TO
     1       DT       CPMM     PEAKMAG                    )
    7 FORMAT(1H ,A4,4X,A4,3X,F10.2,2F7.2,F7.1,F8.3,F9.2,F8.0)
      WRITE(61,8)
      WRITE(61,9) IDATE(1),IDATE(2),IDATE(3),SLOPE,TMAX,CPM
    8 FORMAT(1H0,4X,4HDATE,12X,5HSLOPE,6X,4HTMAX,7X,3HCPM)
    9 FORMAT(1H ,3A4,3X,F10.4,2F10.2)
      WRITE(61,3)
    2 FORMAT(79H
     1                                                              )
    3 FORMAT(//)
      CALL CARDIN(DUMMY,NPTS,INTYP,CPM,DT,TMAX)
C     CONVERTING TO COUNTS PER CENTIMETER
      CONFAC = 0.1/CPMM
C     NORMALIZED TO 9.0 DEG OR 1000 KM
      CONFAC = CONFAC * SQRT(SIN(DEG*0.0174529))/SQRT(0.15643)
      IF(CPS.GT.0) CONFAC = CONFAC * CPS
      DO 115 I = 1,NPTS
      XI = I - 1
      DATA(I) = TO + XI * DT
C     SPECTRAL AMPLITUDES ARE IN CM-SEC
      DUMMY(I) = DUMMY(I) +SLOPE*XI
      IF(CPS.LE.0) GO TO 115
      DUMMY(I) = DUMMY(I) / CPS
  115 CONTINUE
```

```
      IF(ITREND.GE.1) CALL TREND(DUMMY,NPTS,ITREND)
      IF(IPLOT.LT.0) GO TO 119
      LABEL(1)=6HTIME I
      LABEL(2)=6HN SECO
      LABEL(3)=6HNDS
      CALL SCALE(DATA,5.0,NPTS,1)
      CALL SCALE(DUMMY,2.0,NPTS,1)
      IF(CPS.LE.0) GO TO 500
C     THIS MAKES SEISMOGRAM PLOT 1 - 1 REPRODUCTION OF ORIGINAL TRACE
      IF(DUMMY(NPTS+2).LT.DATA(NPTS+2)) GO TO 4001
      GO TO 4002
 4001 DUMMY(NPTS+2) = DATA(NPTS+2)
      DUMMY(NPTS+1) = - DUMMY(NPTS+2)
      GO TO 4003
 4002 CONTINUE
      DATA(NPTS+2) = DUMMY(NPTS+2)
 4003 CONTINUE
  500 CONTINUE
      CALL AXIS(0.0,0.0,LABEL,-16,5.0,90.0,DATA(NPTS+1),DATA(NPTS+2))
      ICOMP = 4HAMPL
      CALL AXIS(0.0,0.0,ICOMP,4,2.0,180.0,DUMMY(NPTS+1),DUMMY(NPTS+2))
      DUMMY(NPTS+2) = -DUMMY(NPTS+2)
      CALL LINE(DUMMY,DATA,NPTS,1,0,0)
      CALL SYMBOL(-2.50,1.85,0.14,STA,90.0,4)
      CALL SYMBOL(-2.50,2.55,0.14,COMP,90.0,4)
      CALL SYMBOL(-2.25,1.95,0.10,IDATE(1),90.0,4)
      CALL SYMBOL(-2.25,2.35,0.10,IDATE(2),90.0,4)
      CALL SYMBOL(-2.25,2.70,0.10,IDATE(3),90.0,3)
      CALL SYMBOL(-2.00,1.50,0.10,3HD =  ,90.0,3)
      CALL NUMBER(-2.00,1.90,0.10,DEG,90.0,1)
      CALL SYMBOL(-2.00,2.55,0.10,4HBAZ=  ,90.0,4)
      CALL NUMBER(-2.00,3.05,0.10,BACKAZ,90.0,1)
      CALL PLOT(6.0,0.0,-3)
  119 CONTINUE
      DO 118 I = 1,NPTS
  118 DUMMY(I) = DUMMY(I) * CONFAC
      DO 120 I = 1,N2
  120 DATA(I) = 0.0
      DO 121 I = 1,NPTS
      J = 2 * I - 1
  121 DATA(J) = DUMMY(I)
C     FOR CONVERSION INTO RADIAL AND TRANSVERSE,DT MUST BE THE SAME
      CALL FOUR2(DATA,N,1,-1)
      DF = 1./(N*DT)
      DO 122 I = 1,N2
  122 DATA(I) = DATA(I) * DT
C     REMOVAL OF INSTRUMENT RESPONSE
      CALL INSTRM(DATA,N,DF,PEAK,ICONTRL)
C     INSTRM RETURNS ONLY FIRST HALF OF ARRAY CORRESPONDING TO POSITIVE
C     FREQ
```

```
      IF(ITYPE.EQ.IDATA) GO TO 100
C     DATUM = EW AND DATA = NS TRANSFORM  WHEN IDATA = 2
      DO 125 I = 1,N
  125 DATUM(I) = DATA(I)
  100 CONTINUE
C     FORMATION OF RADIAL AND TRANSVERSE COMPONENTS IF IDATA.EQ.2
      IF(IDATA.NE.2) GO TO 200
      BACKAZ = BACKAZ * 0.0174533
      A = SIN(BACKAZ)
      B = COS(BACKAZ)
      DO 160 I = 1,N
      RADIAL = -DATA(I) * B -DATUM(I) * A
      TRANS =   DATA(I) * A - DATUM(I) * B
C     DATUM = RADIAL = + AWAY FROM EPIC
      DATA(I) = TRANS
  160 DATUM(I) = RADIAL
      BACKAZ = BACKAZ/0.0174533
  200 CONTINUE
      DO 400 ITYPE = 1,IDATA
      IF(IDATA.NE.2) GO TO 405
      IF(ITYPE.EQ.1) COMP = 4HUT
      IF(ITYPE.EQ.2) COMP = 4HUR
  405 IF(ITAPE.LT.0) GO TO 425
      GO TO (410,420),ITYPE
  410 CALL TAPEWR(DATA ,ND8,NWRITE,STA,COMP,DIST,DEG,BACKAZ,T0,DT,
     1 IDATE,NPTS)
      GO TO 425
  420 CALL TAPEWR(DATUM,ND8,NWRITE,STA,COMP,DIST,DEG,BACKAZ,T0,DT,
     1 IDATE,NPTS)
  425 CONTINUE
      IF(IPRNT.LT.0) GO TO 450
      GO TO (430,440),ITYPE
  430 CALL PRIN(DATA ,ND2 ,STA,COMP,DIST,DEG,BACKAZ,T0,DT,
     1 IDATE)
      GO TO 450
  440 CALL PRIN(DATUM,ND2 ,STA,COMP,DIST,DEG,BACKAZ,T0,DT,
     1 IDATE)
  450 CONTINUE
  400 CONTINUE
      GO TO 303
 1001 CONTINUE
      NWRITE = NWRITE - 1
      WRITE(61,1001) INDEX,NWRITE
 1001 FORMAT(1H0,10X,10HSTART =      ,I5,5X,10H,   END =    ,I5)
      IF(IPLOT.LT.0) GO TO 1002
      CALL PLOT(8.0,0.0,999)
 1002 CONTINUE
      STOP
      END

      SUBROUTINE FOUR2(DATA,NN,IDUM,ISIGN)
```

```
C       THE COOLEY-TOOKEY FAST FOURIER TRANSFORM IN USASI BASIC FORTRAN
C       TRANSFORM(J) = SUM(DATA(I)*W**((I-1)(J-1)), WHERE I AND J RUN
C       FROM 1 TO NN AND W = EXP(ISIGN*2*PI*SQRT(-1)/NN).  DATA IS A ONE-
C       DIMENSIONAL COMPLEX ARRAY (I.E., THE REAL AND IMAGINARY PARTS OF
C       DATA ARE LOCATED IMMEDIATELY ADJACENT IN STORAGE, SUCH AS
C       FORTRAN IV PLACES THEM) WHOSE LENGTH NN IS A POWER OF TWO.  ISIGN
C       IS +1 OR -1, GIVING THE SIGN OF THE TRANSFORM.  TRANSFORM VALUES
C       ARE RETURNED IN ARRAY DATA, REPLACING THE INPUT DATA.  THE TIME IS
C       PROPORTIONAL TO N*LOG2(N), RATHER THAN THE USUAL N**2
C       RMS RESOLUTION ERROR BEING BOUNDED BY 6*SQRT(I)*LOG2(NN)*I**(-B),
C       WHERE B IS THE NUMBER OF BITS IN THE FLOATING POINT FRACTION.
C       PROGRAM AUTOMATICALLY DIVIDES TRANSFORM BY NN FOR INVERSE
C       TRANSFORM
        DIMENSION DATA(1)
        N = 2 * NN
        IF(ISIGN.EQ.-1) GO TO 1002
        DO 1001 IIII = 1,N
 1001   DATA(IIII) = DATA(IIII)/NN
 1002   CONTINUE
        J = 1
        DO 5 I=1,N,2
        IF(I-J)1,2,2
    1   TEMPR = DATA(J)
        TEMPI = DATA(J+1)
        DATA(J) = DATA(I)
        DATA(J+1)=DATA(I+1)
        DATA(I) = TEMPR
        DATA(I+1) = TEMPI
    2   M = N/2
    3   IF(J-M) 5,5,4
    4   J = J-M
        M = M/2
        IF(M-2)5,3,3
    5   J=J+M
        MMAX = 2
    6   IF(MMAX-N)7,10,10
    7   ISTEP= 2 *MMAX
        THETA = 6.2831853071795/FLOAT(ISIGN*MMAX)
        SINTH=SIN(THETA/2.)
        WSTPR=-2.*SINTH*SINTH
        WSTPI=SIN(THETA)
        WR=1.0
        WI=0.0
        DO 9 M=1,MMAX,2
        DO 8 I=M,N,ISTEP
        J=I+MMAX
        TEMPR=WR*DATA(J)-WI*DATA(J+1)
        TEMPI=WR*DATA(J+1)+WI*DATA(J)
        DATA(J)=DATA(I)-TEMPR
        DATA(J+1)=DATA(I+1)-TEMPI
```

```
      DATA(I)=DATA(I)+TEMPR
    8 DATA(I+1) = DATA(I+1)+TEMPI
      TEMPR = WR
      WR = WR*WSTPR-WI*WSTPI + WR
    9 WI = WI*WSTPR+TEMPR*WSTPI + WI
      MMAX = ISTEP
      GO TO 6
   10 RETURN
      END

      SUBROUTINE TAPENR(X,M ,NWRITE,STA,COMP,DIST,DEG,BACKAZ,T0,DT,
     1 IDATE,NPTS)
      CHARACTER STA,COMP,IDATE
      DIMENSION X(1),IDATE(3)
      WRITE(01,310) M,NPTS  ,STA,COMP,DIST,DEG,BACKAZ,T0,DT,
     1 IDATE(1),IDATE(2),IDATE(3)
  310 FORMAT(2I5,A4,1X,A4,1X,5F10.2,3A4)
      DO 312 I=1,M
      K = I * 8
      J = K - 7
  312 WRITE(01,311) NWRITE,(X(L),L=J,K)
  311 FORMAT(I5,8E15.8)
      NWRITE = NWRITE + 1
      RETURN
      END

      SUBROUTINE TREND(X,NPTS,ITREND)
      DIMENSION X(1)
C     ITREND = 1    DC COMPONENT REMOVED
C     ITREND = 2    LINEAR COMPONENT REMOVED
      SUM2 = 0.0
      SUM1 = 0.0
      N1 = NPTS/2
      DO 1 I = 1,N1
    1 SUM1 = SUM1 + X(I)
      N21 = N1 + 1
      DO 2 I = N2,NPTS
    2 SUM2 = SUM2 + X(I)
      N2 = NPTS - N1
      DC = (SUM1 + SUM2)/NPTS
      IF(ITREND - 1)6,6,7
    6 B = DC
      SLP = 0.0
      GO TO 8
    7 CONTINUE
      SLP = 2.*((SUM2/N2) - (SUM1/N1))/NPTS
      B = (SUM1/N1) - 0.5*N21*SLP
    8 CONTINUE
      DO 3 I = 1,NPTS
      X = I
```

```
    3 X(I) = X(I) - B - SLP*XI
      WRITE(61,5) DC,SLP
    5 FORMAT(1H ,4HDC = , E11.4,4X,7HSLOPE = , E11.4)
      RETURN
      END

      SUBROUTINE TAPEIN(INDEX,IOTP)
C     INDEX IS TOTAL NUMBER OF SPECTRA TO BE BYPASSED BEFORE WRITING
C     STARTS
      IF(INDEX.LE.0) GO TO 2
      DO 1 I=1,INDEX
      READ(IOTP,10) N
      DO 1 J=1,N
      READ(IOTP,10) IDUM
    1 CONTINUE
    2 RETURN
   10 FORMAT(I5)
      END

      SUBROUTINE PHASE(X,Y,PHI)
C     ARGUMENT PHI IS RETURNED AS VARYING FROM 0.0 TO 1.0 CIRCLES
      IF(X) 21,20,22
   20 IF(Y) 23,24,25
   23 PHI = 1.5* 3.14159 27
      GO TO 28
   24 PHI = 0.0
      GO TO 28
   25 PHI = 0.5 * 3.1415927
      GO TO 28
   21 PHI = ATAN(Y/X) + 3.1415927
      GO TO 28
   22 IF(Y) 26,27,27
   27 PHI = ATAN(Y/X)
      GO TO 28
   26 PHI = ATAN(Y/X) + 2.0 * 3.1415927
      GO TO 28
   28 CONTINUE
      PHI = PHI/6.2831854
      PHI = PHI - AINT(PHI)
      RETURN
      END

      SUBROUTINE PRIN(X,M,STA,COMP,DIST,DEG,BACKAZ,TO,DT,IDATE)
      CHARACTER STA,COMP,IDATE
      DIMENSION X(1),IDATE(3),T(46)
      DATA T/.1,.2,.3,.4,.5,.6,.7,.8,.9,1.,1.1,1.2,1.3,1.4,1.5,1.6,1.7,
     1 1.8,1.9,2.,2.5,3.,3.5,4.,5.0,6.,7.,8.,9.,10.,12.,14.,16.,18.,20.,
     2 22.,24.,26.,28.,30.,35.,40.,50.,60.,70.,80.,90.,100./
  100 FORMAT(1H ,4(9X,E11.4))
      WRITE(61,99) STA,COMP,IDATE(1),IDATE(2),IDATE(3)
```

```
   99 FORMAT(1H0,A4,2X,A4,2X,3A4)
      WRITE(61,98)
   98 FORMAT(1H0,11X,6HPERIOD,13X,9HFREQUENCY,11X,9HAMPLITUDE,13X,
     1 5HPHASE, /)
      K = 46
      DO 10 I = 3,M
      PER1 = 2.*M*DT/(I-1)
      PER2 = 2.*M*DT/I
      FREQ = 1./PER1
      DO 15 J=1,K
      IF(PER1.GT.T(J).AND.PER2.LE.T(J)) GO TO 16
   15 CONTINUE
      GO TO 17
   16 K = J
      II = 2 * I
      III= II -1
      AMP = SQRT(X(II)*X(II) + X(III)*X(III))
      CALL PHASE(X(III),X(II),PHI)
      PHI = PHI - T0 * FREQ
      PHI = PHI - AINT(PHI)
      IF(PHI.LT.0) PHI = PHI + 1.0
      WRITE(61,100) PER1,FREQ,AMP,PHI
   17 CONTINUE
   10 CONTINUE
      RETURN
      END

      SUBROUTINE INSTRM(X,NN,DF,PEAK,ICONTRL)
C     THIS SUBROUTINE CORRECTS SPECTRA FOR INSTRUMENTAL RESPONSE
      COMMON/INST/MAGIN,NP,PER(100),RESP(100)
      COMMON/MAGI/TS,TG,HS,HG,SIGMA,PK,FPK
      DIMENSION X(1)
C     REDUCED SPECTRA FOR ZERO FREQUENCY
      MAGIN = 0
      X(1) = 0.0
      X(2) = 0.0
      NN2 = NN/2
      DO 10 I=2,NN2
      XI = I - 1
      FREQ = XI * DF
      J = 2 * I - 1
      K = 2 * I
      GO TO(1,2,3,4,5,6,8,9),ICONTRL
    1 CALL SEISM1(FREQ,PEAK,XR,XI)
      GO TO 7
    2 CALL SEISM2(FREQ,PEAK,XR,XI)
      GO TO 7
    3 CALL SEISM3(FREQ,PEAK,XR,XI)
      GO TO 7
    4 CALL SEISM4(FREQ,PEAK,XR,XI)
```

```
      GO TO 7
    5 CALL SEISM5(FREQ,PEAK,XR,XI)
      GO TO 7
    6 XR = 1.
      XI = 0.0
      GO TO 7
    8 CALL SEISM7(FREQ,PEAK,XR,XI)
      GO TO 7
    9 CALL SEISM8(FREQ,XR,XI)
    7 CONTINUE
      TEMPR = XR*X(J) - XI*X(K)
      TEMPI = XR*X(K) + XI*X(J)
      X(J) = TEMPR
   10 X(K) = TEMPI
      IF(ICONTRL.LT.8) RETURN
C     COMPLETE NORMALIZATION FOR HAGIWARA'S EQUATION
      PK=SQRT(PK)
      FAC = PK/PEAK
      DO 20 I=2,NN2
      J = 2*I-1
      K = 2*I
      X(J)=FAC*X(J)
      X(K) = FAC*X(K)
   20 CONTINUE
      WRITE(61,30)TS,TG,HS,HG,SIGMA,PK,FPK
   30 FORMAT(1H0,20HHAGIWARA'S EQUATION ,3HTS=F10.2,4H TG=,F10.2,4H HS=
     1,F10.2,4H HG=,F10.2,7H SIGMA=,F6.3,4H PK=,F10.3,3H AT,E10.3,3H HZ)
      RETURN
      END

      SUBROUTINE SEISM1(FREQ,PEAK,XR,XI)
C     15-100 SYSTEM
C     WWSSN INSTRUMENT CONSTANTS FROM U. CHANDRA, BSSA 1970 VOL 60
C     PP 539-563
C     PEAK MAGNIFICATIONS ARE 350,700,1400,2800,5600
      IF(FREQ.GT.1.0) FREQ = 1.0
      IF(FREQ.LT.0.005) FREQ = 0.005
      WE = 6.28318553*FREQ
      INDEX = (PEAK + 1.)/375.
      GO TO (1,2,2,3,3,3,3,4,4,4,4,4,4,4,4,5),INDEX
    1 FMAG = 278.
      SIGMA = 0.003
      GO TO 6
    2 FMAG = 556.
      SIGMA = 0.013
      GO TO 6
    3 FMAG = 1110.
      SIGMA = 0.047
      GO TO 6
    4 FMAG = 2190.
```

```
      SIGMA = 0.204
      GO TO 6
    5 FMAG = 3950.
      SIGMA = 0.905
    6 ZETA = 0.93
      ZETA1=1.
      WN=.418879
      WN1 = .062831853
      AR= (WE*WE-WN*WN)*(WE*WE-WN1*WN1)-4.*ZETA*ZETA1*WN*WN1*(1.-SIGMA)
     1*WE*WE
            AI=2.*WE*(ZETA1*WN1*(WN*WN-WE*WE)+ZETA*WN*(WN1*WN1-WE*WE))
      FACTOR = 1./(FMAG*WE*WE*WE)
      XR = - AI * FACTOR
      XI = AR * FACTOR
      RETURN
      END

      SUBROUTINE SEISM2(FREQ,PEAK,XR,XI)
C     30-100 SYSTEM
C     WWSSN INSTRUMENT CONSTANTS FROM U. CHANDRA, BSSA 1970 VOL 60
C     PP 539-563
      IF(FREQ.GT.1.0) FREQ = 1.0
      IF(FREQ.LT.0.005) FREQ = 0.005
      WE = 6.2831853*FREQ
      INDEX = (PEAK+1.)/375.
      GO TO (1,2,2,3,3,3,3,4,4,4,4,4,4,4,4,5),INDEX
    1 FMAG = 251.9
      SIGMA = 0.103
      GO TO 6
    2 FMAG = 503.1
      SIGMA = 0.312
      GO TO 6
    3 FMAG = 1001.5
      SIGMA = 0.144
      GO TO 6
    4 FMAG = 1941.9
      SIGMA = 0.195
      GO TO 6
    5 FMAG = 2241.8
      SIGMA = 0.767
      GO TO 6
    6 ZETA = 1.5
      ZETA1 = 1.
      WN = 0.209439
      WN1 = 0.062831853
      AR= (WE*WE-WN*WN)*(WE*WE-WN1*WN1)-4.*ZETA*ZETA1*WN*WN1*(1.-SIGMA)
     1*WE*WE
            AI=2.*WE*(ZETA1*WN1*(WN*WN-WE*WE)+ZETA*WN*(WN1*WN1-WE*WE))
      FACTOR = 1./(FMAG*WE*WE*WE)
      XR = - AI * FACTOR
```

```
      WRITE(61,303) ((PER(I),RESP(I)),I=1,M)
  300 FORMAT(1H0,20HVELOCITY SENSITIVITY     )
  301 FORMAT(1H0,24HDISPLACEMENT SENSITIVITY    )
  302 FORMAT(1H ,7X,3HPER,8X,4HRESP,4(9X,3HPER,8X,4HRESP) / )
  303 FORMAT(1H ,10F12.2)
      IF(N) 3,4,4
    3 DO 5 I=1,M
C     CONVERSION FROM VELOCITY SENSITIVITY TO DISPLACEMENT SENSITIVITY
    5 RESP(I) =  RESP(I) * 6.2831853/PER(I)
    4 CONTINUE
      MAGIN = 1
  100 CONTINUE
      IF(FREQ.LT.0.005) FREQ = 0.005
      T = 1./FREQ
      IF(T.LE.PER(1)) T = PER(1)
      IF(T.GE.PER(M)) T = PER(M)
      DO 200 I=1,M
      IF(T.GE.PER(I).AND.T.LE.PER(I+1)) GO TO 160
  200 CONTINUE
  160 XR = RESP(I) +  (RESP(I+1)-RESP(I))/(PER(I+1)-PER(I))*(T-PER(I))
      XR = 1./XR
      XI = 0
      RETURN
      END

      SUBROUTINE SEISMS(FREQ,PEAK,XR,XI)
C     STANDARD WOOD-ANDERSON TO = 0.8  ZETA = 0.8
      WN = 1.25
      ZETA = 0.8
      WNFR = WN/FREQ
      XR =-(WNFR*WNFR-1.)/PEAK
      XI =-2.*ZETA*WNFR/PEAK
      RETURN
      END

      SUBROUTINE SEISP7(FREQ,PEAK,XR,XI)
C     LRSM RESPONSE FOR LP SYSTEM WITH FILTER 6824-13
C     PHASE RESPONSE OBTAINED FROM HILBERT TRANSFORM OF AMPLITUDE
C     RESPONSE.  GAIN NORMALIZED TO 1.0 AT T = 25 SECONDS
      DIMENSION FRE(28),P(28),PHI(28)
      DATA FRE/.001,.002,.003,.004,.005,.006,.007,.008,.009,.01,.02,.03,
     1.04,.05,.06,.07,.08,.09,.1,.2,.3,.4,.5,.6,.7,.8,.9,1./
      DATA P/.000015,.000391,.00131,.00310,.00609,.01068,.01713,.02556,
     1.03618,.04848,.28030,.67553,1.0,1.09448,1.0044,.86969,.74511,.6355
     27,.54613,.12153,.04830,.02741,.01827,.01328,.01017,.008052,.006545
     3,.005404/
      DATA PHI/265.0,259.1,253.4,248.1,242.8,236.9,230.3,223.4,216.4,
     1209.7,153.4,102.0,54.6,14.4,-16.8,-40.4,-58.2,-73.3,-85.4,-146.4,
     2-153.9,-155.3,-156.4,-157.7,-159.2,-160.6,-162.3,-163.8/
      M = 28
```

```
      DEGRAD = 0.01745329
      IF(FREQ.GT.0.5) FREQ = 0.5
      IF(FREQ.LT.0.005) FREQ = 0.005
      DO 200 I = 1,M
      IF(FREQ.GE.FRE(I).AND.FREQ.LE.FRE(I+1)) GO TO 160
  200 CONTINUE
  160 PF= PHI(I)+(PHI(I+1)-PHI(I))/(FRE(I+1)-FRE(I))*(FREQ-FRE(I))
      PH = P(I) + (P(I+1) - P(I))/(FRE(I+1)-FRE(I))*(FREQ-FRE(I))
      PF = PF * DEGRAD
      XR = COS(PF)/(PH*PEAK)
      XI = - SIN(PF)/(PH*PEAK)
      RETURN
      END

      SUBROUTINE SEISM8(FREQ,XR,XI)
C     THIS SUBROUTINE READS IN A SET OF SEISMOGRAPH CONSTANTS FOR
C     USE WITH HAGIWARA'S EQUATION AND CORRECTS FOR INSTRUMENT RESPONSE
      COMMON/INST/MAGIN,M,PER(100),RESP(100)
      COMMON /HAGI/ TS,TG,HS,HG,SIGMA,PK,FPK
      IF(MAGIN.NE.0) GO TO 100
      READ(60,1) TS,HS,TG,HG,SIGMA
    1 FORMAT(5F10.2)
      MAGIN = 1
      PK=0.0
      FPK=0.0
  100 CONTINUE
      IF(FREQ.GT.1.0) FREQ=1.0
      IF(FREQ.LT.0.005) FREQ=0.005
      WE=6.2831853*FREQ
      WN= 6.2831853/TS
      WN1 = 6.2831853/TG
      ZETA = HS
      ZETA1 = HG
      AR=(WE**2-WN**2)*(WE**2-WN1**2)-4.*ZETA*ZETA1*WN*WN1*(1.-SIGMA)
     1*WE**2
      AI=2.*WE*(ZETA1*WN1*(WN**2-WE**2)+ZETA*WN*(WN1**2-WE**2))
      FACTOR=1./(WE**2*WE**2)
      XR= -AI * FACTOR
      XI= AR*FACTOR
      XPK=1./(XR**2+XI**2)
      IF(XPK.GT.PK) FPK=FREQ
      IF(XPK.GT.PK) PK=XPK
      RETURN
      END

      SUBROUTINE CARDIN(DUMMY,NPTS,INTYP,DPM,DT,TMAX)
      COMMON/DTA/X(2048),Y(2048)
      DIMENSION DUMMY(1)
      DIMENSION XJUMP(11)
      XJUMP(1) = 0.
```

```
      XJUMP(2) = 10000.
      XJUMP(3) = 20000.
      XJUMP(4) = 30000.
      XJUMP(5) = 40000.
      XJUMP(6) = 50000.
      XJUMP(7) = 60000.
      XJUMP(8) = 70000.
      XJUMP(9) = 80000.
      XJUMP(10) = 90000.
      XJUMP(11) = 100000.
      IF(INTYP.EQ.2) GO TO 2
      DO 910 I = 1,2048,12
      J = I + 11
      READ(60,911)  (DUMMY(K),K=I,J)
      WRITE(61,919) (DUMMY(K),K=I,J)
  919 FORMAT(1H ,,12(F6.0,1X))
  911 FORMAT(12(F5.0,1X))
      DO 910 K = I , J
      IF(DUMMY(K)-9999.) 910,912,912
  910 CONTINUE
  912 NPTS = K - 1
      WRITE(61,909) NPTS
  909 FORMAT(1H ,6HNPTS =  ,I5)
      RETURN
    2 CONTINUE
      CPS = CPM/60.
      DO 110 I = 1,2048,8
      J = I + 7
      READ(60,111) ((X(K),Y(K)),K=I,J)
      WRITE(61,112)((X(K),Y(K)),K=I,J)
  111 FORMAT(16F5.0)
  112 FORMAT(1H ,16F7.0)
      DO 110 K = I,J
      IF(X(K)+9999.) 115,115,110
  110 CONTINUE
  115 NUM = K - 1
      WRITE(61,907) NUM
  907 FORMAT(1H ,6H NUM =  ,I5)
      JUMP = 1
      DO 200 I = 2,NUM
      Q = X(I) + XJUMP(JUMP)
      IF(ABS(Q - X(I-1)).GT.9000.) JUMP = JUMP + 1
      X(I) = X(I) + XJUMP(JUMP)
  200 CONTINUE
      WRITE(61,908) JUMP
  908 FORMAT(1H , 6HJUMP =  ,I5)
      TIME1 = 0.0
      NPTS = 1
      DO 300 I = 2,NUM
  305 CONTINUE
```

```
      TIME = TIME1 * CPS
      JUMP = 1
      IF(TIME.LT.X(I).AND.TIME.GE.X(I-1)) JUMP = 2
      GO TO (301,302),JUMP
  302 DUMMY(NPTS) = Y(I) + (TIME-X(I))*((Y(I)-Y(I-1))/(X(I)-X(I-1)))
      NPTS = NPTS + 1
      TIME1 = TIME1 + DT
      IF(TIME1.GT.TMAX) GO TO 500
      GO TO 305
  301 CONTINUE
  300 CONTINUE
  500 NPTS = NPTS - 1
      WRITE(61,909) NPTS
      RETURN
      END
```

```
   1
   0
   1    2    1    1    2    2

ALQ WE     1455.8     13.1        82.4        338.9       0.25        30.4267    3000.
25 MAR 76                  240.        456.4
0000 0000 0028 0012 0039-0004 0056-0009 0076 0012 0092-0008 0111-0002 0135 00
0171 0023 0193-0021 0217 0030 0240 0026 0252 0019 0282 0051 0312 0027 0337 00
0360 0036 0383-0005 0404 0038 0415 0057 0433-0006 0451-0003 0476 0044 0490 00
0508-0006 0525 0019 0544 0043 0561-0017 0575-0008 0584 0001 0597 0034 0607 00
0623-0031 0633-0039 0649-0017 0654-0020 0666 0008 0687-0060 0693-0040 0706 00
0714 001  0727 0030 0745 0002 0751 0010 0769 0034 0780 0037 0791 0026 0811 01
0833 0122 0837 0096 0851 0084 0859 0078 0875 0072 0894 0124 0907 0114 0911 01
0926 0059 0937 0084 0955 0064 0965 0057 0986 0120 0999 0098 1019 0073 1039 01
1056 0092 1062 0088 1075 0024 1094 0068 1108 0086 1122 0108 1132 0101 1145 01
1151 0127 1172-0101 1190-0090 1185-0068 1211 0213 1217 0204 1240 0039 1250 00
1259 0136 1280-0043 1297-0061 1316 0170 1322 0173 1327 0116 1341 0040 1357 00
1380 0014 1397 0082 1415 0004 1428-0019 1443-0000 1463 0027 1488-0015 1509 00
1528-0019 1539-0018 1553 0043 1571 0000 1586-0032 1612 0042 1637-0008 1647-00
1670-0030 1691 0021 1717 0006 1729 0012 1750-0023 1770 0005 1783 0046 1802-00
1831 0062 1843 0019 1919 0019-9999-9999

ALQ UN     1455.8     13.1        82.4        338.9       0.25        30.44      3000.
25 MAR 76                  240.        456.6
0000 0000 0022 0006 0033-0000 0053 0003 0074-0005 0097 0014 0124 0015 0143 00
0160 0033 0178 0023 0199 0033 0211 0041 0232 0044 0263 0032 0294 0019 0322 00
0344 0027 0366 0007 0389 0005 0401 0005 0425 0013 0437 0040 0446 0048 0466-00
0485 0019 0501 0004 0515 0002 0524 0036 0537 0081 0553 0097 0557 0085 0565 00
0575-0036 0591 0050 0606 0047 0601 0107 0611 0173 0619 0163 0631 0115 0638 00
0642 0105 0651 0064 0665 0091 0671 0095 0681 0188 0699 0009 0709-0032 0718-00
0736-0107 0749-0005 0764-0015 0764 0049 0772 0238 0781 0259 0788 0229 0797 01
0807 0119 0814 0121 0822 0054 0834-0004 0844-0011 0853-0054 0864-0004 0871-00
0881 0000 0889-0006 0901 0032 0910 0021 0919 0006 0926 0017 0932 0039 0944 01
0955 0109 0964 0118 0973 0092 0988 0019 0990 0009 0996-0020 1007-0086 1015-00
1033 0145 1038 0133 1050 0047 1061-0013 1071-0008 1089 0045 1103-0006 1126 01
1151-0053 1163-0065 1173 0006 1193 0117 1208 0056 1225-0009 1240 0048 1252 00
1271 0009 1276 0015 1294 0029 1310-0019 1328-0054 1332-0048 1345 0061 1354 00
1378-0043 1391-0025 1402 0009 1418 0002 1436 0053 1437 0051 1457 0019 1469 00
1488 0111 1512 0074 1523 0095 1541 0093 1563 0094 1571 0083 1586 0105 1595 01
1611 0082 1624 0081 1644 0093 1650 0073 1670 0090 1683 0086 1699 0054 1707 00
1725 0042 1741 0114 1755 0104 1771 0041 1786 0019 1803 0108 1823 0081 1832 00
1867 0081 1879 0077-9999-9999
   4    1    1   -1    2    2

OTT UZ    1650.9     14.8       234.0       338.9       0.5         30.6133
25 MAR 76                  300.        459.2
0000 0000 0029 0013 0055-0015 0082 0013 0118-0003 0148 0006 0169-0005 0206 00
0225-0002 0254 0005 0275-0007 0303 0013 0309 0011 0328-0019 0340-0001 0365 00
0375 0001 0392-0005 0423 0007 0454-0001 0490 0002 0497 0003 0518-0002 0538-00
0572 0001 0607-0001 0626 0006 0629 0008 0648-0022 0685 0014 0721-0003 0760-00
```

DATA

```
 0797-0003 0822-0005 0841 0005 0862-0007 0884-0001 0904 0017 0913-0009 0937-00
 0937-0061 0949 0054 0964-0027 0966-0028 0973-0062 0984 0098 1005-0139 1014 01
 1028 0002 1034-0006 1041-0007 1042-0009 1061-0103 1069 0137 1091-0067 1106-00
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 1202-0039 1212 0052 1226-0026 1236-0070 1261 0029 1283-0011 1297-0023 1307-00
 1317 0007 1330-0041 1336 0016 1351 0019 1362 0039 1373 0030 1378-0009 1386-00
 1401-0061 1411-0098 1419 0031 1438 0166 1441 0153 1471-0227 1479-0226 1480-02
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 1595-0003 1606 0039 1626-0040 1637-0040 1644-0012 1660 0064 1672 0025 1687-00
 1687-0059 1706 0050 1717 0008 1732-0069 1749 0043 1770-0045 1778-0026 1798-00
 1808 0003 1820-0000 1834 0018 1864 0005 1872 0005 1894-0051 1908-0021 1918 00
 1932 0052 1955-0056 1971-0013 1989 0001 2009 0019 2027-0044 2035-0038 2058 00
 2071 0011 2092-0055 2115 0029 2129 0031 2152-0064 2162-0023 2177 0034 2211-00
 2218-0004 2237 0010 2259-0018 2276-0011 2302-0011 2322-0005 2331 0006-9999-99
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2,        300.      3.        600.      4.        1000.     5.        1500.
6.        2100.     8.        3500.     10.       5000.     15.       7600.
20.       9500.     30.       11500.    40.       11500.    50.       10500.
60.       10000.    80.       8000.     100.      6800.     150.      4000.
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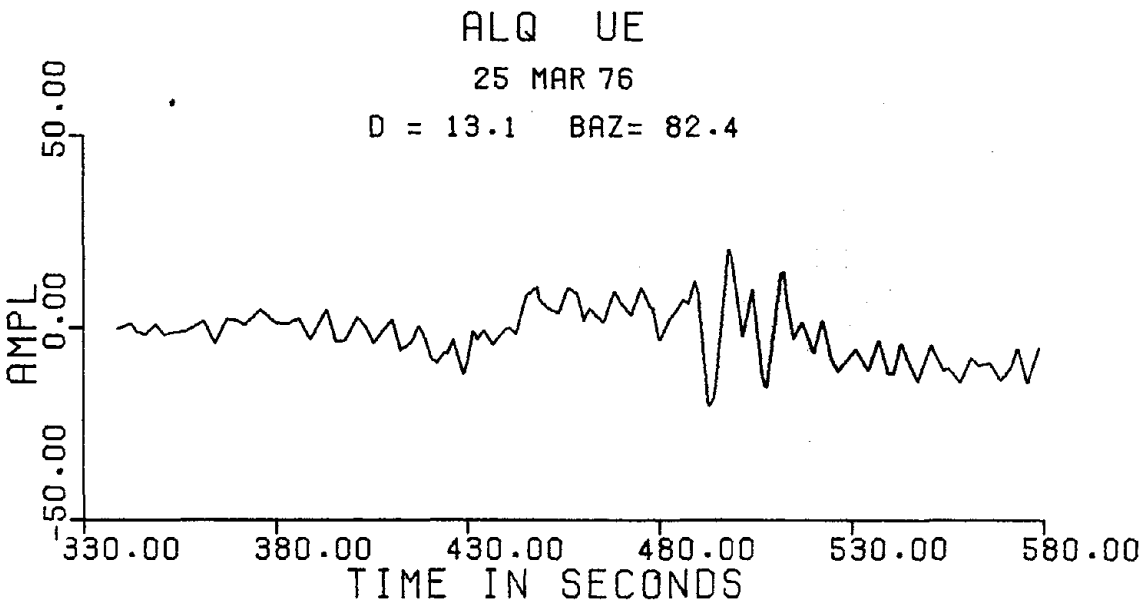
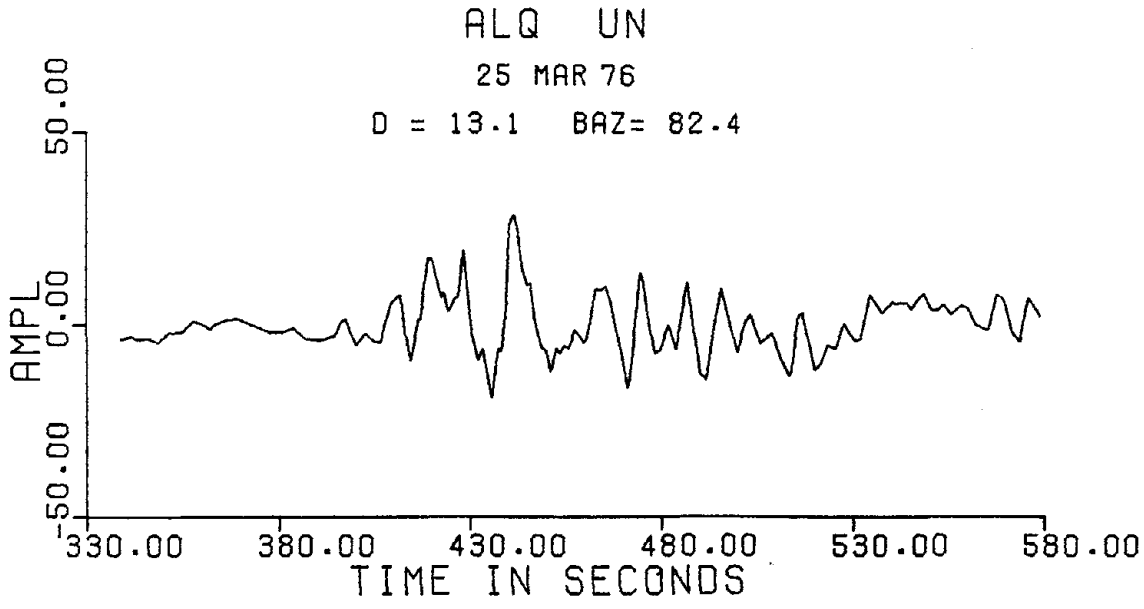

ALQ UE
25 MAR 76
D = 13.1 BAZ= 82.4
AMPL
50.00
0.00
-50.00
330.00
380.00
430.00
480.00
530.00
580.00
TIME IN SECONDS


ALQ UN
25 MAR 76
D = 13.1 BAZ= 82.4
AMPL
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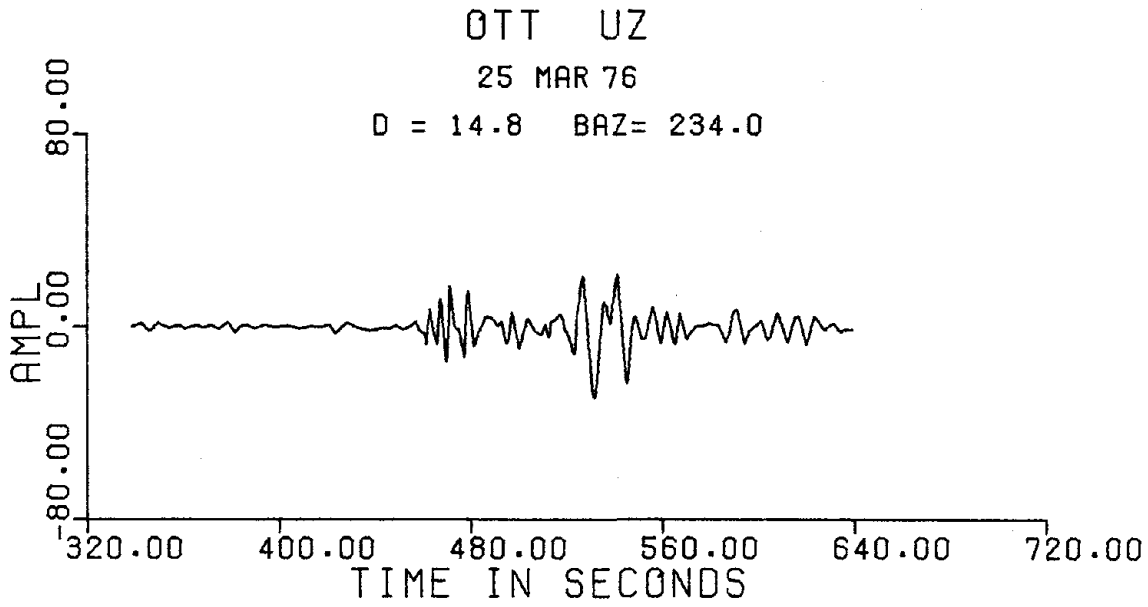
380.00
430.00
480.00
530.00
580.00
TIME IN SECONDS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25 MAR 76
D = 14.8 BAZ= 234.0
AMPL
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0.00
-80.00
320.00
400.00
480.00
560.00
640.00
720.00
TIME IN SECONDS

```
  1    2    1    1    2    2

STA     COMP     DIST KM     DEG    BACKAZ    TO       DT      CPMR     PEAKMAG
ALQ      UE       1455.80   13.10   82.40   338.9    0.250    30.43    3000.

    DATE             SLOPE        YMAX        CPM
25 MAR 76            0.          240.00     856.40

    0.     0.    28.    12.    39.    24.    56.    49.    76.    12.    92.    -8.   111.    -2.   135.     0.
  171.    23.   193.   -21.   217.    30.   240.    86.   262.    19.   282.    51.   312.    27.   337.    25.
  360.    36.   383.    -5.   404.    38.   415.    87.   433.    -6.   451.    -3.   476.    44.   490.    30.
  508.    -6.   525.    19.   548.    33.   561.   -17.   575.    -8.   584.     1.   597.    34.   607.    15.
  623.   -31.   633.   -39.   647.   -17.   654.   -20.   666.     8.   687.   -60.   693.   -40.   706.    29.
  714.    10.   727.    30.   749.     2.   751.    10.   769.    34.   780.    37.   791.    26.   811.   104.
  833.   122.   837.    96.   851.    84.   859.    78.   875.    72.   894.   124.   907.   114.   911.   113.
  926.    59.   937.    84.   952.    84.   965.    87.   986.   120.   999.    98.  1019.    73.  1039.   130.
 1056.    92.  1062.    88.  1079.    24.  1094.    68.  1108.    86.  1122.   108.  1132.   101.  1145.   146.
 1151.   127.  1172.  -101.  1180.   -90.  1185.   -88.  1211.   213.  1217.   204.  1240.    39.  1250.    88.
 1259.   136.  1280.   -43.  1287.   -61.  1316.   170.  1322.   173.  1327.   116.  1341.    40.  1357.    76.
 1380.    14.  1397.    82.  1412.     4.  1428.   -19.  1443.     0.  1463.    27.  1488.   -15.  1509.    49.
 1528.   -19.  1539.   -18.  1553.    13.  1571.     0.  1586.   -32.  1612.    42.  1637.    -8.  1647.    -2.
 1670.   -30.  1691.    21.  1707.     6.  1729.    12.  1750.   -83.  1770.     5.  1783.    46.  1802.   -26.
 1831.    62.  1843.    19.  1919.    19. -9999. -9999.     0.     0.     0.     0.     0.     0.     0.     0.
NUM =  115
JUMP =   1
NPTS =  961
DC = 0.5652E 01    SLOPE = 0.1137E-01

STA     COMP     DIST KM     DEG    BACKAZ    TO       DT      CPMR     PEAKMAG
ALQ      UN       1455.80   13.10   82.40   338.9    0.250    30.44    3000.

    DATE             SLOPE        YMAX        CPM
25 MAR 76            0.          240.00     856.60

    0.     0.    22.     6.    33.     0.    53.     3.    74.    -5.    97.    14.   124.    15.   143.    37.
  160.    33.   178.    23.   189.    83.   211.    41.   232.    44.   263.    32.   294.    19.   322.    10.
  344.    27.   366.     7.   389.     5.   401.     5.   425.    13.   437.    40.   446.    48.   456.    -5.
  485.    19.   501.     4.   518.     2.   524.    36.   537.    81.   553.    97.   557.    85.   565.    20.
  575.   -36.   591.    50.   596.    37.   601.   107.   611.   173.   619.   163.   631.   115.   638.    91.
  642.   105.   651.    64.   668.    91.   671.    95.   681.   188.   699.     9.   709.   -32.   718.    -7.
  736.  -107.   749.    -5.   758.   -15.   764.    49.   772.   238.   781.   259.   788.   229.   797.   154.
  807.   119.   814.   121.   822.    94.   834.    44.   844.   -11.   853.   -54.   864.    -4.   871.   -16.
  881.     0.   889.    -6.   903.    32.   910.    21.   919.     6.   926.    17.   932.    39.   944.   113.
  955.   109.   964.   118.   978.    92.   988.    19.   990.     9.   996.   -20.  1007.   -86.  1015.   -33.
 1033.   145.  1038.   133.  1050.    37.  1061.   -13.  1071.    -8.  1089.    45.  1103.    -6.  1126.   129.
 1151.   -93.  1163.   -65.  1179.     6.  1193.   117.  1208.    86.  1225.    -9.  1240.    48.  1252.    67.
 1271.     9.  1278.    15.  1298.    29.  1310.   -19.  1328.   -54.  1332.   -48.  1345.    61.  1354.    73.
 1378.   -43.  1391.   -25.  1402.     9.  1418.     2.  1436.    53.  1437.    51.  1457.    19.  1469.    22.
 1488.   111.  1512.    74.  1538.    95.  1541.    93.  1563.    94.  1571.    83.  1586.   105.  1595.   114.
 1611.    82.  1624.    81.  1634.    93.  1650.    73.  1670.    90.  1683.    86.  1699.    54.  1707.    50.
 1725.    42.  1741.   114.  1758.   104.  1771.    41.  1786.    19.  1803.   108.  1823.    81.  1832.    58.
 1867.    81.  1879.    77. -9999. -9999.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
NUM =  138
JUMP =   1
NPTS =  961
DC = 0.5488E 01    SLOPE = 0.3611E-02

ALQ   UT    25 MAR 76

          PERIOD              FREQUENCY           AMPLITUDE           PHASE
        0.1280E 03          0.7813E-02          0.6094E-01          0.1291E 00
```

0,8533E 02	0,1172E-01	0.4904E-02	0.1141E 00
0,6400E 02	0.1563E-01	0.1088E-01	0.9939E 00
0,5120E 02	0,1953E-01	0.2323E-02	0.2920E 00
0,4267E 02	0,2344E-01	0.3423E-02	0.1306E-01
0,3657E 02	0.2734E-01	0.1437E-02	0.9851E 00
0,3200E 02	0,3125E-01	0.1098E-02	0.9109E 00
0,2844E 02	0,3516E-01	0.2139E-02	0.1529E 00
0,2560E 02	0.3906E-01	0.2460E-02	0.5034E 00
0,2327E 02	0,4297E-01	0.2501E-02	0.8110E 00
0,2133E 02	0,4688E-01	0,3161E-02	0.1166E 00
0.1829E 02	0.5469E-01	0,3483E-02	0.6586E 00
0,1707E 02	0.5859E-01	0,2315E-02	0,9462E 00
0,1422E 02	0,7031E-01	0,9942E-03	0,9263E 00
0,1219E 02	0,8203E-01	0,1375E-02	0,6883E 00
0,1024E 02	0,9766E-01	0,2198E-02	0,6744E 00
0,9143E 01	0,1094E 00	0,1768E-02	0,5610E-02
0,8258E 01	0,1211E 00	0,1807E-02	0,3232E 00
0,7111E 01	0,1406E 00	0,1192E-02	0,3063E 00
0,6095E 01	0,1641E 00	0,2214E-03	0,3785E 00
0,5020E 01	0,1992E 00	0,5991E-03	0,9751E 00
0,4063E 01	0,2461E 00	0,1156E-02	0,5387E 00
0,3507E 01	0,2852E 00	0,2487E-03	0,6225E 00
0,3012E 01	0,3320E 00	0,6278E-03	0,3267E-01
0,2510E 01	0,3984E 00	0,2072E-03	0,7299E 00
0,2016E 01	0,4961E 00	0,3915E-03	0,7283E 00
0,1910E 01	0,5434E 00	0,2362E-03	0,5973E 00
0,1803E 01	0,5747E 00	0,1069E-03	0,8577E 00
0,1707E 01	0,5959E 00	0,3556E-03	0,1604E 00
0,1610E 01	0,6211E 00	0,3102E-03	0,2887E 00
0,1506E 01	0,6641E 00	0,4080E-03	0,8898E 00
0,1407E 01	0,7109E 00	0,2833E-03	0,1763E 00
0,1306E 01	0,7656E 00	0,3386E-03	0,2881E 00
0,1202E 01	0,8320E 00	0,1304E-03	0,6845E 00
0,1103E 01	0,9062E 00	0,1527E-03	0,9935E 00
0,1004E 01	0,9961E 00	0,1286E-03	0,6153E 00
0,9014E 00	0,1109E 01	0,9749E-04	0,8306E 00
0,8025E 00	0,1246E 01	0,6494E-04	0,8151E 00
0,7014E 00	0,1426E 01	0,9895E-04	0,5003E 00
0,6009E 00	0,1664E 01	0,2727E-04	0,5435E 00
0,5010E 00	0,1996E 01	0,3867E-04	0,1053E 00

ALQ UR 25 MAR 76

PERIOD	FREQUENCY	AMPLITUDE	PHASE
0,1280E 03	0,7813E-02	0,7441E-01	0.2191E 00
0,8533E 02	0,1172E-01	0.4868E-02	0.7162E 00
0,6400E 02	0,1563E-01	0,8044E-02	0.9886E 00
0,5120E 02	0,1953E-01	0.2456E-02	0.4056E 00
0,4267E 02	0,2344E-01	0.2996E-02	0.4633E 00
0,3657E 02	0,2734E-01	0.2787E-02	0.1421E 00
0,3200E 02	0,3125E-01	0,1324E-02	0,3284E 00
0,2844E 02	0,3516E-01	0,9800E-03	0,6369E 00
0,2560E 02	0,3906E-01	0,2833E-03	0,7259E 00
0,2327E 02	0,4297E-01	0,9231E-03	0,1566E 00
0,2133E 02	0,4688E-01	0,6569E-03	0,9673E 00
0,1829E 02	0,5469E-01	0.9483E-03	0.5313E-01
0,1707E 02	0,5859E-01	0,1344E-02	0,1630E 00
0,1422E 02	0,7031E-01	0,1964E-02	0.2726E 00
0,1219E 02	0,8203E-01	0,1615E-02	0.4884E 00
0,1024E 02	0,9766E-01	0,1233E-02	0,7608E 00
0,9143E 01	0,1094E 00	0,6164E-03	0,2947E 00
0,8258E 01	0,1211E 00	0,9795E-03	0,1967E 00
0,7111E 01	0,1406E 00	0,1828E-02	0,7150E 00
0,6095E 01	0,1641E 00	0,1124E-02	0,6123E 00
0,5020E 01	0,1992E 00	0,5822E-03	0,5113E 00
0,4063E 01	0,2461E 00	0,2796E-03	0,4478E 00

```
          0,3907E 01          0,2852E 00          0,1784E-03          0.8057E 00
          0,3012E 01          0,3320E 00          0,5338E-03          0.3001E 00
          0,2510E 01          0,3984E 00          0,2662E-03          0.8185E 00
          0,2016E 01          0,4961E 00          0,4608E-03          0.3816E 00
          0,1910E 01          0,5234E 00          0,2808E-03          0.5288E 00
          0,1803E 01          0,5747E 00          0,6502E-04          0.7491E 00
          0,1707E 01          0,5859E 00          0,2089E-03          0.2565E 00
          0,1610E 01          0,6211E 00          0,1843E-03          0.2532E 00
          0,1506E 01          0,6641E 00          0,3357E-03          0.9661E 00
          0,1407E 01          0,7109E 00          0,2884E-03          0.9002E 00
          0,1306E 01          0,7656E 00          0,6097E-04          0.8146E-01
          0,1202E 01          0,8320E 00          0,1332E-03          0.7816E 00
          0,1103E 01          0,9062E 00          0,4961E-04          0.4266E 00
          0,1004E 01          0,9961E 00          0,1797E-03          0.8274E-02
          0,9014E 00          0,1109E 01          0,1233E-03          0.1626E 00
          0,8025E 00          0,1246E 01          0,1921E-03          0.9937E 00
          0,7014E 00          0,1426E 01          0,8038E-04          0.7609E 00
          0,6009E 00          0,1664E 01          0,8078E-04          0.4959E-02
          0,5010E 00          0,1996E 01          0,8924E-04          0.6958E 00
  4    1    1   -1    2    2

STA     COMP     DIST KM     DEG    BACKAZ     TO       DT      CRMM     PEAKMAG
OTT      UZ        1650.90  14.80   434.00   338.9    0.500     30.61       0.

    DATE            SLOPE       TMAX        CPM
25 MAR 76            0.         300.30      359.20

    0.      0.     29.    13.    58.   -15.    82.    13.   118.    -3.   148.     6.   169.    -5.   206.     5.
  225.     -2.    254.     5.    279.    -7.    303.    13.   389.    11.   328.   -19.   340.    -1.   365.     7.
  375.      1.    392.    -5.    423.     7.    454.    -1.   490.     2.   497.     3.   518.    -2.   538.    -5.
  572.      1.    607.    -1.    620.     6.    629.     8.   648.   -22.   685.    14.   721.    -3.   760.   -13.
  797.     -3.    822.    -5.    841.     5.    862.    17.   884.    -1.   904.    17.   913.    -7.   937.   -26.
  937.    -61.    949.    54.    964.   -27.    966.   -28.   973.   -62.   984.    98.  1005.  -139.  1014.   133.
 1028.      2.   1034.    -6.   1041.    17.   1042.    49.  1061.  -103.  1069.   137.  1091.   -67.  1106.   -15.
 1109.    -15.   1127.    31.   1139.    30.   1152.    24.  1156.    18.  1166.     1.  1179.    17.  1194.   -57.
 1202.    -39.   1212.    52.   1220.   -26.   1236.   -70.  1261.    29.  1283.   -11.  1297.   -23.  1307.   -28.
 1317.      7.   1330.   -41.   1336.    16.   1351.    19.  1362.    39.  1373.    30.  1378.    -9.  1386.   -18.
 1401.    -61.   1411.   -98.   1419.    21.   1438.   166.  1441.   153.  1471.  -227.  1479.  -226.  1480.  -219.
 1503.     66.   1508.    79.   1516.    57.   1526.     2.  1539.   107.  1549.   178.  1578.  -167.  1582.  -176.
 1595.     -3.   1606.    39.   1629.   -40.   1637.   -40.  1644.   -12.  1660.    64.  1672.    25.  1687.   -62.
 1687.    -59.   1706.    50.   1717.     8.   1732.   -67.  1749.    43.  1770.   -45.  1778.   -26.  1798.    -2.
 1808.      3.   1820.     0.   1842.   -10.   1864.     5.  1872.     5.  1894.   -81.  1908.   -21.  1918.    44.
 1932.     52.   1955.   -56.   1973.   -33.   1989.     1.  2009.    19.  2027.   -44.  2035.   -38.  2058.    45.
 2071.     11.   2092.   -55.   2118.    29.   2129.    81.  2152.   -64.  2162.   -23.  2177.    34.  2211.   -15.
 2218.     -4.   2237.    10.   2251.   -18.   2276.   -11.  2302.   -11.  2322.    -9.  2331.     6.  .9999.  .9999.
 NUM =  343
JUMP =    1
NPTS =  601
DC =-0.1209E 00     SLOPE =-0.62878-03

VELOCITY SENSITIVITY
      PER        RESP        PER        RESP        PER        RESP        PER        RESP        PER        RESP
     2,00      300,00        3,00      600,00        4,00     1000,00        5,00     1500,00        6,00     2100,00
     8,00     3500,00       10,00     5000,00       15,00     7600,00       20,00     9500,00       30,00    11500,00
    40,00    11500,00       50,00    10500,00       60,00    10000,00       80,00     8000,00      100,00     6800,00
   150,00     4000,00
-10    0    0    0    0    0

         START    =    1     ;   END =     3
```

II. SPSPEC

PROGRAMMER: R. B. Herrmann / Jan 73

PURPOSE:

This program is similar to the program EXSPEC in purpose. The essential difference is that this program can take a 4096 point time series instead of a 2048 point series. The tape output of this program is compatible with the program DATAPLT for plotting of the ground motion Fourier amplitude density spectrum. The spectra are corrected for geometrical spreading to a reference distance of 9.0° (1000 km). Because of space limitations, this program accepts only tabulated values of instrument response, or the 15-100 or 30-100 WWSSN instrument responses.

INPUT/OUTPUT

The input of the digitized seismogram is on card FILE 60. Two output tapes may be used, one FILE 10, for plotting the digitized seismogram, the other, FILE 01, for storage of the complex values of the positive frequency components of the ground motion Fourier transform. Printer output is on FILE 61.

PROGRAM DESCRIPTION

PROGRAM SPSPEC: This is the main control link. The data are read in, corrected for digitizing trends and instrument effects. Only one component is analyzed at a time: formation of the transverse and radial components of the ground motion is not possible. The spectra are corrected for geometrical spreading on a sphere. Up to 4096 point Fast Fourier Transform can be used.

SUBROUTINE TAPEWR: This subroutine writes a basic block of spectra on tape together with all pertinent header information. The tape write formats are compatible with the tape read formats of program DATAPLT.

SUBROUTINE TREND: This subroutine either does nothing to the original time series, or removes a constant value from all amplitudes or removes both the DC offset and linear trend from the data.

SUBROUTINE TAPEIN: When FILE 01 is used for master storage of spectra, TAPEIN is used to skip over previously written spectra stored on the tape in order to add new spectra determinations at the end of the previous set. If the tape used does not have any spectra written on it, INDEX is set equal to zero, and succeeding positions on the tape.

SUBROUTINE INSTRM: This is a main control link for removing instrument response from the spectra. The option ICONTRL = 6 causes no instrument effect to be removed from the spectra.

SUBROUTINE SEISM1: This gives the instrument response of the 15-100 WWSSN long period seismograph system.

SUBROUTINE SEISM2: This gives the instrument response of the 30-100 WWSSN long period seismograph system.

SUBROUTINE SEISM4: This reads in tabulated displacement of velocity sensitivity curves, short period values first followed by longer period values. If the velocity sensitivity is read in, it is converted to displacement sensitivity. Since only the sensitivities are read in, the resultant ground motion spectra are not corrected for instrument phase response, only for the amplitude response.

SUBROUTINE PHASE: Given the arguments X and Y, this subroutine determines the phase PHI = arctan (Y/X), where PHI is given as fractions of a circle between 0.0 and 1.0 .

SUBROUTINE PRIN: This subroutine prints selected values of the amplitude and phase spectrum of the instrument corrected spectra.

SUBROUTINE CARDIN: This subroutine reads in the digitized seismogram. The seismogram may be either a series of Y amplitudes taken at equally spaced times or a series of X-Y coordinate pairs of the digitized seismogram trace which are to be linearly interpolated to form a new evenly spaced time series of Y values. Since the digitizer used writes a 5 digit numerical field consisting of a + sign and 4 digits for each X and Y value, care must be taken with very long seismograms or seismograms with very large amplitudes. In the case of very long seismograms, the plot of X(K) versus K would result in a sawtooth type of trace. The program recognizes this sawtooth and corrects for it by using the XJUMP parameters.

SUBROUTINE FOUR2: This is a compact version of the Fast Fourier Transform developed by Brenner (1967).

REFERENCES

Brenner, N. M. (1967). Three Fortran Programs that perform the Cooley-Tukey Fourier Transform, Technical Note 1967-2, Lincoln Laboratory.

Card Sequence	Column	Name	Format	Explanation
A.	1-5	IPLOT	I5	LT.0 Seismogram not plotted on 10 GE.0 Seismogram plotted.
	6-10	M	I5	Number of points of Fast Fourier Transform, power of 2. M = 0 defaults to M = 2048. M = 4096 is maximum allowed.
B.	1-5	INDEX	I5	Number of spectra on output tape to be skipped before writing new spectra. Can be zero.
C.	1-5	ICONTRL	I5	0 or neg. end program 1 15-100 seismograph 2 30-100 seismograph 3-5 read in tabulated resp. 6 no instrument resp. removed.
	6-10	IDATA	I5	Set equal to 1. dummy variable.
	11-15	ITAPE	I5	LT.0 no spectra written on 01 GE.0 spectra written on unit 01
	16-20	IPRNT	I5	LT.0 do not print selected spectral values. GE.0 print selected spectral values
	21-25	ITREND	I5	0 or neg bypass TREND 1 DC offset removed 2 DC offset and linear trend removed.
	26-30	INTYP	I5	NE 2 Y values entered for evenly spaced time increments. Terminated by a +9999 punch after last data value.

Card Sequence	Column	Name	Format	Explanation
C. (cont'd)	26-30	INTYP	I5	EQ 2 array of X, Y pairs which will be evenly spaced at an interval of DT by CARDIN. The first pair must be +0000+0000. The data set is terminated by -9999-9999 pair.
D.	79H			Identification card. A 1 punch in column 1 will cause the printer to skip to the next page.
E.	1-4	STA	A4	Station identifier
	5-8	COMP	A4	Component identifier
	11-20	DIST	F10.5	Station distance from epicenter in kilometers.
	21-30	DEG	F10.5	Station distance from epicenter in degrees. If no correction for geometrical spreading desired set DEG=9.0 .
	31-40	BACKAZ	F10.5	Back azimuth from station to epicenter, measured clockwise from north.
	41-50	TO	F10.5	Time digitizing began in seconds after origin time.
	51-60	DT	F10.5	Digitizing interval used (INTYP.NE.2) or desired (INTYP.EQ.2).
	61-70	CPMM	F10.5	Digitizer counts per millimeter of original record.
	71-80	PEAK	F10.5	Peak instrument response. Has no meaning for ICONTRL = 4 or 6.

Card Sequence	Column	Name	Format	Explanation
F.	1-12	IDATE(3)	3A4	Date of event
	16-25	SLOPE	F10.5	Trend of record trace below true zero line in counts per DT unit. Can be zero.
	26-35	TMAX	F10.5	Total length of desired digitized record.
	36-45	CPM	F10.5	Counts per minute on original record.

G. Digitized data

INTYP.NE.2	DUMMY(I)	12(F5.0,1X)	Digitized trace for equispaced time values. End of trace signified by +9999 punch
INTYP.EQ.2	X(I),Y(I)	16F5.0	X,Y pairs. First must be +0000 +0000 and last -9999-9999.

H. Instrument response options.

If ICONTRL = 4 the following instrument response values are read in:

a.	1	I5	N	Negative - velocity sensitivity read in, a total of ABS(N) values.
				Positive - displacement sensitivity read in, a total of N values
b.	N/4	8F10.5	PER(1)	Period listed in order of increasing period

Card Sequence	Column	Name	Format	Explanation
b. (cont'd)			RESP(I)	Velocity or displacement sensitivity

At this point the program returns to C. to check for more data.

```
C       PROGRAM SPSPEC
C       THIS PROGRAM IS AMENABLE FOR SHORT PERIOD SPECTRAL STUDIES.
C       IT CAN CONSIDER A TIME SERIES 4096 UNITS LONG
        CHARACTER STA,COMP,LABEL,IDATE,ICOMP
        COMMON/DTA/DATA(8192)
        COMMON/INST/MAGIN,NP,PER(100),RESP(100)
        DIMENSION IBUF(1026),IDATE(3),DUMMY(4098)
        DIMENSION LABEL(4)
        READ(60,63) IPLOT,M
C       IPLOT .GE. 0 CALCOMP PLOT PREPARED
C       M = NUMBER OF POINTS OF FOURIER TRANSFORM,  POWER OF 2
        IF(M.EQ.0) N = 2048
        DO 1 I = 1,12
        NN = 2**I
        NM = NN * 2
        IF(M.GE.NN.AND.M.LT.NM) N = NN
      1 CONTINUE
        IF(N.GT.4096) N = 4096
        N2 = N*2
        ND2 = N/2
        ND8 = N/8
        IF(IPLOT.LT.0) GO TO 62
        CALL PLOTS(IBUF,1026,10)
        CALL PLOT(0.0,-11.0,-3)
        CALL PLOT(0.0,3.0,-3)
     62 CONTINUE
        READ(60,63) INDEX
C       INDEX IS THE NUMBER OF SETS OF DATA ON TAPE TO BE SKIPPED BEFORE
C       WRITING
        CALL TAPEIN(INDEX,1)
        INDEX = INDEX + 1
        NWRITE = INDEX
    303 READ(60,63) ICONTRL,IDATA,ITAPE,IPRNT,ITREND,INTYP
        WRITE(61,63)ICONTRL,IDATA,ITAPE,IPRNT,ITREND,INTYP
     63 FORMAT(6I5)
        IF(ICONTRL.LE.0) GO TO 1000
C       ICONTRL PICKS PROPER MAGNIFICATION ROUTINE. SEE INSTRM
C       IDATA = 1 ONE COMPONENT ANALYZED
C       ITAPE .GE. 0    WRITE POSITIVE FREQUENCIES OF SPECTRA ON TAPE
C       IPRNT .GT. 0  PRINT AMPLITUDES AND PHASES AT SELECTED PERIODS
C       ITREND = 1  REMOVE DC COMPONENT  = 2 REMOVE DC + LINEAR TREND
C       FROM DATA
C       INTYP.NE.2  EVENLY SPACED Y VALUES . DATA SET ENDED BY 9999
C       INTYP.EQ.2  ARRAY OF X, Y VALUES. ENDED BY -9999-9999 IF FIELD OF
C       X EXCEEDS 9999 AND NEXT COUNT IS 0001 PROGRAM ADJUSTS TO 10001.
C       THE RANGE OF X IS UNLIMITED SINCE ADJUSTMENT TO 20000, IS TAKEN
C       WHEN NEXT DROP OCCURS.  *****NOTE***** FIRST X MUST BE 0000
        MAGIN = 0
        READ(60,2)
        WRITE(61,2)
```

```
      READ(60,10) STA,COMP,DIST,DEG,BACKAZ,TO,DT,CPMM,PEAK
C     STA = IDENTIFICATION OF STATION
C     COMP = IDENTIFICATION OF COMPONENT
C     DIST = DISTANCE IN KILOMETERS
C     DEG = DISTANCE FROM EPICENTER TO STATION IN DEGREES
C     BACKAZ = BACK AZIMUTH FROM STATION TO EPICENTER MEASURED CLOCKWISE
C     FROM N
C     TO = TIME WHEN DIGITIZING BEGAN IN SECONDS AFTER ORIGIN TIME OF
C     EVENT
C     DT = TIME INTERVAL BETWEEN DIGITIZING POINTS IN SECONDS
C     CPMM = COUNTS PER MILLIMETER OF ORIGINAL RECORD
C     PEAK = PEAK MAGNIFICATION OF INSTRUMENT RESPONSE
   10 FORMAT(2A4,2X,7F10.5)
      READ(60,11) IDATE(1),IDATE(2),IDATE(3),SLOPE,TMAX,CPM
C     SLOPE IS THE TREND OF THE RECORD TRACE BELOW THE ZERO LINE PER
C     UNIT DT
C     IF OPTION INTYP = 2 TMAX = TOTAL LENGTH DESIRED OF DIGITIZED
C     RECORD
C        CPM = COUNTS PER MINUTE
      CPS = CPM/60.
   11 FORMAT(3A4,3X,3F10.5)
      WRITE(61,6)
      WRITE(61,7) STA,COMP,DIST,DEG,BACKAZ,TO,DT,CPMM,PEAK
    6 FORMAT(1H ,30H STA    COMP    DIST KM    DEG   BACKAZ   TO
     1      DT      CPMM    PEAKMAG                )
    7 FORMAT(1H ,A4,4X,A4,3X,F10.2,2F7.2,F7.1,F8.3,F9.2,F5.0)
      WRITE(61,8)
      WRITE(61,9) IDATE(1),IDATE(2),IDATE(3),SLOPE,TMAX,CPM
    8 FORMAT(1H0,4X,4HDATE,12X,5HSLOPE,6X,4HTMAX,7X,3HCPM)
    9 FORMAT(1H ,3A4,3X,F10.4,2F10.2)
      WRITE(61,3)
    2 FORMAT(79H
     1                                                              )
    3 FORMAT(//)
      CALL CARDIN(DUMMY,NPTS,INTYP,CPM,DT,TMAX)
C     CONVERTING TO COUNTS PER CENTIMETER
      CONFAC = 0.1/CPMM
C     NORMALIZED TO 9.0 DEG OR 1000 KM
      CONFAC = CONFAC * SQRT(SIN(DEG*0.0174529))/SQRT(0.15643)
      IF(CPS.GT.0) CONFAC = CONFAC * CPS
      DO 115 I = 1,NPTS
      XI = I - 1
      DATA(I) = TO + XI * DT
C     SPECTRAL AMPLITUDES ARE IN CM-SEC
      DUMMY(I) = DUMMY(I) +SLOPE*XI
      IF(CPS.LE.0) GO TO 115
      DUMMY(I) = DUMMY(I) / CPS
  115 CONTINUE
      IF(ITREND.GE.1) CALL TREND(DUMMY,NPTS,ITREND)
      IF(IPLOT.LT.0) GO TO 119
```

```
      LABEL(1)=6HTIME I
      LABEL(2)=6HN SECO
      LABEL(3)=6HNDS
      CALL SCALE(DATA,5.0,NPTS,1)
      CALL SCALE(DUMMY,2.0,NPTS,1)
      IF(CPS.LE.0) GO TO 500
C     THIS MAKES SEISMOGRAM PLOT 1 - 1 REPRODUCTION OF ORIGINAL TRACE
      IF(DUMMY(NPTS+2).LT.DATA(NPTS+2)) GO TO 4001
      GO TO 4002
 4001 DUMMY(NPTS+2) = DATA(NPTS+2)
      DUMMY(NPTS+1) = - DUMMY(NPTS+2)
      GO TO 4003
 4002 CONTINUE
      DATA(NPTS+2) = DUMMY(NPTS+2)
 4003 CONTINUE
  500 CONTINUE
      CALL AXIS(0.0,0.0,LABEL,-16,5.0,90.0,DATA(NPTS+1),DATA(NPTS+2))
      ICOMP = 4HAMPL
      CALL AXIS(0.0,0.0,ICOMP,4,2.0,180.0,DUMMY(NPTS+1),DUMMY(NPTS+2))
      DUMMY(NPTS+2) = -DUMMY(NPTS+2)
      CALL LINE(DUMMY,DATA,NPTS,1,0,0)
      CALL SYMBOL(-2.50,1.85,0.14,STA,90.0,4)
      CALL SYMBOL(-2.50,2.55,0.14,COMP,90.0,4)
      CALL SYMBOL(-2.25,1.95,0.10,IDATE(1),90.0,4)
      CALL SYMBOL(-2.25,2.35,0.10,IDATE(2),90.0,4)
      CALL SYMBOL(-2.25,2.70,0.10,IDATE(3),90.0,3)
      CALL SYMBOL(-2.00,1.50,0.10,3HD =  ,90.0,3)
      CALL NUMBER(-2.00,1.90,0.10,DEG,90.0,1)
      CALL SYMBOL(-2.00,2.55,0.10,4HBAZ=  ,90.0,4)
      CALL NUMBER(-2.00,3.05,0.10,BACKAZ,90.0,1)
      CALL PLOT(6.0,0.0,-3)
  119 CONTINUE
      DO 118 I = 1,NPTS
  118 DUMMY(I) = DUMMY(I) * CONFAC
      DO 120 I = 1,N2
  120 DATA(I) = 0.0
      DO 121 I=1,NPTS
      J = 2 * I - 1
  121 DATA(J) = DUMMY(I)
      CALL FOUR2(DATA,N,1,-1)
      DF = 1./(N*DT)
      DO 122 I = 1,N2
  122 DATA(I) = DATA(I) * DT
C     REMOVAL OF INSTRUMENT RESPONSE
      CALL INSTRM(DATA,N,DF,PEAK,ICONTRL)
C     INSTRM  RETURNS ONLY FIRST HALF OF ARRAY CORRESPONDING TO POSITIVE
C     FREQ.  NOTE THE AMPLITUDE CORRESPONDING TO THE NYQUIST FREQUENCY
C     IS NOT PLOTTED
  405 IF(ITAPE.LT.0) GO TO 425
  410 CALL TAPEWR(DATA ,NDB,NWRITE,STA,COMP,DIST,DEG,BACKAZ,T0,DT,
```

```
     1 IDATE,NPTS)
  425 CONTINUE
      IF(IPRNT.GT.0) CALL PRIN(DATA,ND2 ,STA,COMP,DIST,DEG,BACKAZ,T0,DT,
     1 IDATE)
      GO TO 3
 1000 CONTINUE
      NWRITE = NWRITE - 1
      WRITE(61,1001) INDEX,NWRITE
 1001 FORMAT(1H0,10X,10HSTART    =      ,I5,5X,10H,   END =    ,I5)
      IF(IPLOT.LT.0) GO TO 1002
      CALL PLOT(8.0,0.0,999)
 1002 CONTINUE
      STOP
      END

      SUBROUTINE TAPEWR(X,M ,NWRITE,STA,COMP,DIST,DEG,BACKAZ,T0,DT,
     1 IDATE,NPTS)
      CHARACTER STA,COMP,IDATE
      DIMENSION X(1),IDATE(3)
      WRITE(01,310) M,NPTS  ,STA,COMP,DIST,DEG,BACKAZ,T0,DT,
     1 IDATE(1),IDATE(2),IDATE(3)
  310 FORMAT(2I5,A4,1X,A4,1X,5F10.2,3A4)
      DO 312 I=1,M
      K = I * 8
      J = K - 7
  312 WRITE(01,311) NWRITE,(X(L),L=J,K)
  311 FORMAT(I5,8E15.8)
      NWRITE = NWRITE + 1
      RETURN
      END

      SUBROUTINE TREND(X,NPTS,ITREND)
      DIMENSION X(1)
C     ITREND = 1    DC COMPONENT REMOVED
C     ITREND = 2    LINEAR COMPONENT REMOVED
      N1 = NPTS/2
      SUM1 = 0
      SUM2 = 0
      DO 1 I=1,N1
    1 SUM1 = SUM1 + X(I)
      N21 = N1 + 1
      DO 2 I = N21,NPTS
    2 SUM2 = SUM2 + X(I)
      N2 = NPTS - N1
      DC = (SUM1 + SUM2)/NPTS
      IF(ITREND - 1)6,6,7
    6 B = DC
      SLP = 0.0
      GO TO 8
    7 CONTINUE
```

```
      SLP = 2.*((SUM2/N2) - (SUM1/N1))/NPTS
      B = (SUM1/N1) - 0.5*N21*SLP
    8 CONTINUE
      DO 3 I = 1,NPTS
      XI = I
    3 X(I) = X(I) - B - SLP*XI
      WRITE(61,5) DC,SLP
    5 FORMAT(1H ,4HDC = , E11.4,4X,7HSLOPE = , E11.4)
      RETURN
      END

      SUBROUTINE TAPEIN(INDEX,IOTP)
C     INDEX IS TOTAL NUMBER OF SPECTRA TO BE BYPASSED BEFORE WRITING
C     STARTS
      IF(INDEX.LE.0) GO TO 2
      DO 1 I=1,INDEX
      READ(IOTP,10) N
      DO 1 J=1,N
      READ(IOTP,10) ILUM
    1 CONTINUE
    2 RETURN
   10 FORMAT(I5)
      END

      SUBROUTINE INSTRM(X,NN,DF,PEAK,ICONTRL)
C     THIS SUBROUTINE CORRECTS SPECTRA FOR INSTRUMENTAL RESPONSE
      DIMENSION X(1)
C     REDUCED SPECTRA FOR ZERO FREQUENCY
      X(1) = 0.0
      X(2) = 0.0
      NN2 = NN/2
      DO 10 I=2,NN2
      XI = I - 1
      FREQ = XI * DF
      J = 2 * I - 1
      K = 2 * I
      GO TO (1,2,4,4,4,6),ICONTRL
    1 CALL SEISM1(FREQ,PEAK,XR,XI)
      GO TO 7
    2 CALL SEISM2(FREQ,PEAK,XR,XI)
      GO TO 7
    4 CALL SEISM4(FREQ,PEAK,XR,XI)
      GO TO 7
    6 XR = 1.0
      XI = 0.0
    7 CONTINUE
      TEMPR = XR*X(J) - XI*X(K)
      TEMPI = XR*X(K) + XI*X(J)
      X(J) = TEMPR
   10 X(K) = TEMPI
```

```
      RETURN
      END

      SUBROUTINE SEISM1(FREQ,PEAK,XR,XI)
C     15-100 SYSTEM
C     WWSSN INSTRUMENT CONSTANTS FROM U. CHANDRA, BSSA 1970 VOL 60
C     PP 539-563
C     PEAK MAGNIFICATIONS ARE 350,700,1400,2800,5600
      IF(FREQ.GT.1.0) FREQ = 1.0
      IF(FREQ.LT.0.00005) FREQ = 0.00005
      WE = 6.28318530*FREQ
      INDEX = (PEAK+1.)/375.
      GO TO (1,2,2,3,3,3,3,4,4,4,4,4,4,4,4,5),INDEX
    1 FMAG = 275.
      SIGMA = 0.003
      GO TO 6
    2 FMAG = 556.
      SIGMA = 0.013
      GO TO 6
    3 FMAG = 1110.
      SIGMA = 0.047
      GO TO 6
    4 FMAG = 2190.
      SIGMA = 0.204
      GO TO 6
    5 FMAG = 3950.
      SIGMA = 0.805
    6 ZETA = 0.93
      ZETA1=1.
      WN=.4188790
      WN1 = .06283185
      AR= (WE*WE-WN*WN)*(WE*WE-WN1*WN1)-4.*ZETA*ZETA1*WN*WN1*(1.-SIGMA)
     1*WE*WE
            AI=2.*WE*(ZETA1*WN1*(WN*WN-WE*WE)+ZETA*WN*(WN1*WN1-WE*WE))
      FACTOR = 1./(FMAG*WE*WE*WE)
      XR = -AI * FACTOR
      XI = AR * FACTOR
      RETURN
      END

      SUBROUTINE SEISM2(FREQ,PEAK,XR,XI)
C     30-100 SYSTEM
C     WWSSN INSTRUMENT CONSTANTS FROM U. CHANDRA, BSSA 1970 VOL 60
C     PP 539-563
      IF(FREQ.GT.1.0) FREQ = 1.0
      IF(FREQ.LT.0.005) FREQ = 0.005
      WE = 6.28318530*FREQ
      INDEX = (PEAK+1.)/375.
      GO TO (1,2,2,3,3,3,3,4,4,4,4,4,4,4,4,5),INDEX
    1 FMAG = 251.9
```

```
      SIGMA = 0.003
      GO TO 6
    2 FMAG = 503.1
      SIGMA = 0.012
      GO TO 6
    3 FMAG = 1001.5
      SIGMA = 0.044
      GO TO 6
    4 FMAG = 1941.9
      SIGMA = 0.195
      GO TO 6
    5 FMAG = 2241.8
      SIGMA = 0.767
      GO TO 6
    6 ZETA = 1.5
      ZETA1 = 1.
      WN = 0.2094395
      WN1 = 0.06283853
      AR= (WE*WE-WN*WN)*(WE*WE-WN1*WN1)-4.*ZETA*ZETA1*WN*WN1*(1.-SIGMA)
     1*WE*WE
            AI=2.*WE*(ZETA1*WN1*(WN*WN-WE*WE)+ZETA*WN*(WN1*WN1-WE*WE))
      FACTOR = 1./(FMAG*WE*WE*WE)
      XR = - AI * FACTOR
      XI = AR * FACTOR
      RETURN
      END

      SUBROUTINE SEISM4(FREQ,PEAK,XR,XI)
C     MAGNIFICATION OF TABULATED SYSTEMS.  PHASE RESPONSE NOT INCLUDED
C     TABULATED PERIODS MUST BE LISTED IN ORDER OF INCREASING PERIOD
C     N = NUMBER OF PERIOD-RESPONSE PAIRS
C     N = NEGATIVE  VELOCITY SENSITIVITY READ IN AND CONVERTED TO
C     DISPLACEMENT SENSITIVITY
C     N = POSITIVE  DISPLACEMENT SENSITIVITY IS READ IN
      COMMON/INST/MAGIN,M,PER(100),RESP(100)
      IF(MAGIN.NE.0) GO TO 100
      READ(60,1) N
      M = IABS(N)
      READ(60,2) ((PER(I),RESP(I)),I=1,M)
    1 FORMAT(I5)
    2 FORMAT(8F10.5)
      IF(N.LT.0) WRITE(61,300)
      IF(N.GT.0) WRITE(61,301)
      WRITE(61,302)
      WRITE(61,303) ((PER(I),RESP(I)),I=1,M)
  300 FORMAT(1H0,20HVELOCITY SENSITIVITY       )
  301 FORMAT(1H0,24HDISPLACEMENT SENSITIVITY   )
  302 FORMAT(1H ,7X,3HPER,8X,4HRESP,4(9X,3HPER,8X,4HRESP) / )
  303 FORMAT(1H ,10F12.2)
      IF(N) 3,4,4
```

```
    3 DO 5 I=1,M
C     CONVERSION FROM VELOCITY SENSITIVITY TO DISPLACEMENT SENSITIVITY
    5 RESP(I) =  RESP(I) * 6.2831853/PER(I)
    4 CONTINUE
      MAGN = 1
  100 CONTINUE
      IF(FREQ.LT.0.005) FREQ = 0.005
      T = 1./FREQ
      IF(T.LE.PER(1)) T = PER(1)
      IF(T.GE.PER(M)) T = PER(M)
      DO 200 I=1,M
      IF(T.GE.PER(I).AND.T.LE.PER(I+1)) GO TO 160
  200 CONTINUE
  160 XR = RESP(I) +  (RESP(I+1)-RESP(I))/(PER(I+1)-PER(I))*(T-PER(I))
      XR = 1./XR
      XI = 0
      RETURN
      END

      SUBROUTINE PHASE(X,Y,PHI)
C     ARGUMENT PHI IS RETURNED AS VARYING FROM 0.0 TO 1.0 CIRCLES
      IF(X) 21,20,22
   20 IF(Y) 23,24,25
   23 PHI = 1.5* 3.14159?7
      GO TO 26
   24 PHI = 0.0
      GO TO 28
   25 PHI = 0.5 * 3.1415927
      GO TO 28
   21 PHI = ATAN(Y/X) + 3.1415927
      GO TO 26
   22 IF(Y) 26,27,27
   27 PHI = ATAN(Y/X)
      GO TO 28
   26 PHI = ATAN(Y/X) + 2.0 * 3.1415927
      GO TO 28
   28 CONTINUE
      PHI = PHI/6.2831854
      PHI = PHI - AINT(PHI)
      RETURN
      END

      SUBROUTINE PRIN(X,M,STA,COMP,DIST,DEG,BACKAZ,TO,DT,IDATE)
      CHARACTER STA,COMP,IDATE
      DIMENSION X(1),IDATE(3),T(48)
      DATA T/.1,.2,.3,.4,.5,.6,.7,.8,.9,1.,1.1,1.2,1.3,1.4,1.5,1.6,1.7,
     1 1.8,1.9,2.,2.5,3.,3.5,4.,5.0,6.,7.,8.,9.,10.,12.,14.,16.,18.,20.,
     2 22.,24.,26.,28.,30.,35.,40.,50.,60.,70.,80.,90.,100./
  100 FORMAT(1H ,4(9X,E11.4))
      WRITE(61,99) STA,COMP,IDATE(1),IDATE(2),IDATE(3)
```

```
   99 FORMAT(1H0,A4,2X,A4,2X,3A4)
      WRITE(61,98)
   98 FORMAT(1H0,11X,6HPERIOD,13X,9HFREQUENCY,11X,9HAMPLITUDE,13X,
     1 5HPHASE, /)
      K = 48
      DO 10 I = 3,M
      PER1 = 2.*M*DT/(I-1)
      PER2 = 2.*M*DT/I
      FREQ = 1./PER1
      DO 15 J=1,K
      IF(PER1.GT.T(J).AND.PER2.LE.T(J)) GO TO 16
   15 CONTINUE
      GO TO 17
   16 K = J
      II = 2 * I
      III= II -1
      AMP = SQRT(X(II)*X(II) + X(III)*X(III))
      CALL PHASE(X(III),X(II),PHI)
      PHI = PHI - T0 * FREQ
      PHI = PHI - AINT(PHI)
      IF(PHI.LT.0) PHI = PHI + 1.0
      WRITE(61,100) PER1,FREQ,AMP,PHI
   17 CONTINUE
   10 CONTINUE
      RETURN
      END

      SUBROUTINE CARDIN(DUMMY,NPTS,INTYP,DPM,DT,TMAX)
      COMMON/DTA/X(4096),Y(4096)
      DIMENSION DUMMY(1)
      DIMENSION XJUMP(10)
      XJUMP(1) = 0.
      XJUMP(2) = 10000.
      XJUMP(3) = 20000.
      XJUMP(4) = 30000.
      XJUMP(5) = 40000.
      XJUMP(6) = 50000.
      XJUMP(7) = 60000.
      XJUMP(8) = 70000.
      XJUMP(9) = 80000.
      XJUMP(10) = 90000.
      IF(INTYP.EQ.2) GO TO 2
      DO 910 I = 1,4096,12
      J = I + 11
      READ(60,911)  (DUMMY(K),K=I,J)
      WRITE(61,919) (DUMMY(K),K=I,J)
  919 FORMAT(1H ,12(F6.0,1X))
  911 FORMAT(12(F5.0,1X))
      DO 910 K = I , J
      IF(DUMMY(K)-9999.) 910,912,912
```

```
  910 CONTINUE
  912 NPTS = K - 1
      WRITE(61,909) NPTS
  909 FORMAT(1H ,6HNPTS = , I5)
      RETURN
    2 CONTINUE
      CPS = CPM/60.
      DO 110 I = 1,4096,8
      J = I + 7
      READ(60,111) ((X(K),Y(K)),K=I,J)
      WRITE(61,112)((X(K),Y(K)),K=I,J)
  111 FORMAT(16F5.0)
  112 FORMAT(1H ,16F7.0)
      DO 110 K = I,J
      IF(X(K)+9999.) 115,115,110
  110 CONTINUE
  115 NUM = K - 1
      WRITE(61,907) NUM
  907 FORMAT(1H ,6H NUM =  , I5)
      JUMP = 1
      DO 200 I = 2,NUM
      G = X(I) + XJUMP(JUMP)
      IF(ABS(G - X(I-1)).GT.9000.) JUMP = JUMP + 1
      X(I) = X(I) + XJUMP(JUMP)
  200 CONTINUE
      WRITE(61,908) JUMP
  908 FORMAT(1H , 6HJUMP =  ,I5)
      TIME1 = 0.0
      NPTS = 1
      DO 300 I = 2,NUM
  305 CONTINUE
      TIME = TIME1 * CPS
      JUMP = 1
      IF(TIME.LT.X(I).AND.TIME.GE.X(I-1)) JUMP = 2
      GO TO (301,302),JUMP
  302 DUMMY(NPTS) = Y(I) + (TIME-X(I))*((Y(I)-Y(I-1))/(X(I)-X(I-1)))
      NPTS = NPTS + 1
      TIME1 = TIME1 + DT
      IF(TIME1.GT.TMAX) GO TO 500
      GO TO 305
  301 CONTINUE
  300 CONTINUE
  500 NPTS = NPTS - 1
      WRITE(61,909) NPTS
      RETURN
      END

      SUBROUTINE FOUR2(DATA,NN,IDUM,ISIGN)
C     THE COOLEY-TOOKEY FAST FOURIER TRANSFORM IN USASI BASIC FORTRAN
C     TRANSFORM(J) = SUM(DATA(I)*W**((I-1)(J-1)), WHERE I AND J RUN
```

```
C       FROM 1 TO NN AND W = EXP(ISIGN*2*PI*SQRT(-1)/NN).  DATA IS A ONE-
C       DIMENSIONAL COMPLEX ARRAY (I.E., THE REAL AND IMAGINARY PARTS OF
C       DATA ARE LOCATED IMMEDIATELY ADJACENT IN STORAGE, SUCH AS
C       FORTRAN IV PLACES THEM) WHOSE LENGTH NN IS A POWER OF TWO.  ISIGN
C       IS +1 OR -1, GIVING THE SIGN OF THE TRANSFORM.  TRANSFORM VALUES
C       ARE RETURNED IN ARRAY DATA, REPLACING THE INPUT DATA.  THE TIME IS
C       PROPORTIONAL TO N*LOG2(N), RATHER THAN THE USUAL N**2
C       RMS RESOLUTION ERROR BEING BOUNDED BY 6*SQRT(I)*LOG2(NN)*2**(-B),
C       WHERE B IS THE NUMBER OF BITS IN THE FLOATING POINT FRACTION.
C       PROGRAM AUTOMATICALLY DIVIDES TRANSFORM BY NN FOR INVERSE
C       TRANSFORM
        DIMENSION DATA(1)
        N = 2 * NN
        IF(ISIGN.EQ.-1) GO TO 1002
        DO 1001 IIII = 1,N
 1001   DATA(IIII) = DATA(IIII)/NN
 1002   CONTINUE
        J = 1
        DO 5 I=1,N,2
        IF(I-J)1,2,2
    1   TEMPR = DATA(J)
        TEMPI = DATA(J+1)
        DATA(J) = DATA(I)
        DATA(J+1)=DATA(I+1)
        DATA(I) = TEMPR
        DATA(I+1) = TEMPI
    2   M = N/2
    3   IF(J-M) 5,5,4
    4   J = J-M
        M = M/2
        IF(M-2) 5,3,3
    5   J=J+M
        MMAX = 2
    6   IF(MMAX-N)7,10,10
    7   ISTEP= 2 *MMAX
        THETA = 6.28318307/FLOAT(ISIGN*MMAX)
        SINTH=SIN(THETA/2.)
        WSTPR=-2.*SINTH*SINTH
        WSTPI=SIN(THETA)
        WR=1.0
        WI=0.0
        DO 9 M=1,MMAX,2
        DO 8 I=M,N,ISTEP
        J=I+MMAX
        TEMPR=WR*DATA(J)-WI*DATA(J+1)
        TEMPI=WR*DATA(J+1)+WI*DATA(J)
        DATA(J)=DATA(I)-TEMPR
        DATA(J+1)=DATA(I+1)-TEMPI
        DATA(I)=DATA(I)+TEMPR
    8   DATA(I+1) = DATA(I+1)+TEMPI
```

```
      TEMPR = WR
      WR = WR*WSTPR-WI*WSTPI + WR
    9 WI = WI*WSTPR+TEMPR*WSTPI + WI
      MMAX = ISTEP
      GO TO 6
   10 RETURN
      END
```

```
    1
    0
    4    1    1   -1    2    2

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 0174 0378 0194-0733 0211 0412 0219 0266 0224 0200 0227 0188 0244-0741 0263 08
 0286-0704 0301 0286 0312-0336 0326 0980 0342-1237 0356 1046 0378-1335 0389 02
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 4450 0003 4454 0015 4470 0120 4482-0061 4495 0021 4507-0129 4526 0242 4547-01
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6650 0135 6680 0001 6696 0157 6720 0030 6739 0006 6751 0025 6764 0039 6767 00
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0.4       3250.     0.5       3750.     0.6       4200.     0.7       4500.
0.8       4700.     0.9       4800.     1.0       4850.     1.3       4800.
1.5       4600.     1.7       4250.     1.8       4050.     2.0       3350.
3.0       1400.     4.0       740.      5.0       540.
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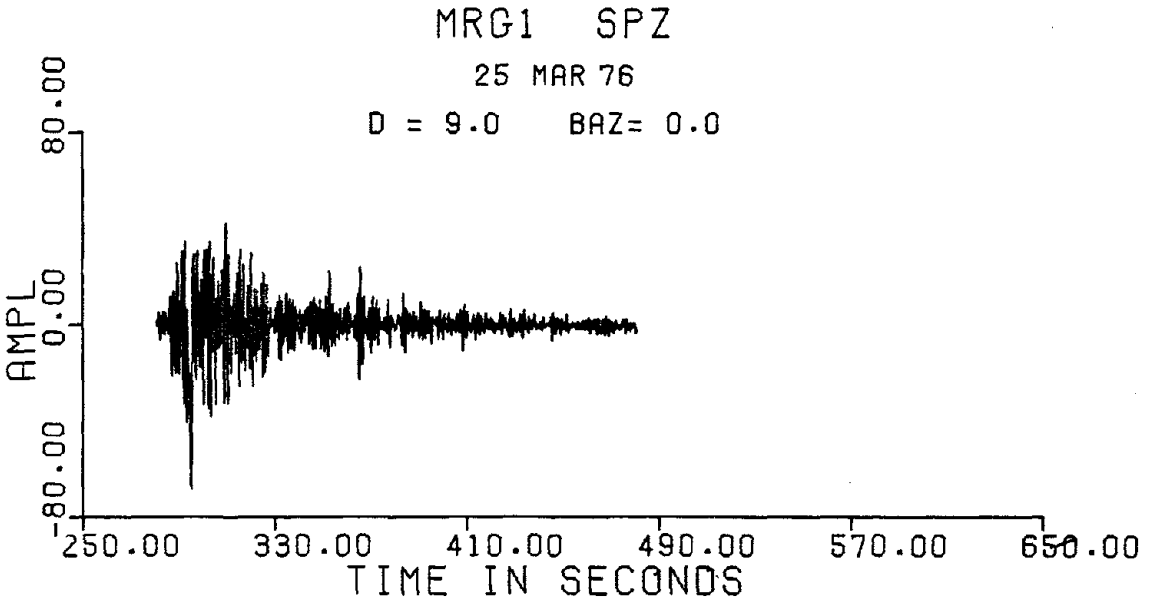
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25 MAR 76
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AMPL
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330.00
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490.00
570.00
650.00
TIME IN SECONDS

4 1 1 -1 2 2

STA	COMP	DIST KM	DEG	BACKAZ	TO	DT	CPMR	PEAKMAG
MRG1	SPZ	1028.50	9.00	0.	280.8	0.100	30.68	0.

DATE	SLOPE	TMAX	CPM
25 MAR 76	0.	200.00	1841.00

0.	0.	14.	-70.	0.	98.	12.	-64.	26.	141.	42.	-249.	56.	91.	76.	-129.
86.	122.	98.	-165.	111.	184.	126.	-66.	136.	46.	148.	-149.	158.	22.	162.	54.
174.	378.	194.	-733.	213.	412.	219.	266.	224.	200.	227.	188.	244.	-741.	263.	823.
286.	-704.	301.	286.	312.	-336.	326.	980.	342.	-1237.	356.	1046.	378.	-1335.	389.	205.
404.	-680.	416.	-680.	442.	-2144.	455.	685.	460.	658.	470.	893.	488.	-652.	492.	-630.
500.	-750.	514.	1015.	534.	-326.	539.	-370.	546.	-578.	558.	160.	561.	175.	572.	594.
591.	-1230.	605.	1004.	621.	-297.	640.	1067.	652.	-1304.	671.	1208.	686.	-1459.	697.	704.
711.	-439.	728.	907.	749.	-1083.	759.	448.	772.	-434.	787.	642.	802.	-367.	810.	-165.
814.	-80.	835.	686.	854.	-1111.	878.	1334.	904.	-1210.	914.	904.	926.	160.	933.	322.
949.	-701.	962.	288.	974.	-230.	986.	451.	1002.	-458.	1009.	-139.	1015.	-164.	1029.	703.
1047.	-868.	1064.	1006.	1086.	-515.	1092.	-480.	1098.	-515.	1112.	893.	1132.	-612.	1142.	110.
1154.	-336.	1169.	488.	1188.	-612.	1205.	974.	1227.	-814.	1252.	453.	1274.	-512.	1290.	522.
1308.	-392.	1315.	-216.	1324.	-88.	1327.	-54.	1338.	532.	1353.	-696.	1367.	759.	1388.	-700.
1408.	523.	1430.	-418.	1449.	-9.	1446.	45.	1460.	246.	1473.	-41.	1487.	58.	1505.	-136.
1505.	-132.	1522.	216.	1534.	-183.	1546.	308.	1562.	-456.	1570.	434.	1587.	-498.	1603.	370.
1619.	-254.	1632.	-120.	1638.	-85.	1654.	394.	1676.	-398.	1696.	349.	1716.	-360.	1741.	355.
1756.	-387.	1781.	266.	1799.	-78.	1801.	-15.	1817.	-200.	1831.	218.	1846.	-276.	1862.	143.
1871.	-51.	1880.	-24.	1894.	-183.	1906.	190.	1915.	-22.	1929.	244.	1944.	-289.	1967.	299.
1974.	182.	1991.	-339.	2012.	302.	2027.	-367.	2042.	287.	2052.	32.	2056.	11.	2060.	38.
2071.	-156.	2086.	347.	2098.	-340.	2122.	231.	2143.	-380.	2162.	400.	2181.	-338.	2187.	-442.
2209.	690.	2225.	-154.	2239.	-380.	2255.	291.	2274.	-287.	2289.	113.	2291.	135.	2298.	169.
2310.	97.	2308.	75.	2322.	-204.	2328.	-88.	2344.	212.	2352.	80.	2361.	-77.	2372.	-136.
2382.	-84.	2389.	-40.	2404.	248.	2425.	-222.	2428.	-197.	2447.	322.	2462.	-153.	2477.	167.
2486.	-48.	2500.	44.	2504.	44.	2505.	33.	2517.	-187.	2533.	145.	2550.	-216.	2568.	412.
2583.	-743.	2601.	799.	2625.	-570.	2646.	380.	2652.	338.	2663.	-69.	2669.	-116.	2679.	47.
2693.	-222.	2710.	237.	2719.	188.	2735.	-398.	2758.	387.	2778.	-224.	2790.	-50.	2791.	-39.
2807.	326.	2825.	-292.	2841.	246.	2859.	-64.	2864.	-22.	2877.	44.	2892.	-85.	2910.	114.
2923.	-56.	2932.	-88.	2939.	-116.	2957.	364.	2980.	-301.	2998.	148.	3004.	122.	3012.	88.
3019.	94.	3027.	48.	3036.	35.	3044.	-70.	3052.	-50.	3060.	-61.	3074.	16.	3075.	10.
3097.	134.	3104.	141.	3110.	-22.	3122.	48.	3136.	-256.	3158.	441.	3174.	-400.	3195.	248.
3218.	-117.	3238.	169.	3246.	76.	3258.	20.	3268.	-156.	3290.	199.	3304.	-75.	3322.	132.
3332.	18.	3340.	-4.	3351.	-188.	3382.	316.	3398.	-210.	3422.	234.	3438.	-192.	3458.	203.
3472.	-116.	3488.	219.	3507.	-228.	3529.	130.	3540.	44.	3551.	76.	3560.	37.	3564.	30.
3578.	126.	3595.	-186.	3629.	221.	3640.	-69.	3643.	10.	3660.	-188.	3663.	-48.	3679.	165.
3696.	-31.	3716.	-71.	3738.	183.	3763.	-127.	3787.	101.	3801.	-14.	3808.	22.	3821.	-95.
3824.	-56.	3846.	181.	3862.	-88.	3879.	98.	3879.	99.	3890.	240.	3912.	-317.	3937.	294.
3958.	-153.	3978.	222.	3999.	-40.	4011.	-61.	4017.	-76.	4037.	75.	4041.	71.	4054.	167.
4075.	-180.	4090.	51.	4099.	85.	4110.	197.	4123.	-81.	4132.	-107.	4152.	155.	4168.	-13.
4170.	-23.	4181.	-75.	4184.	-76.	4192.	-82.	4204.	97.	4207.	116.	4216.	181.	4237.	-23.
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4450.	3.	4454.	15.	4470.	120.	4482.	-61.	4495.	21.	4507.	-129.	4526.	242.	4547.	-125.
4564.	83.	4577.	117.	4596.	-85.	4610.	29.	4623.	73.	4637.	-62.	4651.	182.	4674.	-158.
4677.	-129.	4696.	247.	4719.	-22.	4735.	58.	4747.	-72.	4763.	154.	4779.	-12.	4784.	-7.
4792.	-85.	4808.	89.	4817.	18.	4830.	183.	4846.	-30.	4862.	55.	4869.	11.	4878.	-5.
4881.	-1.	4883.	-9.	4887.	-14.	4910.	84.	4926.	-97.	4934.	38.	4950.	144.	4962.	2.
4970.	14.	4975.	11.	4990.	41.	4995.	51.	5009.	55.	5010.	39.	5022.	11.	5030.	29.
5045.	148.	5056.	-172.	5076.	223.	5100.	-81.	5108.	-37.	5112.	-31.	5131.	147.	5148.	51.
5151.	45.	5165.	-97.	5185.	129.	5204.	-14.	5221.	71.	5232.	-37.	5247.	182.	5263.	-67.
5284.	53.	5289.	41.	5297.	49.	5309.	7.	5328.	89.	5329.	94.	5348.	9.	5354.	49.
5368.	-22.	5388.	92.	5403.	1.	5422.	54.	5438.	-15.	5457.	111.	5481.	-17.	5480.	-20.
5494.	113.	5507.	-13.	5531.	191.	5541.	-49.	5547.	-63.	5556.	4.	5578.	103.	5593.	-9.
5610.	129.	5629.	-81.	5651.	152.	5662.	12.	5665.	-35.	5681.	-59.	5688.	-31.	5698.	10.
5711.	132.	5731.	-81.	5735.	-69.	5753.	167.	5777.	-93.	5794.	118.	5799.	104.	5812.	-31.

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 5822.    107.   5840.    -64.   5864.     93.   5861.     51.   5876.    110.   5886.     57.   5901.     -7.   5908.     -1.
 5917.     50.   5929.     -1.   5941.     10.   5944.      3.   5963.    127.   5973.    113.   5978.    110.   5996.    -57.
 6009.    146.   6026.     29.   6034.     27.   6050.    -80.   6060.     89.   6075.     19.   6085.     89.   6096.     37.
 6106.     78.   6126.    -55.   6149.     71.   6152.     87.   6163.    157.   6183.      0.   6187.    -17.   6203.    -24.
 6200.    -18.   6209.     64.   6222.     85.   6235.     40.   6241.     23.   6248.     17.   6253.      1.   6272.    105.
 6282.     35.   6296.     -4.   6306.     27.   6316.     81.   6339.    -41.   6358.     97.   6371.     66.   6384.     35.
 6399.     47.   6414.      5.   6427.    -26.   6445.    133.   6463.    -95.   6484.    168.   6507.    -95.   6525.    207.
 6543.   -191.   6562.    161.   6579.     23.   6589.    190.   6610.    -89.   6620.    -21.   6633.     63.   6634.     69.
 6650.    135.   6680.      1.   6696.    157.   6720.     30.   6739.      6.   6751.     25.   6764.     39.   6767.     39.
 6781.     35.   6782.     39.   6807.     82.   6821.     17.   6847.     40.   6853.     22.   6857.     30.   6870.     -1.
 6896.     96.   6910.    -20.   6931.     86.   6941.     76.   6956.     11.   6963.     27.   6975.    -19.   6989.     83.
 7000.     60.   7009.     79.   7029.    -27.   7046.    154.   7068.    -19.   7083.     35.   7099.    160.   7116.    -60.
 7134.     78.   7137.     83.   7159.     37.   7168.     61.   7182.     66.   7197.    -17.   7222.     82.   7241.    -15.
 7255.     61.   7278.     53.   7291.    -22.   7313.     67.   7324.      5.   7338.     45.   7353.     58.   7373.    -23.
 7391.     59.   7405.      4.   7419.     59.   7429.     57.   7442.    -14.   7456.     44.   7479.     60.   7496.    -43.
 7513.     95.   7533.     47.   7541.     30.   7559.     49.   7571.     74.   7578.     75.   7589.     87.   7602.     21.
 7617.     43.   7635.    -29.  -9999.  -9999.      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
 NUM =  562
JUMP =    1
NPTS = 2000
DC = 0.2442E 00    SLOPE = 0.1524E-02

DISPLACEMENT SENSITIVITY
        PER        RESP          PER        RESP          PER        RESP          PER        RESP          PER        RESP
       0.09     5000.00         0.10      925.00         0.20     1775.00         0.30     2600.00         0.40     3250.00
       0.50     3750.00         0.60     4200.00         0.70     4500.00         0.80     4700.00         0.90     4800.00
       1.00     4850.00         1.30     4800.00         1.50     4600.00         1.70     4250.00         1.80     4050.00
       2.00     3350.00         3.00     1400.00         4.00      740.00         5.00      500.00
-10    0    0    0    0    0

          START =    1     ,   END =     1
```

III. DATAPLT

PROGRAMMERS: R. B. HERRMANN, T. J. BENNETT / Jul 72

PURPOSE:

This program takes the spectra written on tape by EXSPEC or some other program, and plots it on log-log paper, 3 cycles per axis of approximately 2.5 inches per cycle. The scale is the same as that of K & E 3 x 3 log-log paper. The period axis is scaled from the maximum period present in the data or from a maximum period specified by the card input. The amplitude is scaled to fit on 3 cycles of log paper and is scaled from the largest value. Amplitudes which are less than 3 orders of magnitude less than the maximum value are not plotted.

INPUT/OUTPUT

Two files are required. One for the input of the raw spectra FILE 01, the other for the CALCOMP plot FILE 10. Cards are read in to control the process from FILE 60. Printed output is on FILE 61.

PROGRAM UNITS

PROGRAM DATAPLT: This is the main control link. Amplitude scaling and plotting specification are performed.

SUBROUTINE AMAXMIN: This subroutine converts amplitude spectral density values to logarithms and locates the extremal values. It also takes the logarithms of the periods and finds the extremal values of the periods.

SUBROUTINE ALOGAXES: This is a general subroutine developed by T. J. Bennett for setting up linear, semi-logarithmic, or log-log axes scales.

SUBROUTINE TAPEIN: This subroutine skips a total of INDEX spectra on the tape containing the spectra.

SUBROUTINE TAPERD: This subroutine reads in the spectra contained on the input tape. The amplitude spectral densities are formed, an array of periods corresponding to the spectral amplitudes is also formed. Amplitude spectral density values corresponding to the periods of infinity and 2 M DT are dropped from the amplitude array. This is done because the resultant plot is to be on log-log paper.

Card Sequence	Column	Name	Format	Explanation
A.	1-5	INDEX	I5	LT.0 end program GE.0 number of spectra sets on data tape to be skipped. Can be zero.
	6-10	NDSET	I5	Number of sets of spectra on data tape to be plotted after the skipping process is completed.
	11-20	TMAX	F10.5	LE.0, the data itself sets the scale of the period axis. GT.0 no spectral amplitudes with periods greater than TMAX are plotted.
	21-30	SIZE	F10.5	A number between zero and 1.0 which scales resulting plot. If SIZE = 1.0 each cycle is 2.5 inches long. If SIZE = 0.4, each cycle is 1.0 inches long, etc. If SIZE .LE.0 or SIZE .GE.1.0, SIZE is set equal to 1.0
	31-35	ISKP	I5	A parameter to save CALCOMP time. Only every ISKP'th spectral point is plotted. If ISKP . LE.0, program internally sets ISKP =2, in which case every other spectral point is plotted.

After the above plotting operations are completed, the program reads another control card until it finds one with INDEX .LT. 0.

```
C       PROGRAM DATAPLT
        CHARACTER LABLE,LABEL,MODEL
        COMMON/DTA/X,Y,NP,MODEL
        COMMON/SKIP/ISKP
        DIMENSION X(2060),Y(2060),IBUF(1026),LABEL(3),LABLE(3)
        DIMENSION MODEL(5)
        CALL PLOTS(IBUF,1026,10)
        CALL PLOT(0.0,-11.0,-3)
        CALL PLOT(0.0,2.0,-3)
        LABEL(1)=6HPERIOD
        LABEL(2)=6H (SEC)
        LABLE(1)=6HAMP (C
        LABLE(2)=6HM-SEC)
        REWIND 01
 1003   CONTINUE
        READ(60,1) INDEX,NDSET,TMAX,SIZE,ISKP
     1  FORMAT(2I5,2F10.5,I5)
        WRITE(61,2) INDEX,NDSET,TMAX,SIZE,ISKP
     2  FORMAT(1H ,2I5,2F10.3,I5)
C
C       SIZE = CALCOMP SCALING FACTOR
C       SIZE = 1.0    3 CYCLE LOG - LOG 2.5 INCHES PER CYCLE
C       SIZE = 0.4    3 CYCLE LOG - LOG 1.0 INCHES PER CYCLE
C
        IF(SIZE.LE.0.OR.SIZE.GT.1.0) SIZE = 1.0
        CALL FACTOR(SIZE)
        IF(ISKP.LE.0) ISKP=2
C       TO SAVE PLOT TIME EVERY OTHER SPECTRAL POINT IS PLOTTED.
C       TO SAVE MORE TIME, MAKE ISKP.GT.2.
        IF(INDEX.LT.0) GO TO 1061
        CALL TAPEIN(INDEX,01)
        DO 1000 KK=1,NDSET
        CALL TAPERD
C
C       TMAX .LE. 0   PERIOD AXIS IS SCALED FROM THE MAXIMUM SPECTRAL
C                     PERIOD GIVEN BY SUBROUTINE TAPERD
C            .GT. 0   MAXIMUM PERIOD IS TMAX, PERIODS GREATER THAN TMAX ARE
C                     DROPPED
C
        IF(TMAX.LE.0) GO TO 400
        DO 401 I = 1,NP
        J = I
        IF(X(I).LT.TMAX) GO TO 402
  401   CONTINUE
  402   DO 403 I = J,NP
        K = I - J + 1
        Y(K) = Y(I)
  403   X(K) = X(I)
        NP = NP - J + 1
  400   CONTINUE
```

```
      XX = ALOG10(X)
      YY = ALOG10(Y)
      XMIN = XX
      XMAX = XX
      YMIN = YY
      YMAX = YY
      CALL AMAXMIN(X,Y,NP,XMAX,XMIN,YMAX,YMIN,3,3)
C     AMAXMIN FORMS ALOG10 OF X AND Y AND RETURNS AS X AND Y
      XAXLEN = 7.535
      YAXLEN = 7.507
      DELTAX = 3./7.535
      DELTAY = 3./7.507
      SCP = 0.03 * YAXLEN
      TTL = (XAXLEN - SCP*20.)/2.
      LMAX = XMAX
      IF(XMAX-LMAX)100,100,101
  101 LMAX = LMAX + 1
  100 CONTINUE
      LMIN = LMAX - 3
      X1 = LMIN
      DO 105 K = 1,NP
      IF(X(K).LT.X1) X(K) = X1
  105 CONTINUE
      LMAX = YMAX
      IF(YMAX - LMAX) 110,110,111
  111 LMAX = LMAX + 1
  110 CONTINUE
      LMIN = LMAX - 3
      Y1 = LMIN
      DO 115 K = 1,NP
      IF(Y(K).LT.Y1) Y(K) = Y1
  115 CONTINUE
      CALL ALOGAXES(XAXLEN,YAXLEN,3,3,LABEL,LABLE,12,12,X1,Y1,DELTAX,
     1 DELTAY)
      X(NP+1) = X1
      Y(NP+1) = Y1
      X(NP+2) = DELTAX
      Y(NP+2) = DELTAY
      CALL LINE(X,Y,NP,1,0,0)
      CALL SYMBOL(TTL,YAXLEN+0.25,SCP,MODEL(1),0.0,4)
      CALL SYMBOL(TTL+4.*SCP,YAXLEN+0.25,SCP,MODEL(2),0,0,4)
      CALL SYMBOL(TTL+8.*SCP,YAXLEN+0.25,SCP,MODEL(3),0.0,4)
      CALL SYMBOL(TTL+12.*SCP,YAXLEN+0.25,SCP,MODEL(4),0.0,4)
      CALL SYMBOL(TTL+16.*SCP,YAXLEN+0.25,SCP,MODEL(5),0,0,4)
      CALL PLOT(12.0,0.0,-3)
      CALL FACTOR(1.0)
      CALL PLOT(2.0,0.0,-3)
      CALL PLOT(0.0,-11.0,-3)
      CALL PLOT(0.0,2.0,-3)
      CALL FACTOR(SIZE)
```

```
 1000 CONTINUE
      GO TO 1003
 1001 CONTINUE
      CALL PLOT(10.5,0.0,999)
      STOP
      END

      SUBROUTINE TAPERD
      CHARACTER MODEL
      COMMON/DTA/X,Y,NP,MODEL
      COMMON/SKIP/ISKP
      DIMENSION X(2060),Y(2060),MODEL(5),Z(4096)
      READ(01,310) M,NWRITE,MODEL(1),MODEL(2),DIST,DEG,BACKAZ,T0,DT,
     1 MODEL(3),MODEL(4),MODEL(5)
  310 FORMAT(2I5,A4,1X,A4,1X,8F10.2,3A4)
      DO 312 I=1,M
      K = I * 8
      J = K - 7
  312 READ(01,311) NWRITE,(Z(L),L=J,K)
  311 FORMAT(I5,8E15.8)
      M = 4 * M
C     THE PERIODS = INFINITY AND 2.*M*DT ARE DROPPED
      L=0
      DO 3 I=3,M,ISKP
      J = 2 * I
      K = J - 1
      L=L+1
      Y(L) = SQRT(Z(J)*Z(J) + Z(K)*Z(K))
      IF(Y(L).EQ.0.0) Y(L) = 1.0E-38
    3 X(L) = 2.*M*DT/(I-1)
      NP=L
      RETURN
      END

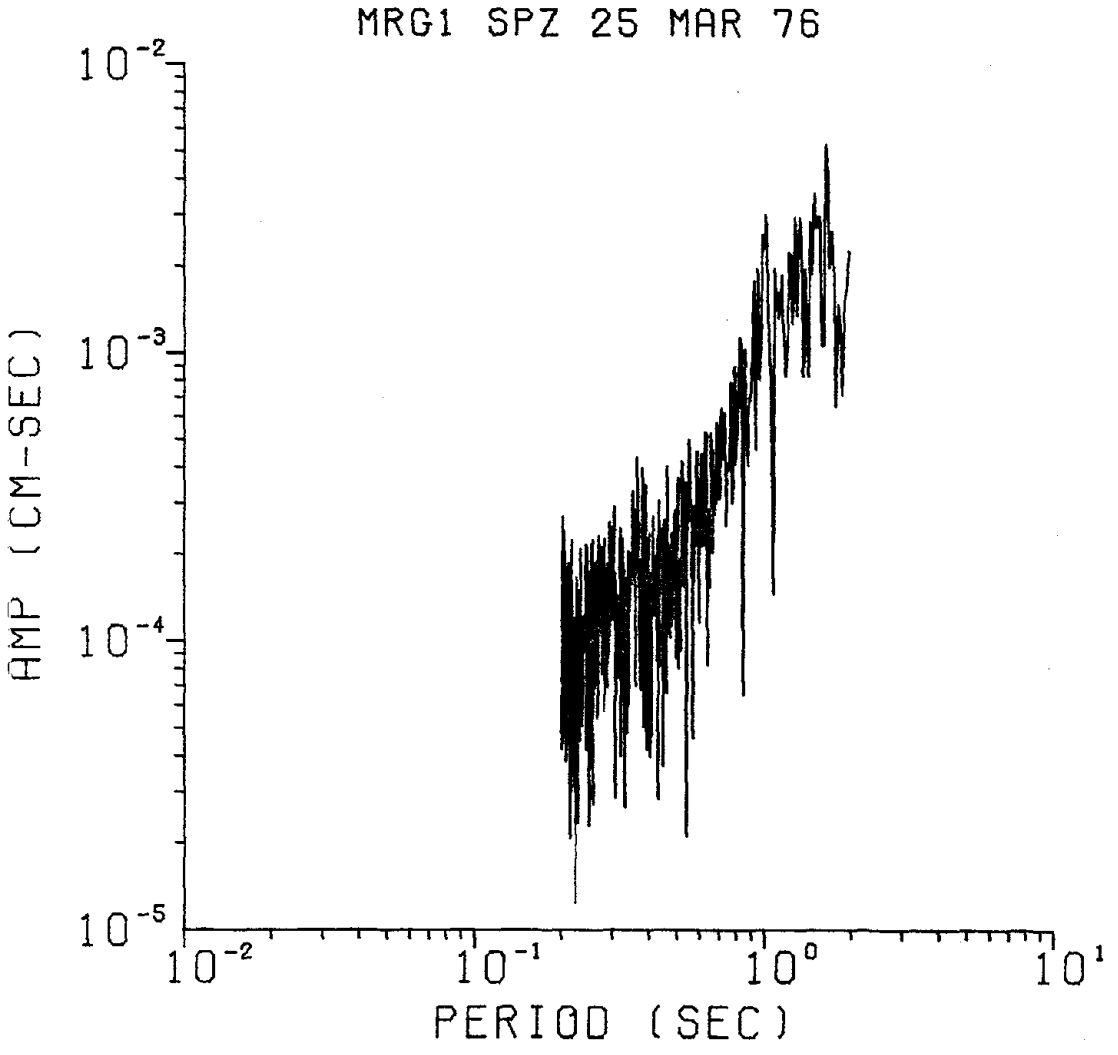
      SUBROUTINE TAPEIN(INDEX,IOTP)
C     INDEX IS THE TOTAL NUMBER OF SPECTRA TO BE BYPASSED BEFORE READING
C     STARTS
      IF(INDEX.LE.0) GO TO 2
      DO 1 I =1,INDEX
      READ(IOTP,10)N
      DO 1 J=1,N
      READ(IOTP,10) IDUM
   10 FORMAT(I5)
    1 CONTINUE
    2 CONTINUE
      RETURN
      END

      SUBROUTINE AMAXMIN(X,Y,NN,XMAX,XMIN,YMAX,YMIN,NOCX,NOCY)
      DIMENSION X(1),Y(1)
```

```
      IF(NOCX.EQ.0) GO TO 102
      DO 101 I = 1,NN
  101 X(I)=ALOG10(X(I))
  102 IF(NOCY.EQ.0) GO TO 104
      DO 103 I = 1,NN
  103 Y(I)=ALOG10(Y(I))
  104 DO 1 I=1,NN
      IF(X(I).GT.XMAX) XMAX = X(I)
      IF(Y(I).GT.YMAX) YMAX = Y(I)
      IF(X(I).LT.XMIN) XMIN = X(I)
      IF(Y(I).LT.YMIN) YMIN = Y(I)
    1 CONTINUE
      RETURN
      END

      SUBROUTINE ALOGAXES(XAXLEN,YAXLEN,NOCX,NOCY,TTLX,TTLY,MTX,MTY,X1,
     1Y1,DELTAX,DELTAY)
      CHARACTER TTLX(1),TTLY(1)
      SLT = 0.02*YAXLEN
      SST = 0.01 * YAXLEN
      SP = -0.06*YAXLEN
      SS = 0.035*YAXLEN
      SSP = SP + SS - 0.06
      TTLP = -0.11*YAXLEN - 0.1
      STTL = 0.035*YAXLEN
      XNUM = 1
      YL = Y1
      YU = Y1 + ANOCY
      IF(ABS(YL).GE.10. .OR. ABS(YU).GE.10. )XNUM = XNUM + 1.
      IF(ABS(YL).GE.100..OR. ABS(YU).GE.100.)XNUM = XNUM + 1.
      IF(Y1.LT.0) XNUM = XNUM + 1.0
      CALL PLOT(-SLT,0.0,2)
      CALL PLOT(0.0,-SLT,3)
      CALL PLOT(0.0,0.0,2)
      XPO = X1
      YPO = Y1
      IF(NOCX.EQ.0) GO TO 4
      ANOCX = NOCX
      FACTX = XAXLEN/ANOCX
      CALL SYMBOL(-.6*SS,SP,SS,2H10,0.0,2)
      CALL NUMBER(999.,SSP,0.5*SS,X1,0.0,-1)
      CALL PLOT(0.0,0.0,3)
      DO 3 J = 1,NOCX
      DO 2 I = 1,10
      X = I
      X = ALOG10(X) *FACTX + (J-1)*FACTX
      IF(I.EQ.1)GO TO 2
      CALL PLOT(X,0.0,2)
      CALL PLOT(X,-SST,2)
    2 CALL PLOT(X,0.0,3)
```

```
      CALL PLOT(X,-SLT,2)
      CALL SYMBOL(X-.6*SS,SP,SS,2H10,0.0,2)
      XPO = XPO + 1.0
      CALL NUMBER(999.,SSP,0.5*SS,XPO,0.0,-1)
    3 CALL PLOT(X,0.0,3)
      XTL = MTX
      XTL = (XAXLEN-XTL*STTL)/2.0
      CALL SYMBOL(XTL,TTLP,STTL,TTLX,0.0,MTX)
      GO TO 6
    4 CALL AXIS(0.0,0.0,TTLX,-MTX,XAXLEN,0.0,X1,DELTAX)
    6 CALL PLOT(0.0,0.0,3)
      IF(NOCY.EQ.0) GO TO 10
      ANOCY = NOCY
      SP = SP - (XNUM - 1.5) * 0.5 * SS
      TTLP = TTLP - (XNUM-1.)*0.5*SS
      FACTY = YAXLEN/ANOCY
      CALL SYMBOL(SP-0.5,-0.5*SS,SS,2H10,0.0,2)
      CALL NUMBER(999.,.5*SS-.06,.5*SS,Y1,0.0,-1)
      CALL PLOT(0.0,0.0,3)
      DO 9 J = 1,NOCY
      DO 8 I = 1,10
      Y = I
      Y = ALOG10(Y) * FACTY + (J-1)*FACTY
      IF(I.EQ.1)GO TO 8
      CALL PLOT(0.0,Y,2)
      CALL PLOT(-SST,Y,2)
    8 CALL PLOT(0.0,Y,3)
      CALL PLOT(-SLT,Y,2)
      CALL SYMBOL(SP-.4,Y-.5*SS,SS,2H10,0.0,2)
      YPO = YPO + 1
      CALL NUMBER(999.,Y+.5*SS-.06,.5*SS,YPO,0.0,-1)
    9 CALL PLOT(0.0,Y,3)
      YTL=MTY
      YTL = (YAXLEN-YTL*STTL)/2.0
      CALL SYMBOL(TTLP-.2,YTL,STTL,TTLY,90.,MTY)
      RETURN
   10 CALL AXIS(0.0,0.0,TTLY,MTY,YAXLEN,90.,Y1,DELTAY)
      RETURN
      END
```


MRG1 SPZ 25 MAR 76
AMP (CM-SEC)
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-2}
10^{-1}
10^{0}
10^{1}
PERIOD (SEC)

IV. FILTER

PROGRAMMER: R. B. HERRMANN / AUG 72

PURPOSE:

This program uses a narrow band-pass filtering technique to determine the spectral amplitudes of individual modes making up a surface wave signal. The Fourier transform of the ground motion is read from the tape or file upon which the transform was placed by the program EXSPEC. A narrow band-pass Gaussian filter acts on the real frequencies of the Fourier transform and the inverse Fourier transform is taken. The envelope of the filtered signal is found by using both the real and imaginary components of the inverse Fourier transform. The envelope is searched for local maxima, which under favorable circumstances reflect the spectral amplitudes of the various modes. The peak of the envelope is multiplied by the theoretical factor $4T_o$, where T_o is the center period of the filter pass-band, so that the result is dimensionally a spectral amplitude. The output is presented on a 3 x 3 log-log plot of spectral amplitude versus period. The information given on the plot is also listed on the printer. Use of the output involves deciding which group velocity corresponds to a particular surface wave mode.

INPUT/OUTPUT

The ground motion spectra are contained on the magnetic tape placed on FILE 01. FILE 10 contains the tape used for the off-line CALCOMP plotter. Tape control data and filter frequencies are read from card from FILE 60. There is printer output on FILE 61.

THEORY

The surface wave seismogram can be represented by the following integral:

$$f(t,r) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega,r) \exp(i\omega t) d\omega$$

$$= \frac{1}{2\pi} \int_{-\infty}^{\infty} \sum_{j=o}^{M} A_j(\omega,r) \exp i(\omega t - k_j r) d\omega$$

where ω is the angular frequency, k_j is the wave number of the j'th mode, A_j is the complex amplitude of the j'th mode, and M+1 is the number of modes present in the signal at a given frequency.

The concept of narrow band-pass filtering is to multiply $F(\omega,r)$ by a Gaussian filter $H(\omega)$ centered at an angular frequency $\omega = \omega_o$, and then to take the inverse Fourier transform to generate a complex time function. The Gaussian filter is defined as

$$H(\omega) = \begin{cases} \exp\ [-\alpha(\omega-\omega_o)^2/\omega_o^2] & |\omega - \omega_o\ | \leq \omega_c \\ 0 & |\omega - \omega_o\ | > \omega_c \end{cases}$$

The resultant filtered time series is

$$g(t,r) = \frac{\omega_o}{2\pi}\sqrt{\frac{\pi}{\alpha}} \sum_{j=o}^{M} A_j(\omega_o,r)\ \exp\ [i(\omega_o t - k_{oj} r)],$$

$$\exp\ [\frac{-\omega_o^2}{4\alpha}\ (t - r/u_{oj})^2]$$

where the subscript j refers to the j'th mode. The zero subscript indicates that the quantity is to be evaluated at the frequency $\omega = \omega_o$, and U_{oj} is the group velocity of the j'th mode at $\omega = \omega_o$. This expression for the filtered signal is valid under the conditions that

$$\omega_c\ \sqrt{\alpha}/\ \omega_o > 2$$

and

$$\frac{\alpha}{\omega_o^2} >> \left|\frac{r}{2}\frac{d^2k}{d\omega_o^2}\right|$$

From these conditions, it is seen that the filter bandwidth ω_c is not a free parameter but is in fact a function of α and ω_o.

The interpretation of the filtered signal is now made. The envelope of the modulus of the complex function $g(t,r)$ will be a series of approximately Gaussian curves which have a maximum amplitude

at the time $t = r / U_{oj}$, as long as two or more modes do not arrive so close together in time that the bell shaped envelopes interfere.

To estimate the region of nodal interference, the duration of the resulting Gaussian envelope for a single mode is defined as the time from peak amplitude of the envelope until it decreases to $\exp(-\pi)$ of the maximum. In terms of α and ω_o,

$$t_d = T_o \sqrt{\frac{\alpha}{\pi}}$$

where T_o is the period corresponding to the angular frequency ω_o. If the maxima of two modes are separated by a time greater than 2 t_d and their individual amplitudes are of the same order of magnitude, then the two modes do not interfere and the group velocity of a mode is determined from the arrival time of the particular envelope maxima and the amplitude spectra of the mode is approximately

$$\left| A_j(\omega_o, r) \right| = T_o \sqrt{\frac{\alpha}{\pi}} \left| g(t,r) \right| \text{ max}$$

When the separation of the mode arrivals is less than 2 t_d, the envelope maximum should not be used for the determination of group velocity or modal amplitude because of modal interference.

In this program $\alpha = 16\pi$, and $\omega_c = 0.25\ \omega_o$.

The printer listing of the output for a given filter period gives the arrival time of the envelope maxima, corresponding group velocity, amplitude spectra, and phase spectra. The phase associated with an envelope maximum may not be very useful since it is not directly related to phase velocity.

REFERENCE

Herrmann, R. B. (1973). Some aspects of band-pass filtering of surface waves, Bull. Seism. Soc. Am. 63, 703-711.

PROGRAM UNITS

PROGRAM FILTER : This is the main control link. It reads in the data, sets up the CALCOMP scaling, and performs the filtering of the ground motion Fourier spectra.

SUBROUTINE MAXVAL : This subroutine, searches through the complex time series generated by the inverse Fourier transform of the filtered spectra. When a maximum of the envelope is found, the group velocity, amplitude spectra, and phase spectra corresponding to the maximum are computed and outputted on tape and printer. The largest amplitude at a given period is flagged by a minus sign in the printer output.

SUBROUTINE TAPEIN : This subroutine is used for skipping through the spectra listed on the input tape of FILE 01 in order to have the tape ready to read the desired spectra.

SUBROUTINE TAPERD : This subroutine reads the spectra from tape together with pertinent header information.

SUB ROUTINE FOUR2 : This subroutine (Brenner, 1967) performs the Fast Fourier Transform. It is used rather than the FOUR2 routine used in EXSPEC and SPSPEC because this version is three times faster.

SUBROUTINE PHASE : This subroutine determines the phase of a complex number and returns the phase in fractions of a circle.

SUBROUTINE ALOGAXES : This subroutine draws the axes for the log-log plot of the spectra.

NOTE: FILTER has been designed to use up to a 4096 point Fast Fourier Transform. The choice of the FFT is dependent on the information on the data tape. If the data tape was written by EXSPEC, up to a 2048 point FFT may be used. If the data tape was written by SPSPEC, up to a 4096 point FFT may be used.

INPUT DATA

Card Sequence	Column	Name	Format	Explanation
A.	1-5	INDEX	I5	Number of spectra on Tape 01 to be skipped before analysis begins
	6-10	NDSET	I5	LE 0 End program GT 0 Number of consecutive data sets to be analyzed.
	11-15	NPER	I5	Number of frequencies at which the analysis will be performed. If negative use previously inputted set of frequencies.
	21-30	SIZE	F10.5	CALCOMP scale factor. 0 <SIZE $\leq$ 1.0. SIZE = 1.0 gives 2.5 inches per cycle of the log-log plot. A value of SIZE outside the range above yield a default value of SIZE = 1.0.
B.	WN(J),J=1 , NPER		8F10.5	Set of filter center frequencies in Hz.

The program performs the desired filtering and returns to the first card. By use of the options, the proper spectra can be selected from tape by skipping over undesired spectra to reach the correct one.

For example,assume that the sequence of spectra on tape is SLM UZ, SLM UT, SLM UR, FLO UT, FLO UR. Then if only the vertical and tangential spectra are desired at 3 periods of 4, 5 and 10 seconds, the control cards would be

```
    0    1    1    2    2    3
....5....0....5....0....5....0
```

```
    0    2    3         1.0
    .25       .2         .1
    1    1   -1
    0   -1
```

```
C       PROGRAM FILTER
C       THIS PROGRAM PERFORMS MULTIPLE FILTER ANALYSIS ON STORED SPECTRUM
        CHARACTER LABEL,LABLE,MODEL
        COMMON/ONE/SAVE,NP,MODEL(5),DIST,DEG,BACKAZ,TC,DT,NPTS
        COMMON/TWO/LABEL(3),LABLE(3),X1,Y1,DELTAX,DELTAY,IBUF(1026),X
        DIMENSION DATA(2,4096),SAVE(2,2048),WN(100)
        CALL PLOTS(IBUF,1026,10)
        CALL PLOT(0.0,-11.0,-3)
        CALL PLOT(0.0,2.0,-3)
        LABEL(1)=6HPERIOD
        LABEL(2)=6H (SEC)
        LABLE(1)=6HAMP (C
        LABLE(2)=6HM-SEC)
        XAXLEN = 7.535
        YAXLEN = 7.507
        DELTAX = 3./7.535
        DELTAY= 3./7.507
        REWIND 1
 1003   CONTINUE
        READ(60,1) INDEX,NDSET,NPER,SIZE
        IF(SIZE.LE.0.OR.SIZE.GT.1.0) SIZE = 1.0
        CALL FACTOR(SIZE)
C
C       SIZE = CALCOMP SCALING FACTOR
C       SIZE = 1.0    3 CYCLE LOG - LOG 2.5 INCHES PER CYCLE
C       SIZE = 0.4    3 CYCLE LOG - LOG 1.0 INCHES PER CYCLE
C
        IF(NDSET.LE.0) GO TO 1004
        IF(NPER.LE.0) GO TO 1005
        NSAVE = NPER
        READ(60,2) (WN(J),J=1,NPER)
      1 FORMAT(3I5,5X,F10.5)
      2 FORMAT(8F10.5)
        WMAX = 0.
        WMIN = 100.
        DO 800 J=1,NPER
        IF(WN(J).LT.WMIN) WMIN = WN(J)
        IF(WN(J).GT.WMAX) WMAX = WN(J)
  800   CONTINUE
        TMIN = 1./WMAX
        TMIN = ALOG10(TMIN)
        LMIN = TMIN
        X1 = LMIN
        IF(TMIN.LT.0.0) X1 = X1 - 1.
 1005   CONTINUE
        NPER = NSAVE
        CALL TAPEIN(INDEX,1)
        DO 1000 NN=1,NDSET
        CALL TAPERD
        MM = 2 * NP
```

```
      MM2 = 2 * MM
      WRITE(61,4) (MODEL(I),I=1,5),DIST,DEG,BACKAZ
    4 FORMAT(1H1,5A4,5X,F10.2,5H KM  ,F10.2,5H DEG  ,F10.2,9H DEG(BAZ)
     1 ,/)
C     VERTICAL SCALING  DETERMINED BY SPECTRA IN FREQUENCY RANGE
C     CONSIDERED
      YMAX = 1.0E-38
      DDF = 1./(MM*DT)
      DO 805 J = 1,NP
      XJ = J - 1
      FREQ = XJ * DDF
      IF(FREQ.LT.0.75*WMIN.OR.FREQ.GT.1.25*WMAX) GO TO 805
      DMM = SAVE(1,J)*SAVE(1,J) + SAVE(2,J)*SAVE(2,J)
      IF(DMM.GT.YMAX) YMAX = DMM
  805 CONTINUE
      YMAX = 0.5 * ALOG10(YMAX)
      LMAX = YMAX
      IF(YMAX.GT.LMAX) LMAX = LMAX + 1
      LMIN = LMAX - 3
      Y1 = LMIN
      CALL ALOGAXES(XAXLEN,YAXLEN,3,3,LABEL,LABLF,12,12,X1,Y1,DELTAX,
     1 DELTAY)
      CALL SYMBOL(1.69,YAXLEN+.01,0.21,MODEL(1),0.0,4)
      CALL SYMBOL(2.49,YAXLEN+.01,0.21,MODEL(2),0.0,4)
      CALL SYMBOL(3.30,YAXLEN+.01,0.21,MODEL(3),0.0,4)
      CALL SYMBOL(4.17,YAXLEN+.01,0.21,MODEL(4),0.0,4)
      CALL SYMBOL(5.01,YAXLEN+.01,0.21,MODEL(5),0.0,4)
      DO 999 JUMP = 1,NPER
      PER = 1./WN(JUMP)
      WRITE(61,5) PER
    5 FORMAT(1H0,16HFILTER PERIOD =   ,F10.5,/)
      PER = ALOG10(PER)
      X = (PER - X1)/DELTAX
      DO 1001  I = 1,MM
      DO 1001 J = 1,2
 1001 DATA(J,I) = 0.0
      FREQUP = 1.25 * WN(JUMP)
      FREQLW = 0.75*WN(JUMP)
      WC = 0.25 * WN(JUMP)
      W0 = WN(JUMP)
      DO 1002 I=1,NP
      XI = I - 1
      FREQ = XI *DDF
      IF(FREQ.GT.FREQUP.OR.FREQ.LT.FREQLW) GO TO 1002
      FAC1 = -50.27*((FREQ-WN(JUMP))/(WN(JUMP)))**2
      FILT = EXP(FAC1)
      DATA(1,I) = FILT * SAVE(1,I)
      DATA(2,I) = FILT * SAVE(2,I)
 1002 CONTINUE
      CALL FOUR2(DATA,MM,1,+1)
```

```
      DF = 1./DT
C     NOTE DF IS 1./N*DT BUT FACTOR 1./N IS ACCOUNTED FOR IN FOUR2
      DO  122 I = 1,MM
      DO 122 J = 1,2
  122 DATA(J,I) = DATA(J,I) * DF
      CALL MAXVAL(DATA,MM,WC,KO)
  999 CONTINUE
      CALL PLOT(12.0,0.0,-3)
      CALL FACTOR(1.0)
      CALL PLOT(2.0,0.0,-3)
      CALL PLOT(0.0,-11.0,-3)
      CALL PLOT(0.0,2.0,-3)
      CALL FACTOR(SIZE)
 1000 CONTINUE
      GO TO 1003
 1004 CONTINUE
      CALL PLOT(10.5,0.0,999)
      STOP
      END

      SUBROUTINE PLT(GPV,AMP,KK)
      CHARACTER LABEL,LABLE
      COMMON/TWO/LABEL(3),LABLE(3),X1,Y1,DELTAX,DELTAY,IBUF(1026),X
      DIMENSION GPV(1),AMP(1)
      DO 300 J = 1,KK
      G = GPV(J)
      AMP(J) = ABS(AMP(J))
      IF(AMP(J).LE.0) GO TO 300
      Y = ALOG10(AMP(J))
      IF(Y.LT.Y1) GO TO 300
      Y = (Y-Y1)/DELTAY
      CALL SYMBOL(X,Y,0.07,3,0.0,-1)
      CALL NUMBER(X+0.09,Y,0.05,G,90.0,2)
  300 CONTINUE
      RETURN
      END

      SUBROUTINE MAXVAL(DATA,N,WC,MO)
      CHARACTER MODEL
      COMMON/ONE/SAVE(4096),NP,MODEL(5),DIST,DEG,BACKAZ,TU,DT,NPTS
      DIMENSION DATA(2,4096),TIME(60),GPV(60),AMP(60),PHAZE(60)
   10 FORMAT(3(3X,4HTIME,6X,9HGROUP VEL,2X,9HAMPLITUDE,3X,5HPHASE,
     1 3X),/)
   11 FORMAT(3(1H ,1PE10.3,1P3E11.4))
      AMP1 =        DATA(1,1)*DATA(1,1) + DATA(2,1)*DATA(2,1)
      AMP2 =        DATA(1,2)*DATA(1,2) + DATA(2,2)*DATA(2,2)
      KK = 0
      NM1 = NPTS - 1
      DO 500 I = 3,NM1
      AMP3 =        DATA(1,I)*DATA(1,I) + DATA(2,I)*DATA(2,I)
```

```
      IF(AMP2.GT.AMP1.AND.AMP2.GE.AMP3) GO TO 400
      GO TO 401
  400 AMP4 = DATA(1,I+1)*DATA(1,I+1) + DATA(2,I+1)*DATA(2,I+1)
      IF(AMP2.LT.AMP4) GO TO 401
      XX = DATA(1,I)
      YY = DATA(2,I)
  402 CALL PHASE(XX,YY,PHI)
      PHI = PHI - W0 * T0
      PHI = PHI - AINT(PHI)
      IF(PHI.LT.0.0) PHI = PHI + 1
      KK = KK + 1
      PHAZE(KK) = PHI
      TIME(KK) = T0 + (I-1) * DT
      GPV(KK) = DIST/TIME(KK)
      AMP(KK) = SQRT(AMP2) * 4./N0
      IF(KK.LT.60) GO TO 401
      CALL PLT(GPV,AMP,KK)
      KK = 0
      JMAX=1
      AMAX=0.
      DO 300 J=1,60
      IF(AMP(J).GT.AMAX) JMAX=J
      AMAX=AMP(JMAX)
  300 CONTINUE
      AMP(JMAX)=-AMP(JMAX)
      WRITE(61,10)
      WRITE(61,11)((TIME(J),GPV(J),AMP(J),PHAZE(J)),J=1,60)
  401 AMP1 = AMP2
      AMP2 = AMP3
  500 CONTINUE
      IF(KK.EQ.0) GO TO 997
      JMAX=1
      AMAX=0.
      DO 301 J=1,KK
      IF(AMP(J).GT.AMAX) JMAX=J
      AMAX=AMP(JMAX)
  301 CONTINUE
      AMP(JMAX)=-AMP(JMAX)
      WRITE(61,10)
      WRITE(61,11) ((TIME(J),GPV(J),AMP(J),PHAZE(J)),J=1,KK)
      CALL PLT(GPV,AMP,KK)
  997 CONTINUE
      RETURN
      END

      SUBROUTINE PHASE(X,Y,PHI)
C     ARGUMENT PHI IS RETURNED AS VARYING FROM 0.0 TO 1.0 CIRCLES
      IF(X) 21,20,22
   20 IF(Y) 23,24,25
   23 PHI = 1.5* 3.14159
```

```
      GO TO 28
   24 PHI = 0.0
      GO TO 28
   25 PHI = 0.5 * 3.1415927
      GO TO 28
   21 PHI = ATAN(Y/X) + 3.1415927
      GO TO 28
   22 IF(Y) 26,27,27
   27 PHI = ATAN(Y/X)
      GO TO 28
   26 PHI = ATAN(Y/X) + 2.0 * 3.1415927
      GO TO 28
   28 CONTINUE
      PHI = PHI/6.2831854
      PHI = PHI - AINT(PHI)
      RETURN
      END

      SUBROUTINE TAPEIN(INDEX,IOTP)
C     INDEX IS THE TOTAL NUMBER OF SPECTRA TO BE BYPASSED BEFORE
C     READING STARTS
      IF(INDEX.LE.0) GO TO 2
      DO 1 I =1,INDEX
      READ(IOTP,10)N
      DO 1 J=1,N
      READ(IOTP,10) IDUM
   10 FORMAT(I5)
    1 CONTINUE
    2 CONTINUE
      RETURN
      END

      SUBROUTINE TAPERD
      CHARACTER MODEL
      COMMON/ONE/Z(4096),NP,MODEL(5),DIST,DEG,BACKAZ,TO,DT,NPTS
      READ(01,310) M,NPTS  ,MODEL(1),MODEL(2),DIST,DEG,BACKAZ,TO,DT,
     1 MODEL(3),MODEL(4),MODEL(5)
  310 FORMAT(2I5,A4,1X,A4,1X,5F10.2,3A4)
      DO 312 I=1,M
      K = I * 8
      J = K - 7
  312 READ(01,311) NWRITE,(Z(L),L=J,K)
  311 FORMAT(I5,8F15.3)
      NP = 4 * M
      RETURN
      END

      SUBROUTINE FOUR2(DATA,NN,NDIM,ISIGN)
C
C     THE COOLEY-TUKEY FAST FOURIER TRANSFORM IN USASI BASIC FORTRAN
```

```
C
C       TRANSFORM(J1,J2,...) = SUM(DATA(I1,I2,...)*W1**(I1-1)(J1-1))
C                                  *W2**(I2-1)(J2-1))*...)
C       WHERE I1 AND J1 RUN FROM 1 TO NN(1) AND W1=EXP(ISIGN*2*PI*
C       SQRT(-1)/NN(1)), ETC
C
C       DATA IS A MULTIDIMENSIONAL FLOATING POINT ARRAY ALL OF WHOSE
C       DIMENSIONS ARE POWERS OF TWO.  THE LENGTH OF EACH DIMENSION IS
C       STORED IN THE INTEGER ARRAY NN, OF LENGTH NDIM.  ISIGN IS
C       +1 OR -1, GIVING THE SIGN OF THE TRANSFORM.  THE REAL AND
C       IMAGINARY PARTS OF A DATUM ARE IMMEDIATELY ADJACENT IN STORAGE
C       SUCH AS FORTRAN IV PLACES THEM .  TRANSFORM RESULTS ARE RETURNED
C       IN ARRAY DATA, REPLACING THE ORIGINAL DATA.  TIME IS PROPORTIONAL
C       TO N*LOG2(N), RATHER THAN THE USUAL N**2. NOTE THAT IF A FORWARD
C       TRANSFORM IS FOLLOWED BY AN INVERSE TRANSFORM, THE ORIGINAL DATA
C       WILL REAPPEAR MULTIPLIED BY NN(1)*NN(2)*... .  EXAMPLE--
C       FORWARD FOURIER TRANSFORM OF A TWO-DIMENSIONAL ARRAY IN FORTRAN II
C       DIMENSION DATA(2,64,32),NN(2)
C       NN(1) = 64
C       NN(2) = 32
C       DO 1 I=1,64
C       DO 1 J=1,32
C       DATA(1,I,J) = REAL PART
C     1 DATA(2,I,J) = IMAGINARY PART
C       CALL FOUR2(DATA,NN,2,-1)
C
C       SAME EXAMPLE IN FORTRAN IV
C       DIMENSION DATA(64,32),NN(2)
C       COMPLEX DATA
C       DATA NN/64,32/
C       DO 1 I=1,64
C       DO 1 J=1,32
C     1 DATA(I,J) = COMPLEX VALUE
C       CALL FOUR2(DATA,NN,2,-1)
C
C       PROGRAM BY NORMAN BRENNER FROM THE BASIC PROGRAM BY CHARLES
C       RADER, MAY, 1967.  THE IDEA FOR THE DIGIT REVERSAL WAS SUGGESTED
C       BY RALPH ALTER, DDC-DSA CLEARINGHOUSE 657-019 .. THREE FORTRAN
C       PROGRAMS THAT PERFORM THE COOLEY-TUKEY FOURIER TRANSFORM BY
C       N. M. BRENNER, MIT JUL 67
C
C       THIS VERSION OF THE FAST FOURIER TRANSFORM IS THE FASTEST KNOWN
C       TO THE AUTHOR.  LOOKING UP SINES AND COSINES IN A TABLE INSTEAD OF
C       COMPUTING THEM WOULD DECREASE RUNNING TIME SEVEN PERCENT.
C       SEE--IEEE AUDIO TRANSACTIONS , JUN 67, SPECIAL ISSUE OF FFT
C
C       FOR N = 1024 NN = 1  TAKES 1.53 SEC ON CDC 3300
C
      DIMENSION DATA(1),NN(1)
      IF(NDIM-1)700,1,1
```

```
    1 NTOT = 2
      DO 2 IDIM=1,NDIM
      IF(NN(IDIM))700,700,2
    2 NTOT = NTOT*NN(IDIM)
      IF(ISIGN.EQ.-1) GO TO 1002
      XN = NTOT/2
      DO 1001 IIII = 1,NTOT
 1001 DATA(IIII) = DATA(IIII) / XN
 1002 CONTINUE
      RTHLF = 0.7071067812
      TWOPI = 6.2831853070
C
C     MAIN LOOP FOR EACH DIMENSION
C
      NP1 = 2
      DO 600 IDIM = 1,NDIM
      N = NN(IDIM)
      NP2 = NP1*N
      IF(N-1)700,600,100
C
C     SHUFFLE DATA BY BIT REVERSAL, SINCE N = 2**K.  AS THE SHUFFLING
C     CAN BE DONE BY SIMPLE INTERCHANGE, NO WORKING ARRAY IS NEEDED
C
  100 NP2HF = NP2/2
      J = 1
      DO 160 I2 = 1,NP2,NP1
      IF (J-I2)110,130,130
  110 I1MAX = I2+NP1 - 2
      DO 120 I1 = I2,I1MAX,2
      DO 120 I3=I1,NTOT,NP2
      J3 = J + I3 - I2
      TEMPR = DATA(I3)
      TEMPI = DATA(I3+1)
      DATA(I3) = DATA(J3)
      DATA(I3+1) = DATA(J3+1)
      DATA(J3) = TEMPR
  120 DATA(J3+1) = TEMPI
  130 M = NP2HF
  140 IF(J-M)160,160,150
  150 J = J - M
      M = M/2
      IF(M-NP1)160,140,140
  160 J = J + M
C
C     MAIN LOOP. PERFORM FOURIER TRANSFORMS OF LENGTH FOUR, WITH ONE OF
C     LENGTH TWO IF NEEDED.  THE TWIDDLE FACTOR W = EXP(ISIGN*2*PI*
C     SQRT(-1)*M/(4*MMAX)).  CHECK FOR THE SPECIAL CASE W=ISIGN*SQRT(-1)
C     AND REPLAT FOR W=W*(1+ISIGN*SQRT(-1))/(SQRT(2).
C
      NP1TW = NP1+NP1
```

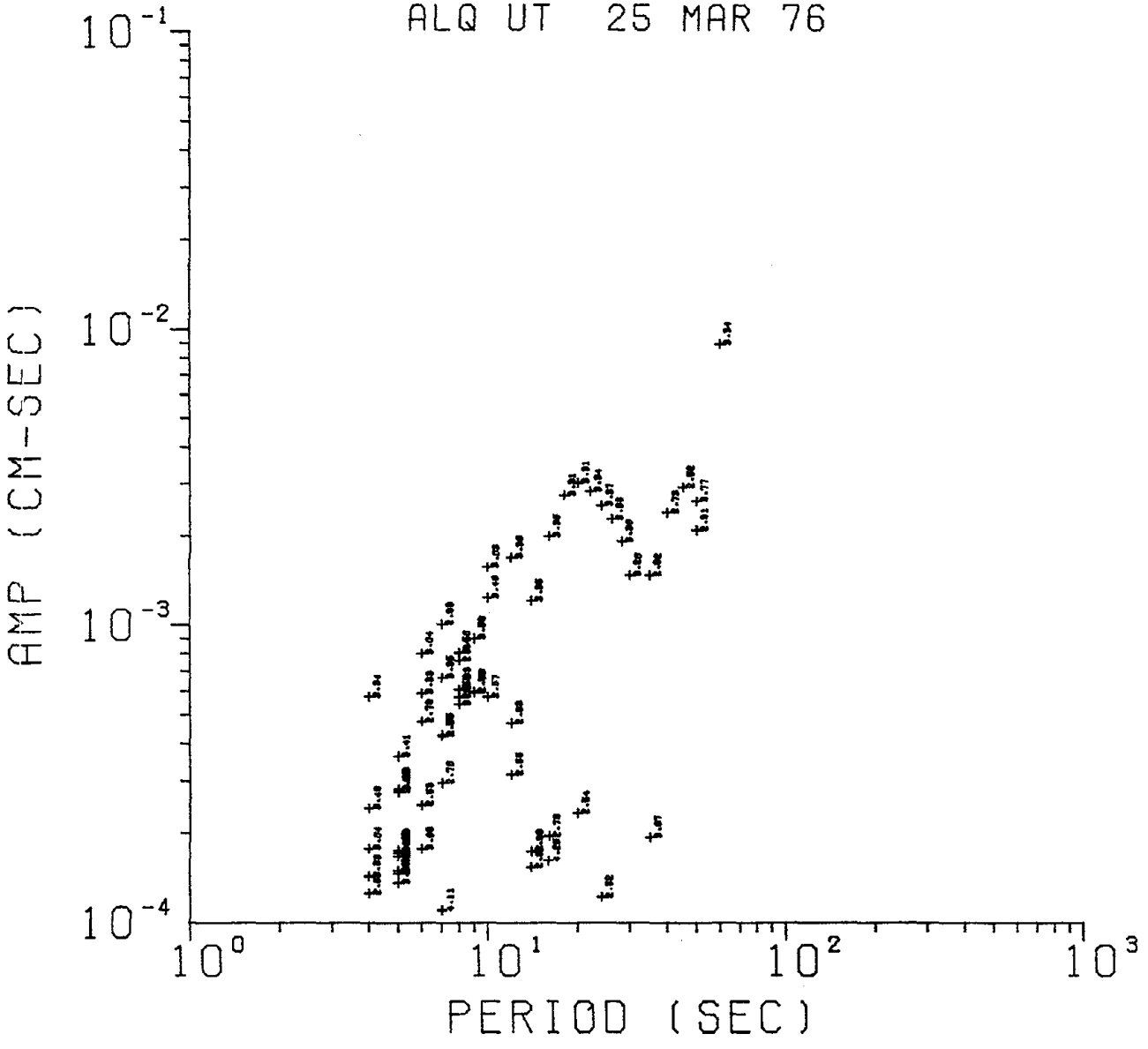
```
      IPAR = N
  310 IF(IPAR-2)350,350,320
  320 IPAR=IPAR/4
      GO TO 310
  330 DO 340 I1=1,NP1,2
      DO 340 K1=I1,NTOT,NP1TW
      K2 = K1 + NP1
      TEMPR=DATA(K2)
      TEMPI=DATA(K2+1)
      DATA(K2)=DATA(K1)-TEMPR
      DATA(K2+1)=DATA(K1+1)-TEMPI
      DATA(K1)=DATA(K1)+TEMPR
  340 DATA(K1+1)=DATA(K1+1)+TEMPI
  350 MMAX = NP1
  360 IF(MMAX-NP2HF)370,600,600
  370 LMAX=MAX0(NP1TW,MMAX/2)
      DO 570 L=NP1,LMAX,NP1TW
      M = L
      IF(MMAX-NP1) 420,420,380
  380 THETA=-TWOPI*FLOAT(M)/FLOAT(4*MMAX)
      IF(ISIGN)400,390,390
  390 THETA = - THETA
  400 WR = COS(THETA)
      WI = SIN(THETA)
  410 W2R = WR*WR-WI*WI
      W2I=2.*WR*WI
      W3R=W2R*WR-W2I*WI
      W3I=W2R*WI+W2I*WR
  420 DO 530 I1=1,NP1,2
      KMIN = IPAR*M+I1
      IF(MMAX-NP1)430,430,440
  430 KMIN = I1
  440 KDIF = IPAR * MMAX
  450 KSTEP = 4 * KDIF
      DO 520 K1=KMIN,NTOT,KSTEP
      K2=K1+KDIF
      K3=K2+KDIF
      K4=K3+KDIF
      IF(MMAX-NP1)460,460,480
  460 U1R=DATA(K1)+DATA(K2)
      U1I=DATA(K1+1)+DATA(K2+1)
      U2R=DATA(K3)+DATA(K4)
      U2I=DATA(K3+1)+DATA(K4+1)
      U3R=DATA(K1)-DATA(K2)
      U3I=DATA(K1+1)-DATA(K2+1)
      IF(ISIGN)470,475,475
  470 U4R=DATA(K3+1)-DATA(K4+1)
      U4I=DATA(K4)-DATA(K3)
      GO TO 510
  475 U4R=DATA(K4+1)-DATA(K3+1)
```

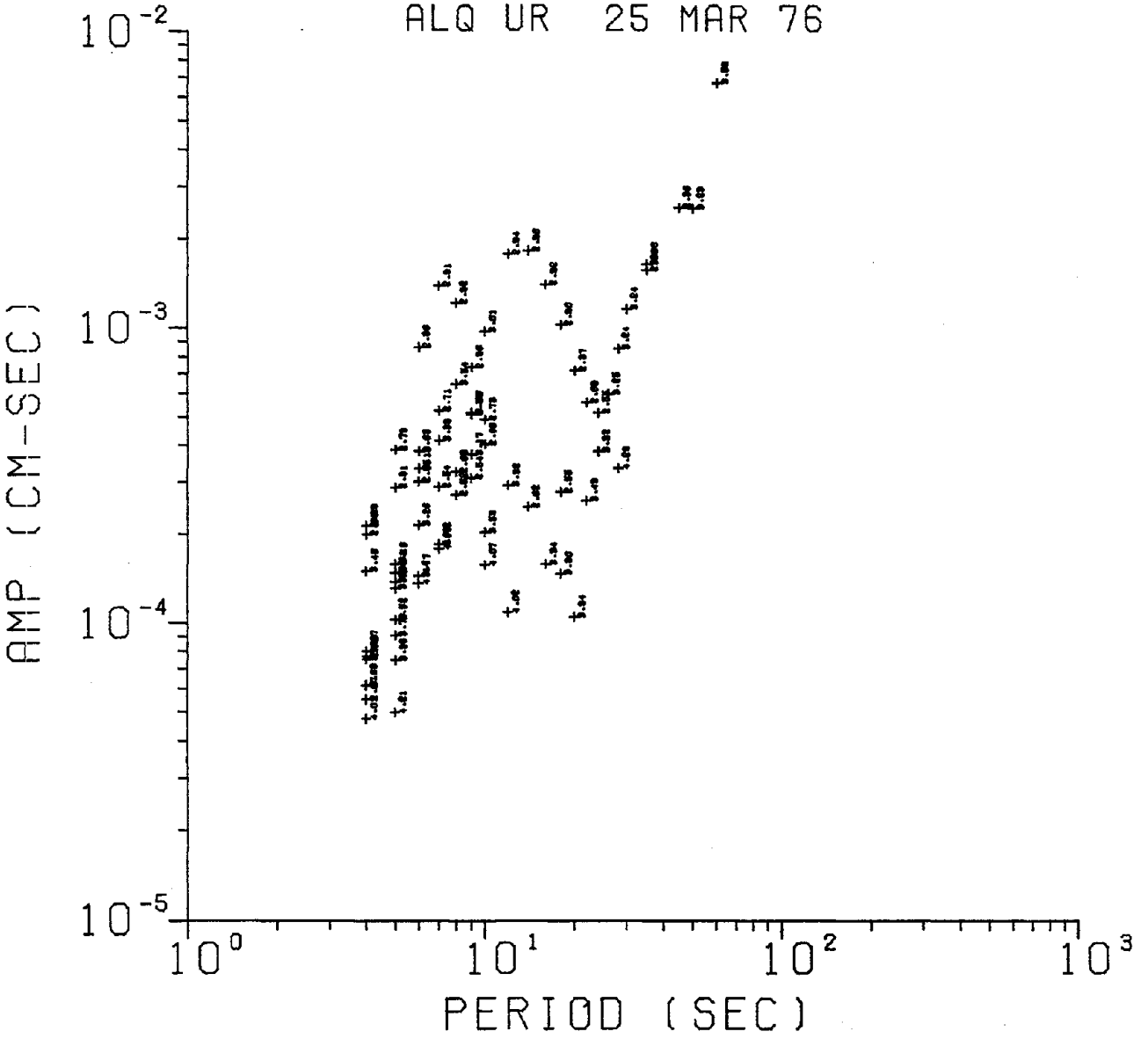
```
      U4I=DATA(K3)-DATA(K4)
      GO TO 510
  480 T2R=W2R*DATA(K2)-W2I*DATA(K2+1)
      T2I=W2R*DATA(K2+1)+W2I*DATA(K2)
      T3R=WR*DATA(K3)-WI*DATA(K3+1)
      T3I=WR*DATA(K3+1)+WI*DATA(K3)
      T4R=W3R*DATA(K4)-W3I*DATA(K4+1)
      T4I=W3R*DATA(K4+1)+W3I*DATA(K4)
      U1R=DATA(K1)+T2R
      U1I=DATA(K1+1)+T2I
      U2R=T3R+T4R
      U2I=T3I+T4I
      U3R=DATA(K1)-T2R
      U3I=DATA(K1+1)-T2I
      IF(ISIGN)490,500,500
  490 U4R=T3I-T4I
      U4I=T4R-T3R
      GO TO 510
  500 U4R=T4I-T3I
      U4I=T3R-T4R
  510 DATA(K1)=U1R+U2R
      DATA(K1+1)=U1I+U2I
      DATA(K2)=U3R+U4R
      DATA(K2+1)=U3I+U4I
      DATA(K3)=U1R-U2R
      DATA(K3+1)=U1I-U2I
      DATA(K4)=U3R-U4R
  520 DATA(K4+1)=U3I-U4I
      KMIN=4*(KMIN-I1)+I1
      KDIF=KSTEP
      IF(KDIF-NP2HF)450,450,530
  530 CONTINUE
      M=M+LMAX
      IF(M-MMAX)540,540,570
  540 IF(ISIGN)550,560,560
  550 TEMPR=WR
      WR=(WR+WI)*RTHLF
      WI=(WI-TEMPR)*RTHLF
      GO TO 410
  560 TEMPR=WR
      WR=(WR-WI)*RTHLF
      WI=(TEMPR+WI)*RTHLF
      GO TO 410
  570 CONTINUE
      IPAR=3-IPAR
      MMAX=MMAX+MMAX
      GO TO 360
  600 NP1=NP2
  700 RETURN
      END
```

```
      SUBROUTINE ALOGAXES(XAXLEN,YAXLEN,NOCX,NOCY,TTLX,TTLY,MTX,MTY,X1,
     1Y1,DELTAX,DELTAY)
      CHARACTER TTLX(1),TTLY(1)
      DIMENSION TTLX(10),TTLY(10)
      SL = 0.02*YAXLEN
      SST = 0.01 * YAXLEN
      SP = -0.06*YAXLEN
      SS = 0.035*YAXLEN
      SSP = SP + SS - 0.06
      TTLP = -0.11*YAXLEN - 0.1
      STTL = 0.035*YAXLEN
      XNUM = 1
      YL = Y1
      YU = Y1 + ANOCY
      IF(ABS(YL).GE.10..OR.ABS(YU).GE.10.)XNUM = XNUM + 1.
      IF(ABS(YL).GE.100..OR.ABS(YU).GE.100.) XNUM = XNUM + 1.
      IF(Y1.LT.0) XNUM = XNUM + 1.0
      CALL PLOT(-SLT,0.0,2)
      CALL PLOT(0.0,-SLT,3)
      CALL PLOT(0.0,0.0,2)
      XPO = X1
      YPO = Y1
      IF(NOCX.EQ.0) GO TO 4
      ANOCX = NOCX
      FACTX = XAXLEN/ANOCX
      CALL SYMBOL(-.6*SS,SP,SS,2H10,0.0,2)
      CALL NUMBER(999.,SSP,0.5*SS,X1,0.0,-1)
      CALL PLOT(0.0,0.0,3)
      DO 3 J = 1,NOCX
      DO 2 I = 1,10
      X = I
      X = ALOG10(X) *FACTX + (J-1)*FACTX
      IF(I.EQ.1)GO TO 2
      CALL PLOT(X,0.0,2)
      CALL PLOT(X,-SSI,2)
    2 CALL PLOT(X,0.0,3)
      CALL PLOT(X,-SLT,2)
      CALL SYMBOL(X-.6*SS,SP,SS,2H10,0.0,2)
      XPO = XPO + 1.0
      CALL NUMBER(999.,SSP,0.5*SS,XPO,0.0,-1)
    3 CALL PLOT(X,0.0,3)
      XTL = MTX
      XTL = (XAXLEN-XTL*STTL)/2.0
      CALL SYMBOL(XTL,TTLP,STTL,TTLX,0.0,MTX)
      GO TO 6
    4 CALL AXIS(0.0,0.0,TTLX,-MTX,XAXLEN,0.0,X1,DELTAX)
    6 CALL PLOT(0.0,0.0,3)
      IF(NOCY.EQ.0) GO TO 10
      ANOCY = NOCY
```

```
      SP = SP - (XNUM - 1.5) * 0.5 * SS
      TTLP = TTLP - ( XNUM-1.)*0.5*SS
      FACTY = YAXLEN/ANOCY
      CALL SYMBOL(SP-0.4,-0.5*SS,SS,2H10,0.0,2)
      CALL NUMBER(999.,.5*SS-.06,.5*SS,Y1,0.0,-1)
      CALL PLOT(0.0,0.0,3)
      DO 9 J = 1,NOCY
      DO 8 I = 1,10
      Y = I
      Y = ALOG10(Y) * FACTY + (J-1)*FACTY
      IF(I.EQ.1)GO TO 8
      CALL PLOT(0.0,Y,2)
      CALL PLOT(-SST,Y,2)
    8 CALL PLOT(0.0,Y,3)
      CALL PLOT(-SLT,Y,2)
      CALL SYMBOL(SP-.4,Y-.5*SS,SS,2H10,0,0,2)
      YPO = YPO + 1
      CALL NUMBER(999.,Y+.5*SS-.06,.5*SS,YPO,0.0,-1)
    9 CALL PLOT(0.0,Y,3)
      YTL=MTY
      YTL = (YAXLEN-YTL*STTL)/2.0
      CALL SYMBOL(TTLP-.2,YTL,STTL,TTLY,90.,MTY)
      RETURN
   10 CALL AXIS(0.0,0.0,TTLY,MTY,YAXLEN,90.,Y1,DELTAY)
      RETURN
      END
```

```
    0    2   22       0.7
.25        .2         .1666667 .1428571  .125      .1111111 .1        .0833333
.07142857 .0625       .05555555 .05        .04545454 .04166667 .03846154 .0357142
.03333333 .02857143 .025        .02222222 .02       .01666666 .01428571 .0125
    0   -1
```


ALQ UT 25 MAR 76
AMP (CM-SEC)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{0}
10^{1}
10^{2}
10^{3}
PERIOD (SEC)


ALQ UR 25 MAR 76
AMP (CM-SEC)
10^{-2}
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10^{-5}
10^{0}
10^{1}
10^{2}
10^{3}
PERIOD (SEC)

ALQ UT 25 MAR 76 1455.80 KM 13.10 DEG 82.40 DEG(BAZ)

FILTER PERIOD = 4.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.627E 02	4.0143E 00	1.8164E-05	9.7013E-01	3.959E 02	3.6772E 00	4.3609E-05	4.8297E-02	4.367E 02	3.4941E 00	2.4248E-04	6.1872E-01
4.364E 02	3.3359E 00	5.7491E-04	2.5327E-01	4.793E 02	3.0351E 00	1.7779E-04	7.8466E-01	5.837E 02	2.8342E 00	1.4318E-04	8.8478E-01
5.444E 02	2.6741E 00	4.7916E-05	9.3390E-01	5.699E 02	2.5596E 00	1.2484E-04	9.1930E-01				

FILTER PERIOD = 5.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.667E 02	3.9705E 00	3.2976E-05	8.4385E-01	3.809E 02	3.8228E 00	2.9023E-05	7.5273E-01	4.007E 02	3.6336E 00	1.3576E-04	9.9965E-01
4.264E 02	3.4142E 00	3.6234E-04	9.2365E-01	4.439E 02	3.2706E 00	2.8025E-04	8.4630E-01	4.899E 02	3.1655E 00	1.7130E-04	7.1326E-01
4.704E 02	3.0948E 00	1.7493E-04	6.3334E-01	4.877E 02	2.9853E 00	2.7514E-04	5.3806E-01	5.452E 02	2.8260E 00	1.4585E-04	2.7866E-02
5.362E 02	2.7153E 00	1.4953E-04	7.5990E-01	5.549E 02	2.6247E 00	1.6718E-04	5.8666E-01	5.782E 02	2.5180E 00	9.4231E-05	7.3569E-01

FILTER PERIOD = 6.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.574E 02	4.0733E 00	8.6749E-05	9.0966E-01	3.959E 02	3.6778E 00	1.7728E-04	4.1175E-01	4.367E 02	3.3340E 00	5.9072E-04	9.5062E-01
4.784E 02	3.0431E 00	7.9978E-04	1.0499E-01	5.219E 02	2.7894E 00	4.7383E-04	5.6173E-01	5.747E 02	2.5334E 00	2.4826E-04	4.2783E-01

FILTER PERIOD = 7.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.544E 02	4.1078E 00	1.1003E-04	1.1887E-01	4.052E 02	3.5932E 00	4.2520E-04	8.1801E-01	4.544E 02	3.3513E 00	6.6523E-04	6.8009E-01
4.892E 02	2.9762E 00	1.0082E-03	8.4654E-01	5.402E 02	2.6958E 00	2.9454E-04	5.1693E-01	5.717E 02	2.5467E 00	4.2699E-04	5.3986E-02

FILTER PERIOD = 8.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.892E 02	4.0535E 00	7.3376E-05	7.6772E-01	4.159E 02	3.5025E 00	-8.0580E-04	2.3988E-01	4.659E 02	3.1247E 00	5.4060E-04	6.7682E-01
4.959E 02	2.9357E 00	7.5799E-04	8.5218E-01	5.144E 02	2.8301E 00	6.0686E-04	3.3308E-01	5.714E 02	2.5478E 00	5.7254E-04	6.7763E-02

FILTER PERIOD = 9.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.644E 02	3.9951E 00	3.1088E-05	2.2723E-01	4.159E 02	3.5004E 00	-9.0235E-04	9.6660E-01	4.824E 02	3.0178E 00	8.9908E-04	7.6979E-02
5.227E 02	2.7854E 00	5.9251E-04	9.4405E-02	5.689E 02	2.5590E 00	5.9675E-04	4.8609E-01				

FILTER PERIOD = 10.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
4.212E 02	3.4567E 00	1.2356E-03	2.6025E-01	4.802E 02	3.0328E 00	-1.5682E-03	6.1291E-01	5.662E 02	2.5714E 00	5.7259E-04	9.6689E-01

FILTER PERIOD = 12.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
4.407E 02	3.3038E 00	-1.6857E-03	6.6667E-01	5.047E 02	2.8848E 00	4.6899E-04	5.5438E-01	5.704E 02	2.5522E 00	3.1434E-04	9.9512E-01

FILTER PERIOD = 14.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
4.344E 02	3.3513E 00	-1.2076E-03	8.1965E-01	4.892E 02	2.9702E 00	1.7357E-04	6.7107E-01	5.457E 02	2.8232E 00	1.5349E-04	6.1498E-01

FILTER PERIOD = 16.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.422E 02	4.2549E 00	1.6131E-04	1.0685E-01	4.347E 02	3.3494E 00	-1.9989E-03	2.5212E-01	5.222E 02	2.7881E 00	1.9534E-04	3.8150E-02

FILTER PERIOD = 18.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
4.402E 02	3.3075E 00	-2.7499E-03	9.1727E-01								

FILTER PERIOD = 20.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
4.399E 02	3.3094E 00	-3.0171E-03	7.8776E-01	5.739E 02	2.5367E 00	2.3366E-04	9.8875E-01				

FILTER PERIOD = 22.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
4.357E 02	3.3417E 00	-2.8254E-03	1.2494E-01								

FILTER PERIOD = 24.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE

```
 4.322E 02 3.3687E 00-2.5271E-03 2.5495E-01  5.779E 02 2.5191E 00 1.2155E-04 8.0577E-02

FILTER PERIOD =   26.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 4.304E 02 3.3824E 00-2.2755E-03 2.7062E-01

FILTER PERIOD =   28.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 4.332E 02 3.3610E 00-1.9139E-03 3.0376E-01

FILTER PERIOD =   30.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 4.344E 02 3.2038E 00-1.4655E-03 3.6054E-01

FILTER PERIOD =   35.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 3.972E 02 3.6656E 00 1.9427E-04 4.4586E-01  5.169E 02 2.8144E 00-1.4709E-03 4.3271E-01

FILTER PERIOD =   40.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 5.332E 02 2.7306E 00-2.4004E-03 5.8900E-02

FILTER PERIOD =   45.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 5.777E 02 2.5202E 00-2.9266E-03 3.0916E-02

FILTER PERIOD =   50.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 3.867E 02 3.7652E 00-2.6188E-03 1.4969E-01  4.997E 02 2.9136E 00 2.0907E-03 1.4576E-01

FILTER PERIOD =   60.00002
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 4.359E 02 3.3398E 00-8.9174E-03 1.5657E-01
```

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FILTER PERIOD = 4.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.634E 02	4.0061E 00	4.7457E-05	8.4368E-01	3.952E 02	3.6843E 00	6.1437E-05	3.0649E-01	4.882E 02	3.4801E 00	1.9029E-04	1.6767E-01
4.449E 02	3.2722E 00	8.0113E-05	9.4933E-01	4.867E 02	2.9915E 00	-2.1404E-04	3.0301E-02	5.892E 02	2.8993E 00	2.0019E-04	6.5621E-02
5.239E 02	2.7788E 00	7.7199E-05	1.1788E-01	5.454E 02	2.6692E 00	5.5275E-05	5.9918E-01	5.784E 02	2.5822E 00	7.5553E-05	1.4968E-01

FILTER PERIOD = 5.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.459E 02	4.2087E 00	4.9852E-05	4.2250E-01	3.657E 02	3.9814E 00	7.4961E-05	6.4543E-01	3.939E 02	3.6959E 00	9.1113E-05	9.1998E-02
4.269E 02	3.3943E 00	1.3138E-04	8.9471E-01	4.417E 02	3.2963E 00	1.3812E-04	9.9199E-01	4.807E 02	3.1603E 00	1.5868E-04	4.0452E-01
4.997E 02	2.9136E 00	2.8851E-04	9.9684E-01	5.209E 02	2.7948E 00	-3.8700E-04	5.4501E-01	5.977E 02	2.6106E 00	1.4825E-04	1.8679E-01
5.774E 02	2.5213E 00	1.0264E-04	2.8136E-01								

FILTER PERIOD = 6.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.519E 02	4.1370E 00	1.3628E-04	6.4417E-01	3.867E 02	3.7652E 00	1.4462E-04	1.1316E-01	4.459E 02	3.2849E 00	2.1522E-04	1.3758E-01
4.652E 02	3.1297E 00	3.3373E-04	4.7309E-01	5.099E 02	2.8565E 00	-8.6114E-04	9.0613E-01	5.439E 02	2.6766E 00	3.8083E-04	1.8344E-01
5.712E 02	2.5489E 00	3.0128E-04	7.8712E-01								

FILTER PERIOD = 7.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.639E 02	4.0005E 00	1.7832E-04	5.7216E-01	3.909E 02	3.7242E 00	1.8525E-04	8.0364E-01	4.297E 02	3.3883E 00	4.1571E-04	7.3062E-01
5.002E 02	2.9107E 00	-1.3930E-03	3.4964E-01	5.374E 02	2.7090E 00	5.2520E-04	2.3398E-01	5.742E 02	2.5356E 00	2.8931E-04	3.3259E-01

FILTER PERIOD = 8.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
4.109E 02	3.5430E 00	6.4793E-04	3.5625E-01	4.987E 02	2.9195E 00	-1.2203E-03	3.9000E-01	5.434E 02	2.6791E 00	3.2524E-04	1.1024E-01
5.777E 02	2.5202E 00	2.7248E-04	8.2663E-01								

FILTER PERIOD = 9.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
4.047E 02	3.5977E 00	5.1730E-04	3.0271E-01	4.589E 02	3.1724E 00	3.7291E-04	3.6541E-02	4.927E 02	2.9550E 00	-7.3759E-04	3.8341E-01
5.152E 02	2.8260E 00	5.1097E-04	1.0696E-01	5.727E 02	2.5422E 00	3.1033E-04	9.9756E-01				

FILTER PERIOD = 10.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.579E 02	4.0676E 00	1.5788E-04	5.3746E-01	4.052E 02	3.5932E 00	2.0349E-04	1.2193E-01	4.832E 02	3.0131E 00	-9.7594E-04	1.6969E-01
5.234E 02	2.7814E 00	4.9202E-04	7.5769E-01	5.607E 02	2.5966E 00	4.0391E-04	4.9857E-01				

FILTER PERIOD = 12.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.619E 02	4.0227E 00	1.0905E-04	5.1496E-01	4.382E 02	3.3226E 00	2.9250E-04	6.7798E-01	4.947E 02	2.9431E 00	-1.7802E-03	8.3263E-01

FILTER PERIOD = 14.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
4.922E 02	2.9580E 00	-1.8235E-03	6.7817E-01	5.562E 02	2.6176E 00	2.4749E-04	5.5817E-01				

FILTER PERIOD = 16.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
4.362E 02	3.3378E 00	1.5885E-04	8.0486E-01	4.982E 02	2.9224E 00	-1.4088E-03	1.0070E-01				

FILTER PERIOD = 18.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.832E 02	3.7996E 00	1.4715E-04	2.8244E-02	5.022E 02	2.8991E 00	-1.0278E-03	6.9657E-01	5.217E 02	2.5467E 00	2.7826E-04	9.3424E-01

FILTER PERIOD = 20.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
3.692E 02	3.9437E 00	1.0511E-04	1.9966E-01	5.072E 02	2.8706E 00	-7.1805E-04	8.3743E-01				

FILTER PERIOD = 22.00000

TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE	TIME	GROUP VEL	AMPLITUDE	PHASE
4.172E 02	3.4899E 00	2.6065E-04	7.3722E-01	5.404E 02	2.6939E 00	-5.6094E-04	9.6978E-01				

```
FILTER PERIOD =   24.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 4.324E 02 3.3668E 00 3.7963E-04 6.2716E-01  4.672E 02 3.1163E 00 3.8106E-04 9.9035E-01  5.214E 02 2.5478E 00-5.1695E-04 6.3199E-01

FILTER PERIOD =   26.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 4.479E 02 3.2503E 00-5.9800E-04 8.1701E-01

FILTER PERIOD =   28.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 3.394E 02 4.2893E 00 3.3407E-04 5.8063E-01  4.489E 02 3.2430E 00-8.5375E-04 2.8510E-01

FILTER PERIOD =   30.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 4.499E 02 3.2358E 00-1.1629E-03 1.2318E-01

FILTER PERIOD =   35.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 4.212E 02 3.4567E 00-1.6511E-03 9.0209E-01  5.099E 02 2.8551E 00 1.5697E-03 4.7630E-01

FILTER PERIOD =   40.00000

FILTER PERIOD =   45.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 5.094E 02 2.8579E 00-2.5614E-03 8.4874E-01

FILTER PERIOD =   50.00000
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 4.502E 02 3.2340E 00-2.5378E-03 3.5579E-01

FILTER PERIOD =   60.00002
  TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE      TIME      GROUP VEL  AMPLITUDE   PHASE
 4.054E 02 3.5910E 00-6.7179E-03 6.7471E-01
```

V. FPDPLT

PROGRAMMER : R. B. HERRMANN / SEP 73

PURPOSE:

This program will accept the orientations of the pressure and tension axes and plot the appropriate P wave focal mechanism. The program can also accept P wave first motion data for plotting on the focal mechanism.

INPUT/OUTPUT

Card input. Calcomp plotter on FILE 10.

PROGRAM DESCRIPTION

PROGRAM FPDPLT: This program accepts the data and plots the P wave data on the focal mechanism which is drawn by the SUBROUTINE NODPL.

SUBROUTINE DIPDD : This SUBROUTINE accepts the orientation of a vector and redefines the vector in terms of the two quantities PHI and DELTA.

SUBROUTINE NODPL : This SUBROUTINE plots the focal mechanism on an equal area projection.

INPUT DATA

Card Sequence	Column	Name	Format	Explanation
A. Title Card				
	2-12	ITTL(K),K=1,3	3A4	9 character title for plot,e.g. 09 NOV 68
B. Mechanism data				
	1-10	DEL	F10.5	Azimuth of T axis. If LT.0 end program

Card Sequence	Column	Name	Format	Explanation
	11-20	BET	F10.5	Angle T axis makes with +z axis (downward)
	21-30	ALP	F10.5	Azimuth of P axis measured clockwise from north
	31-40	GAM	F10.5	Angle P axis makes with downward positive z-axis
	41-50	TIC	F10.5	GT.0 N,E,S,W tics as well as N, P, T symbols and title included on plot EQ.0 only mechanism drawn LT.0 no tics or symbols plotted. Only the + at center of circle and title are plotted
	51-60	RAD	F10.5	Radius of focal circle in inches
	61-70	XX	F10.5	x-coordinate of center of mechanism on plot
	71-80	YY	F10.5	y-coordinate of center of mechanism on plot

Card Sequence	Column	Name	Format	Explanation
C. First motion data				
	2-5	ISTA	A4	Station code
	11-20	AZ	F10.3	Azimuth of polarity point on plot
	21-30	ANGI	F10.3	Take-off angle for P wave data point. LT.90^{o}
	31-40	DIST	F10.3	Epicentral distance in km
	41-44	IPHASE	A4	P phase identification. e.g. I PN or E P* etc.
	46	IPOL	A1	P,+, or C an octagon is plotted M,-, or D a triangle is plotted X an X is plotted

At this point the program returns to C to read another P polarity set. When a card is found for which ISTA = HALT, the plotting of P wave polarities on the focal mechanism is halted and the program returns to A to read in new mechanism data or to terminate the program.

Note when plotting data which would appear on the upper focal sphere, just add 180^{o} to the azimuth, give it a take-off angle between 0 - 90^{o}. The equivalent observation is then plotted on the lower hemisphere.

```
C       THIS PROGRAM PLOTS P WAVE FAULT PLANE SOLUTION DATA
        COMMON / CALC/ IBUF(1026)
        DIMENSION ITTL(3)
        DEGRAD = 0.017452329
        CALL PLOTS(IBUF,1026,10)
        CALL PLOT(0.0,-11.0,-3)
        CALL PLOT(0.0,0.0,-3)
 4321   READ(60,8) (ITTL(K),K=1,3)
    8   FORMAT(1H ,3A6)
        WRITE(61,9)(ITTL(K),K=1,3)
    9   FORMAT(1H1,20X,3A6)
        READ(60,4) DEL,BET,ALP,GAM,TIC,RAD,XX,YY
        IF(DEL.LT.0) GO TO 9999
        WRITE(61,7) DEL,BET,ALP,GAM
C       DEL = AZIMUTH OF T AXIS
C       BET = ANGLE T AXIS MAKES WITH Z AXIS
C       ALP = AZIMUTH OF P AXIS
C       GAM = ANGLE P AXIS MAKES WITH Z AXIS
C       TIC = LT 0 N E S W TICS AND P T  SYMBOLS NO INCLUDED
C       RAD = RADIUS OF FOCAL CIRCLE IN INCHES
C       (XX,YY) COORDINATES OF CENTER OF FOCAL CIRCLE
        DEL = DEL * DEGRAD
        BET = BET * DEGRAD
        ALP = ALP * DEGRAD
        GAM = GAM * DEGRAD
    4   FORMAT(8F10.5)
    7   FORMAT(1H0,20X,4F10.3)
        HT = 0.05 * RAD
        CALL NODPL(DEL,BET,ALP,GAM,TIC,RAD,XX,YY,ITTL)
        IP = 1HP
        IM = 1H-
        IX = 1HX
        IHALT = 4HHALT
        WRITE(61,5)
 4300   READ(60,1) ISTA,AZ,ANGI,DIST,IPHASE,IPOL
        IF(ISTA.EQ.IHALT) GO TO 9998
        WRITE(61,3)
    3   FORMAT(1H )
    1   FORMAT(1H ,A4,5X,3F10.3,A4,1X,A1)
    5   FORMAT(1H0,20X,4HSTA ,5X,6X,4HAZ   ,2X,8HDIST(KM),1X,9HDIST(DEG),
       12X,8HIO (DEG)   )
    2   FORMAT(1H ,20X,A4,5X,4F10.1,1H ,A4,1X,A1)
        DELT = DIST/111.195
        WRITE(61,2) ISTA,AZ,DIST,DELT,ANGI,IPHASE,IPOL
        AZ = AZ * DEGRAD
        ANGI = ANGI * DEGRAD
        SQTWR = 1.414214
        R = RAD * SQTWR * SIN(ANGI/2.)
        Y = YY + R * COS(AZ)
        X = XX + R * SIN(AZ)
```

```
      INTEQ = 0
      IF(IPOL.EQ.IP) INTEQ = 1
      IF(IPOL.EQ.1H+) INTEQ = 1
      IF(IPOL.EQ.1HC) INTEQ = 1
      IF(IPOL.EQ.IM) INTEQ = 2
      IF(IPOL.EQ.1HM) INTEQ = 2
      IF(IPOL.EQ.1HD) INTEQ = 2
       IF(IPOL.EQ.IX) INTEQ = 4
      IF(INTEQ.EQ.0) GO TO 4299
      CALL SYMBOL(X,Y,HT,INTEQ,0.0,-1)
 4299 CONTINUE
      GO TO 4300
 9998 CALL PLOT(11.0,0.0,-3)
      GO TO 4321
 9999 CONTINUE
      CALL PLOT(0.0,0.0,999)
      END

      SUBROUTINE DIPDL(X,Y,Z,PHI,DELTA)
      TWPI = 6.2831853
      CCON = 57.29578
      VNORM = SQRT(X*X+Y*Y+Z*Z)
      IF(Z.GT.0) GO TO 10
      X = -X
      Y = -Y
      Z = -Z
   10 IF(ABS(X).LE.0.0001.AND.ABS(Y).LT.0.001) GO TO 20
      DELTA = ARSIN(Z/VNORM)
      IF(ABS(X).LT.0.0001) GO TO 21
      PHI = ATAN(Y/X)
      IF(X.LT.0) PHI = PHI + TWPI/2.
      IF(PHI.LT.0) PHI = PHI + TWPI
      GO TO 30
   21 IF(Y.LT.0) PHI = -TWPI/4. + TWPI
      IF(Y.GT.0) PHI = TWPI/4
      GO TO 30
   20 DELTA = TWPI/4.
      PHI = 0
   30 PHI = PHI * CCON
      DELTA = DELTA*CCON
      DELTA = 90. - DELTA
      RETURN
      END

      SUBROUTINE NODPL(DEL,BET,ALP,GAM,TIC,RAD,XX,YY,ITTL)
      DIMENSION X(365),Y(365),DELTA(2),GAMMA(2)
      DIMENSION ITTL(3)
C     TIC .GT. 0 N,E,S,W TICS INCLUDED AS WELL AS N,P,T SYMBOLS AND
C     TITLE
C     TIC .EQ. 0 ONLY MECHANISM IS DRAWN
```

```
C     TIC .LT. 0 TITLE AND CENTER + TIC ARE INCLUDED NO OTHER TICS NESW
C     OR PT
C     R EQUALS RADIUS OF FOCAL CIRCLE
C     (XX,YY) = COORDINATES OF CENTER OF FOCAL MECHANISM
C     DEL = AZIMUTH OF T AXIS
C     BET = ANGLE OF T AXIS WITH RESPECT TO + Z AXIS
C     ALP = AZIMUTH OF P AXIS
C     GAM = ANGLE OF P AXIS WITH RESPECT TO + Z AXIS
      IF(TIC.EQ.0) GO TO 109
      HT = 0.1 * RAD
      DD = 0.06 * RAD
      XXX = XX - 0.3 * HT
      YYY = YY + 1.2 * RAD
      IF(TIC.LT.0) GO TO  110
      CALL SYMBOL(XXX,YYY,HT,1HN,0.0,1)
      CALL PLOT(XX,YY+RAD+DD,3)
      CALL PLOT(XX,YY+RAD-DD,2)
      CALL PLOT(XX,YY-RAD+DD,3)
      CALL PLOT(XX,YY-RAD-DD,2)
      CALL PLOT(XX+RAD+DD,YY,3)
      CALL PLOT(XX+RAD-DD,YY,2)
      CALL PLOT(XX-RAD+DD,YY,3)
      CALL PLOT(XX-RAD-DD,YY,2)
  110 CONTINUE
      CALL SYMBOL(XX,YY,HT,3,0.0,-1)
      YYY = YY + 1.5 * RAD
      XXX = XXX - 4. * HT
      CALL SYMBOL(XXX,YYY,HT,ITTL,0.0,9)
  109 CONTINUE
      DEGRAD = 0.017452329
      DO 111 I=1,361
      ANGI = DEGRAD * ( I - 1 )
      X(I) = XX + RAD * COS(ANGI)
  111 Y(I) = YY + RAD * SIN(ANGI)
      X(362) = 0.0
      Y(362) = 0.0
      X(363) = 1.0
      Y(363) = 1.0
      CALL LINE(X,Y,361,1,0,0)
      SQTWR = 1.414214
      IF(TIC.LE.0)  GO TO 112
C     PLOT P, T SYMBOLS
      HT = 0.07 * RAD
      R = SQTWR * SIN(GAM/2.)  * RAD
      X = XX + R * SIN(ALP) - 0.3 * HT
      Y = YY + R * COS(ALP) - 0.5 * HT
      CALL SYMBOL(X,Y,HT,1HP,0.0,1)
      R = SQTWR * SIN(BET/2.)  * RAD
      X = XX + R * SIN(DEL) - 0.3 * HT
      Y = YY + R * COS(DEL) - 0.5 * HT
```

```
      CALL SYMBOL(X,Y,HT,1HT,0.0,1)
  112 CONTINUE
      TWPI = 6.2831853
      DINC = 1.
      NP = 179
      X1 = SIN(BET)*COS(DEL)
      Y1 = SIN(BET) * SIN(DEL)
      Z1 = COS(BET)
      X2 = SIN(GAM)*COS(ALP)
      Y2 = SIN(GAM)*SIN(ALP)
      Z2 = COS(GAM)
      CALL DIPDD(X1+X2,Y1+Y2,Z1+Z2,GAMMA(1),DELTA(1))
      CALL DIPDD(X1-X2,Y1-Y2,Z1-Z2,GAMMA(2),DELTA(2))
      WRITE(51,1) ((GAMMA(L),DELTA(L)),L=1,2)
    1 FORMAT(1H ,20X,4F10.3)
      DO 2 I = 1,2
      GAMMA(I) = GAMMA(I) - 180.
      IF(GAMMA(I).LT.0) GAMMA(I) = GAMMA(I) + 360.
    2 CONTINUE
      DO 100 K = 1,2
      IF(DELTA(K).GE.1.) GO TO 50
      NPOINT = NP+2
      DO 40 I=1,NPOINT
      THETA =(GAMMA(K)-90.+(I-1)*DINC)*DEGRAD
      IF(THETA.LT.0) THETA = THETA + TWPI
      IF(THETA.GT.TWPI) THETA = THETA-TWPI
      X(I) = RAD * SIN(THETA) + XX
      Y(I) = RAD * COS(THETA) + YY
   40 CONTINUE
      GO TO 90
   50 IF(ABS(DELTA(K)-90.).GE.1.) GO TO 70
      NPOINT = 2
      DO 60 I=1,2
      THETA =(GAMMA(K)-90.+(I-1)*180.)*DEGRAD
      IF(THETA.LT.0) THETA = THETA + TWPI
      IF(THETA.GT.TWPI) THETA = THETA - TWPI
      X(I) = RAD * SIN(THETA) + XX
      Y(I) = RAD * COS(THETA) + YY
   60 CONTINUE
      GO TO 90
   70 THETA = (GAMMA(K)-90.) * DEGRAD
      IF(THETA.LT.0) THETA = THETA + TWPI
      X(1) = RAD * SIN(THETA) + XX
      Y(1) = RAD * COS(THETA) + YY
      THETA=(GAMMA(K)+90.) * DEGRAD
      IF(THETA.GT.TWPI) THETA = THETA - TWPI
      X(NP+2) = RAD * SIN(THETA) + XX
      Y(NP+2) = RAD * COS(THETA) + YY
      NPOINT = NP + 2
      TANI = TAN ((90.-DELTA(K))*DEGRAD)
```

```
      DO 80 I=1,NP
      THETA = GAMMA(K)-90. + I*DINC
      IF(THETA.LT.0) THETA = THETA + 360.
      IF(THETA.GT.360.) THETA = THETA - 360.
      ALPHA = (THETA-GAMMA(K)) * DEGRAD
      XJ = ATAN(TANI/COS(ALPHA))
      R = SQTWR * SIN(XJ/2.) * RAD
      X(I+1) = R*SIN(THETA*DEGRAD) + XX
      Y(I+1) = R*COS(THETA*DEGRAD) + YY
   80 CONTINUE
   90 CONTINUE
      X(NPOINT+1) = 0.0
      Y(NPOINT+1) = 0.0
      X(NPOINT+2) = 1.0
      Y(NPOINT+2) = 1.0
      CALL LINE(X,Y,NPOINT,1,0,0)
  100 CONTINUE
      RETURN
      END

      FUNCTION TAN(Z)
      TAN = SIN(Z)/COS(Z)
      RETURN
      END
```

DATA PAGE 1

```
03 APR 74
173.22    76.01     266.78    76.01     1.0       2.0       0.0       5.5
AAM       42.3      49.       551.0          X
BLO       64.4      67.       149.4          D
BLA       102.8     47.       689.8          D
CPO       146.2     49.       399.4          C
OXF       194.8     49.       468.0          X
CGM       222.3     49.       191.1          D
GRV       230.2     49.       266.5          D
ROL       258.5     49.       340.8          D
TYS       267.8     49.       218.0          D
SLM       271.5     49.       188.8          D
GOL       274.7     47.       1498.8         D
HALT

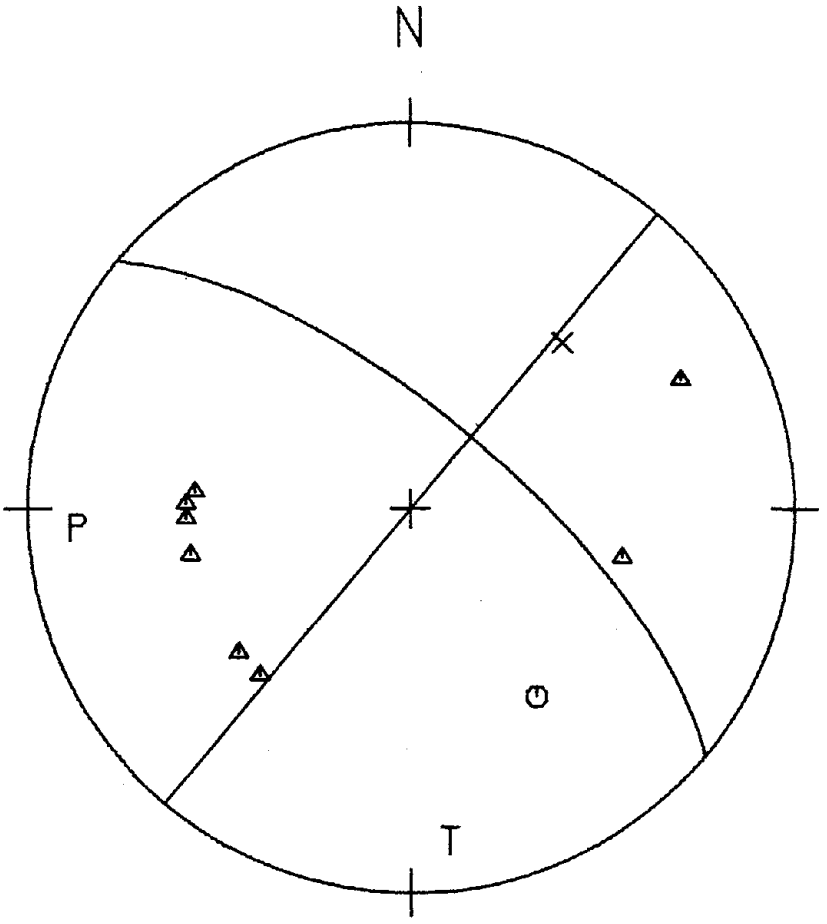
-1.
```

03 APR 74

173.220	76.018	266.780	76.010
219.988	70.008	309.988	90.000

STA	AZ	DIST(KM)	DIST(DEG)	IO (DEG)	
AAM	42.3	551.0	5.0	49.0	X
BLO	64.4	149.4	1.3	67.0	D
BLA	102.8	689.8	6.2	47.0	D
CPO	146.2	399.4	3.6	49.0	C
OXF	194.8	468.0	4.2	49.0	X
CGM	222.3	191.1	1.7	49.0	D
GRV	230.2	266.5	2.4	49.0	D
ROL	258.5	340.8	3.1	49.0	D
TYS	267.8	218.0	2.0	49.0	D
SLM	271.5	188.8	1.7	49.0	D
GOL	274.7	1498.8	13.5	47.0	D

3 APR 74



VI. EDABAC

PROGRAMMER : U. CHANDRA, A. NECIOGLU, R. B. HERRMANN /
JUNE 1972

PURPOSE:

This program accepts epicenter coordinates together with station coordinates and calculates epicentral distance, azimuth, back azimuth, P and S arrival times, P and S take off angles at the source, angles of incidence of P and S at base of crust, P and S wave mantle attenuation factors, and P and S wave geometrical spreading factors. Up to 150 stations can be used for a given epicenter.

INPUT/OUTPUT

The epicentral coordinates, origin time, and focal depth are accepted from card. The station coordinates are also from card. The Jeffreys-Bullen P and S wave arrival times for various focal depths are taken from FILE 01. Output is on printer.

THEORY

The meaning of the output of this program must be discussed. The output, for NOPTION.EQ.3, contains the following columns.

NO — Number of the station in order of initial input

STA — This is a four letter identification code for the station.

EPIDIST KM — Distance in kilometers from epicenter to station on an elliptical earth.

EPIDIST DEG — Distance in degrees from epicenter to station on an elliptical earth.

P WAVE H M S — Predicted Jeffreys-Bullen P wave arrival time for given origin time and focal coordinates at the station.

S WAVE H M S — Predicted Jeffreys-Bullen S wave arrival time at the station.

AZ DEG — Azimuth in degrees from epicenter to station.

BAZ DEG	Back azimuth from station to epicenter in degrees.
ID P DEG	P wave angle of incidence at source
IO P DEG	P wave angle of incidence in degrees at the free surface.
GEOM SPREAD P	P wave geometrical spreading factor. (See below).
ATTEN FACTOR P	P wave anelastic attenuation factor due to Q structure of earth. (See below)
ID S DEG	S wave angle of incidence at source
IO S DEG	S wave angle of incidence at the free surface
GEOM SPREAD S	S wave geometrical spreading factor. (See below).
ATTEN FACTOR S	S wave anelastic attenuation factor due to Q structure of earth. (See below).

The travel times for a given distance and focal depth are obtained by linear interpolation of the Jeffreys-Bullen travel time tables. The angles of incidence are obtained by using the definition of the ray parameter $p = r \sin i / v$.

The effects of geometrical spreading of the seismic ray and the anelasticity of the earth were considered by Ben-Menahem et al (1965) and Teng and Ben-Menahem (1965). They stated that the total dimunition of amplitude along a ray is

$$D \exp(-\omega g(\Delta;h))$$

where D is the GEOM SPREAD factor above and is defined as

$$D = \frac{1}{r_o} \quad \frac{\sin_h}{\cos i_o \sin \Delta} \quad \frac{di_h}{d\Delta}$$

where r_o is the radius of the earth's crust = 6338 km, i_h is the angle of incidence of the ray at the source, i_o is the angle of incidence of the ray at the base of the crust, and Δ is the epicentral distance in degrees.

The anelastic attenuation factor was approximated by the relation

$$g(\Delta ; h) = \frac{r_o}{v(a)} \frac{\sin (i_h - i_o)}{\sin i_h} \quad 10^{-3} \text{ sec.}$$

For P waves, v(a) = 7.76 km/sec; for S waves, v(a) = 4.6 km/sec.

REFERENCES

Ben-Menahem, A., S. W. Smith, and T. Teng (1965). A procedure for source studies from spectrums of long period seismic body waves, Bull. Seism. Soc. Am. 55, 203-235.

Teng, T., and A. Ben-Menahem (1965). Mechanisms of deep earthquakes from spectrums of isolated body-wave signals. 1. The Banda Sea earthquake of March 21, 1964, J. Geophys. Res. 70, 5157-5170.

PROGRAM UNITS

PROGRAM EDABAC : This is the main input-output control link.

SUBROUTINE AZEP : This calculates the epicentral distance, azimuths, and back azimuths to each station.

SUBROUTINE STIME : This calculates the S arrival time from the J-B tables.

SUBROUTINE SANG : This calculates the S wave angle of incidence at the source.

SUBROUTINE GMMMM : This calculates the geometric spreading factor and anelastic attenuation factor for S waves as well as the angle of incidence of the S wave at the free surface.

SUBROUTINE PTIME : This calculates the P arrival time by interpolating the J-B P travel time table entries.

SUBROUTINE PANG : This determines the P wave angle of incidence at the source.

SUBROUTINE GEOMS : This calculates the geometrical spreading factor and the anelastic attenuation factor for P waves together with the angle of incidence of the P wave at the free surface.

INPUT DATA

Card Sequence	Column	Name	Format	Explanation
A.	1-3	NOPTION	I3	EQ.1 azimuth, back azimuth, distance, P & S arrival times outputted EQ.2 P&S angles of incidence as well as output of above. EQ.3 attenuation and spreading factors for P and S in addition all the information above.
B.	1-4	ENAME	A4	Epicenter identification
	5-13	EP	F9.3	Epicenter latitude, N = positive
	14-22	EL	F9.3	Epicenter longitude E = positive
	23-25	CNTRL	F3.0	LT 0 end program EQ 0 use stations previously read in GT 0 read in station cards
	29-31	IOH	I3	Origin time hour

Card Sequence	Column	Name	Format	Explanation
	34-36	IOM	I3	Origin time minutes
	39-43	OS	F5.1	Origin time second and tenth of second
	44-48	H	F5.0	Focal depth in kilometers
	54-56	IDAY	I3	Day of event
	59-61	IMO	I3	Month of event
	64-66	IYR	I3	Year of event

C. If CONTRL GT 0 read in the following data cards

1-4	STN	A4	Station abbreviation
5-13	STNP	F9.3	Station latitude N = positive
14-22	STNL	F9.3	Station longitude E = positive

Continue reading until last card of station set has STNP GE 100. This tells the program that all stations have been entered.

At this point the program returns to B to read in a new ENAME, EP, EL, etc. data card.

```
C      PROGRAM EDABAC
C      THIS PROGRAM IS FOR CALCULATING AZIMUTH, EPICENTRAL DISTANCE
       DIMENSION PV(14),SV(14)
       DIMENSION JP(120,14),JS(122,14) ,DEL(122)
       DIMENSION STN(150),STNP(150),STNL(150)
       COMMON STN,STNP,STNL,EPILC,EPIPC,RAD,ESQ1,JS,JP,DEL,W,R,H,OT,ANGI,
      1PV,SV,VP,VS,EPIPR
       DO 715 I=1,120
       READ(01,710) (JP(I,J),J=1,14)
  710  FORMAT(14I5)
  715  CONTINUE
       DO 725 I=1,122
       READ(01,720) (JS(I,J),J=1,14),DEL(I)
  720  FORMAT(14I5,F6.1)
  725  CONTINUE
       READ(01,700) (PV(I),SV(I),I=1,14)
  700  FORMAT( 7(F5.2,F4.2))
       READ 403,NOPTION
  403  FORMAT(I3)
C      NOPTION=1 IS TO CALCULATE DISTANCE AZIMUTH, BACK AZIMUTH, P + S
C      TRAVEL TIMES.
C      NOPTION=2 IN ADDITION TO ABOVE QUANTITIES TAKE OFF ANGLES OF P + S
C      WAVES ARE CALCULATED.
C      NOPTION=3 IS FOR ALL ABOVE QUANTITIES + ATTENUATION + GEOMETRICAL
C      SPREADING.
 3000  READ 1,    ENAME,EP,EL,CNTRL,IOH,IOM,OS,H,IDAY,IMO,IYR
    1  FORMAT(A4,F9.3,F9.3,F3.0,3X,I3,2X,I3,2X,F5.1,F5.0,5X,I3,2X,I3,
      12X,I3)
       IF(CNTRL.LT.0) GO TO 26
       PRINT 272, ENAME,IDAY,IMO,IYR
  272  FORMAT(1H1,26HEPICENTER INDENT. NO. IS  ,A4,5X,3HDAY,2X,I3,3X,
      15HMONTH,2X,I3,3X,4HYEAR,2X,I3)
       PRINT 273 ,EP,EL
  273  FORMAT(1H ,11HLOCATION   ,F9.3,2X,4HLAT.,3X,F9.3,2X,5HLONG.)
       PRINT 275,H,IOH,IOM,OS
  275  FORMAT(1H ,16HDEPTH OF FOCUS= ,F7.0,1X,2HKM,2X,13HORIGIN TIME= ,
      1I3,1X,4HHOUR,I3,1X,3HMIN,F5.1,1X,3HSEC,1X,3HGMT,//)
       IF(CNTRL) 26,2000,2000
 2000  DO 3 I= 1,150
       READ 2, STN(I),STNP(I),STNL(I)
    2  FORMAT(A4,F9.3,F9.3)
       IF(STNP(I)-100.) 3,2009,2009
    3  CONTINUE
 2009  N= I-1
 2001  ESQ1=0.9932315
       IF(NOPTION-2) 550,555,560
  550  PRINT 565
  565  FORMAT(1H ,10X,15HEPIDIST EPIDIST,3X,7HP  WAVE,5X,7HS  WAVE,6X,
      C2HAZ,4X,3HBAZ)
       PRINT 570
```

```
  570 FORMAT(1H ,6HNO.STA,6X,3HKM.,5X,3HDEG,4X,4HH  M,4X,5HS   H,2X,6HM
     C   S,4X,3HDEG,4X,3HDEG  /)
      GO TO 573
  555 PRINT 571
  571 FORMAT(1H ,10X,15HEPIDIST EPIDIST,3X,7HP  WAVE,5X,7HS  WAVE,6X,2HA
     CZ,4X,3HBAZ,3X,4HID P,3X,4HID P,3X,4HID S,3X,4HID S )
      PRINT 572
  572 FORMAT(1H ,6HNO.STA,6X,3HKM.,5X,3HDEG,4X,4HH  M,4X,5HS   H,2X,6HM
     C   S,4X,3HDEG,4X,3HDEG,3X,3HDEG,3X,3HDEG  /)
      GO TO 573
  560 PRINT 9002
 9002 FORMAT(1H ,10X,15HEPIDIST EPIDIST,3X,7HP  WAVE,5X,7HS  WAVE,6X,2HA
     CZ,4X,3HBAZ,3X,4HID P,3X,4HID P,5X,4HGEOM,6X,5HATTEN,5X,4HID S,3X,
     C4HID S,4X,4HGEOM,6X,5HATTEN  )
      PRINT 9003
 9003 FORMAT( 1H ,6HNO.STA,6X,3HKM.,5X,3HDEG,4X,4HH  M,4X,5HS   H,2X,5HM
     C   S,5X,3HDEG,4X,3HDEG,3X,3HDEG,4X,3HDEG,4X,8HSPREAD P,3X,8HFACTOR
     C P,2X,3HDEG,3X,3HDEG,3X,8HSPREAD S,2X,8HFACTOR S    /)
  573 RAD=0.01745329
      EPIPR = EP * RAD
      EPIPR = 90.*RAD-ATAN(ESQ1*(SIN(EPIPR)/COS(EPIPR)))
      EPIPC = EPIPR/RAD
      IF(EL) 200,201,201
  200 EPILC = 360.+EL
      GO TO 202
  201 EPILC=EL
  202 NH=IOH*60
      NM=(IOM+NH)*60
      DM=NM
      OT=DM+OS
      IF(H-33.)300,300,305
  300 J=1
      VP=PV(J)+(PV(J+1)-PV(J))*H/33.
      VS=SV(J)+(SV(J+1)-SV(J))*H/33.
      GO TO 904
  305 DO 310 KL=1,12
      AK=KL
      Q=33.+AK*63.38
      IF(H-Q)315,315,310
  310 CONTINUE
  315 J=KL+1
      R=H-Q
      R = ABS(R)
      VP=PV(J+1)+(PV(J)-PV(J+1))*R/63.38
      VS=SV(J+1)+(SV(J)-SV(J+1))*R/63.38
  904 DO 5 I=1,N
      CALL AZEP(RANGE,AZ,BAZ,I)
      IF(H-97.)101,101,106
  101 IF(ANGI   -107.)141,141,147
  106 IF(H-287.)111,111,116
```

```
  111 IF(ANGI   -106.)141,141,147
  116 IF(H-540.)121,121,126
  121 IF(ANGI   -105.)141,141,147
  126 IF(H-667.)131,131,146
  131 IF(ANGI   -104.)141,141,147
  146 IF(H-800.)151,151,147
  151 IF(ANGI   -103.)141,141,147
  141 IF(ANGI   -10.)320,335,335
  320 W=2.
      DO 325 NN=1,20
      AN=NN
      AN=AN*.5
      IF(ANGI   -AN)330,330,325
  325 CONTINUE
  330 K=NN+2
      GO TO 380
  335 W=1.
      DO 345 NM=10,107
      AN=NM
      IF(ANGI   -AN)350,350,345
  345 CONTINUE
  350 K=NM+12
  380 CALL STIME (ISHOU,ISMIN,SSEC,K,J,I)
      IF(NOPTION-1) 385,390,385
  385 CALL SANG(SAN,K,J)
      IF(K-6) 35,30,30
   30 KDUM = K
      GO TO 40
   35 KDUM=6
   40 CONTINUE
      CALL SANG(SAN1,KDUM-4,J)
      CALL SANG(SAN2,KDUM+4,J)
      DIDDS=(SAN2-SAN1)/(DEL(KDUM+4)-DEL(KDUM-4))
      CALL GMMMN(GEUSS,ATTENS,SISUR,SAN,DIDDS,DEL(KDUM))
C     FOR GEOMETRICAL SPREADING AND APPROXIMATE MANTLE ANELASTIC
C     ATTENUATION SEE TENG AND BEN-MENAHEM, J GEOPHYS RES, VOL 70,
C     OCT 65, P 5157
C     IT IS ASSUMED THAT Q(ALPHA) = Q(BETA)
  390 IF(H-33.) 100,100,105
  100 IF(ANGI   -105.)140,140,145
  105 IF(H-287.)110,110,115
  110 IF(ANGI   -104.)140,140,145
  115 IF(H-540.)120,120,125
  120 IF(ANGI   -103.)140,140,145
  125 IF(H-800.)130,130,145
  130 IF(ANGI   -102.)140,140,145
  140 CALL PTIME(IPHOU,IPMIN,PSEC,K,J,I)
      IF(NOPTION-1) 485,490,485
  485 CALL PANG(PAN,K,J)
      IF(K-6)15,25,25
```

```
   15 K=6
   25 CONTINUE
      CALL PANG(PAN1,K-4,J)
      CALL PANG(PAN2,K+4,J)
      DIDD=(PAN2-PAN1)/(DEL(K+4)-DEL(K-4))
      CALL GEOMS(GEOSP,ATTEN,PISUR,PAN,DIDD,DEL(K))
      GO TO 490
  147 ISHOU = 0
      ISMIN = 0
      SSEC = 0.0
      SAN = 0.0
      SISUR = 0.0
      GEOSS = 0.0
      ATTENS = 0.0
  145 IPHOU = 0
      IPMIN = 0
      PSEC = 0.0
      PAN = 0.0
      PISUR = 0.0
      GEOSP = 0.0
      ATTEN = 0.0
  490 IF(NOPTION-2) 500,510,9000
  500 PRINT 530,     I,STN(I),RANGE,ANGI,IPHOU,IPMIN,PSEC,ISHOU,ISMIN,SSE
     CC,AZ,BAZ
      GO TO 5
  530 FORMAT(1H ,I3,A4,F10.1,F8.1,2I3,F5.1,I4,I3,F5.1,2F7.1)
  510 PRINT 535,     I,STN(I),RANGE,ANGI,IPHOU,IPMIN,PSEC,ISHOU,ISMIN,
     1SSEC,AZ,BAZ,PAN,PISUR,SAN,SISUR
  535 FORMAT(1H ,I3,A4,F10.1,F8.1,2I3,F5.1,I4,I3,F5.1,6F7.1)
      GO TO 5
 9000 PRINT 9001,     I,STN(I),RANGE,ANGI,IPHOU,IPMIN,PSEC,ISHOU,ISMIN,SS
     CEC,AZ,BAZ,PAN,PISUR,GEOSP,ATTEN,SAN,SISUR,GEOSS,ATTENS
 9001 FORMAT(1H ,I3,A4,F10.1,F8.1,2I3,F5.1,I4,I3,F5.1,4F7.1,2F11.7,2F6.1
     C,2F10.6)
    5 CONTINUE
      GO TO 3000
   26 CONTINUE
      END

      SUBROUTINE AZEP(RANGE,AZ,BAZ,I)
      DIMENSION JP(120,14),JS(122,14) ,DEL(122)
      DIMENSION STN(150),STNP(150),STNL(150)
      DIMENSION PV(14),SV(14)
      COMMON STN,STNP,STNL,EPILC,EPIPC,RAD,ESQ1,JS,JP,DEL,W,R,H,OT,ANGI,
     1PV,SV,VP,VS,EPIPR
      STPC=STNP(I)*RAD
      STNPR = 90.*RAD-ATAN(ESQ1*(SIN(STPC)/COS(STPC)))
      STPC=STNPR/RAD
      IF(STNL(I)) 211,212,212
  211 STLC=360.+STNL(I)
```

```
      GO TO 213
  212 STLC=STNL(I)
  213 IF(STPC-180.0)69,68,68
   68 ANGI   =180.0-EPIPC
      AZ    =180.0
      BAZ   =0.0
      GO TO 998
C     CONVERT STA. COORDINATES TO RADIANS
   69 PANG = ABS(STLC - EPILC)
      IF(PANG-180.0)71,71,70
   70 PANG=360.0-PANG
   71 PANG=PANG*RAD
      ANGI = COS(EPIPR)*COS(STNPR)+SIN(EPIPR)*SIN(STNPR)*COS(PANG)
      SNANG = SQRT(ABS(1.-ANGI*ANGI))
      ANGI = ATAN(SNANG/ANGI)
      IF(ANGI   )220,221,221
  220 ANGI   =ANGI   +3.1415927
  221 AZ = (COS(STNPR)-COS(EPIPR)*COS(ANGI))/(SIN(EPIPR)*SIN(ANGI))
      SNAZ = SQRT(ABS(1.-AZ*AZ))
      AZ = ATAN(SNAZ/AZ)
      IF(AZ   ) 230,231,231
  230 AZ    =AZ    +3.1415927
  231 AZ    =57.295780*AZ
      BAZ = (COS(EPIPR)-COS(STNPR)*COS(ANGI))/(SIN(STNPR)*SIN(ANGI))
      SNBAZ = SQRT(ABS(1.-BAZ*BAZ))
      BAZ = ATAN(SNBAZ/BAZ)
      IF(BAZ   ) 240,241,241
  240 BAZ   =BAZ   +3.1415927
  241 BAZ   =BAZ   *57.295780
      ANGI   =ANGI   *57.295780
      IF(STLC-EPILC)72,74,73
   72 IF(STLC-EPILC+180.0)80,77,81
   73 IF(STLC-EPILC-180.)80,77,81
   74 IF(STPC-EPIPC)75,78,76
   75 AZ    =0.
      BAZ   =180.
      GO TO 998
   76 AZ    =180.
      BAZ   =0.
      GO TO 998
   77 IF(STPC+EPIPC-180.0)78,79,79
   78 AZ    =0.
      BAZ   =0.
      GO TO 998
   79 AZ    =180.
      BAZ   =180.
      GO TO 998
   80 BAZ   =360.0-BAZ
      GO TO 998
   81 AZ    =360.0-AZ
```

```
  998 RANGE=ANGI    *111.195
      RETURN
      END

      SUBROUTINE STIME(ISHOU,ISMIN,SSEC,K,J,I)
      DIMENSION JP(120,14),JS(122,14) ,DEL(122)
      DIMENSION STN(150),STNP(150),STNL(150)
      DIMENSION PV(14),SV(14)
      COMMON STN,STNP,STNL,EPILC,EPIPC,RAD,ESQ1,JS,JP,DEL,W,R,H,OT,ANGI,
     1PV,SV,VP,VS,EPIPR
      SJ1=JS(K,J)
      SJ1=SJ1/10.
      SJ2=JS(K+1,J)
      SJ2=SJ2/10.
      SJ3=JS(K,J+1)
      SJ3=SJ3/10.
      SJ4=JS(K+1,J+1)
      SJ4=SJ4/10.
      ST1=SJ1+(SJ2-SJ1)*W*(ANGI    -DEL(K))
      ST2=SJ3+(SJ4-SJ3)*W*(ANGI    -DEL(K))
      IF(J-1)390,390,395
  390 ST=ST1+(ST2-ST1)*H/33.
      GO TO 398
  395 ST=ST2+(ST1-ST2)*R/63.38
  398 SAT=OT+ST
      SO=SAT/3600.
      ISHOU =SO
      SH=ISHOU
      SM1=(SO-SH)*60.
      ISMIN=SM1
      SM2=ISMIN
      SSEC=(SM1-SM2)*60.
      IF(ISHOU-24)530,530,531
  531 ISHOU=ISHOU-24
  530 ISHOU=ISHOU
      RETURN
      END

      SUBROUTINE SANG(SAN,K,J)
      DIMENSION JP(120,14),JS(122,14) ,DEL(122)
      DIMENSION STN(150),STNP(150),STNL(150)
      DIMENSION PV(14),SV(14)
      COMMON STN,STNP,STNL,EPILC,EPIPC,RAD,ESQ1,JS,JP,DEL,W,R,H,OT,ANGI,
     1PV,SV,VP,VS,EPIPR
      SJ5=JS(K-2,J)
      SJ5=SJ5/10.
      SJ6=JS(K+2,J)
      SJ6=SJ6/10.
      SJ7=JS(K-2,J+1)
      SJ7=SJ7/10.
```

```
      SJ8=JS(K+2,J+1)
      SJ8=SJ8/10.
      H1=SJ6-SJ5
      H2=SJ8-SJ7
      IF(J-1)600,600,601
  600 BH=H1+(H2-H1)*H/33.
      GO TO 602
  601 BH=H2+(H1-H2)*R/63.38
  602 U=BH*VS*6371./((DEL(K+2)-DEL(K-2))*111.195*(6371.-H))
      U = ABS(U)
      IF(U-1.)511,516,516
  511 SAN = ATAN(U/SQRT(1.-U*U))
      GO TO 517
  516 SAN=1.5708
  517 SAN=SAN*57.2958
      RETURN
      END

      SUBROUTINE GMMMB(GSP,FRAT,ANGS,Q,DIFN,D)
      DIMENSION JP(120,14),JS(122,14),DEL(122)
      DIMENSION PV(14),SV(14)
      DIMENSION STN(150),STNP(150),STNL(150)
      COMMON STN,STNP,STNL,EPILC,EPIPC,RAD,ESQ1,JS,JP,DEL,W,R,H,QT,ANGI,
     1PV,SV,VP,VS,EPIFR
      QQ=Q*RAD
      S = 4.6*(6371.-H)*SIN(QQ)/(VS*6338.)
      S = ABS(S)
      IF(S-1.)10,15,15
   15 QI=1.57
      GO TO 20
   10 CONTINUE
      C = SQRT(1.-S*S)
      QI = ATAN(S/C)
      DD= D*RAD
      HI = 3.141-QQ
      GSP=(SQRT(ABS(SIN(HI)*DIFN/(C*SIN(DD)))))/6338.
      FRAT = (6.338/4.6)*ABS(SIN(HI-QI)/SIN(HI))
      GO TO 21
   20 GSP = 0.0
      FRAT = 0.0
   21 CONTINUE
      PS = 3.5*(6371.-H)*SIN(QQ)/(VS*6371.)
      PS = ABS(PS)
      IF(PS-1.) 25,30,30
   30 ANGS = 1.57
      GO TO 35
   25 CONTINUE
      CS = SQRT(1.-PS*PS)
      ANGS = ATAN(PS/CS)
   35 ANGS = ANGS*57.2958
```

```
      RETURN
      END

      SUBROUTINE PTIME(IPHOU,IPMIN,PSEC,K,J,I)
      DIMENSION PV(14),SV(14)
      DIMENSION STN(150),STNP(150),STNL(150)
      DIMENSION JP(120,14),JS(122,14) ,DEL(122)
      COMMON STN,STNP,STNL,EPILC,EPIPC,RAD,ESQ1,JS,JP,DEL,W,R,H,OT,ANGI,
     1PV,SV,VP,VS,EPIPR
      PJ1=JP(K,J)
      PJ1=PJ1/10.
      PJ2=JP(K+1,J)
      PJ2=PJ2/10.
      PJ3=JP(K,J+1)
      PJ3=PJ3/10.
      PJ4=JP(K+1,J+1)
      PJ4=PJ4/10.
      PT1=PJ1+(PJ2-PJ1)*W*(ANGI    -DEL(K))
      PT2=PJ3+(PJ4-PJ3)*W*(ANGI    -DEL(K))
      IF(J-1)391,391,396
  391 PT=PT1+(PT2-PT1)*R/33.
      GO TO 397
  396 PT=PT2+(PT1-PT2)*R/63.38
  397 PAT=OT+PT
      HO=PAT/3600.
      IPHOU =HO
      PH=IPHOU
      RM1=(HO-PH)*60.
      IPMIN=RM1
      RM2=IPMIN
      PSEC=(RM1-RM2)*60.
      IF(IPHOU-24)520,520,521
  521 IPHOU=IPHOU-24
  520 IPHOU=IPHOU
      RETURN
      END

      SUBROUTINE PANG(PAN,K,J)
      DIMENSION PV(14),SV(14)
      DIMENSION STN(150),STNP(150),STNL(150)
      DIMENSION JP(120,14),JS(122,14) ,DEL(122)
      COMMON STN,STNP,STNL,EPILC,EPIPC,RAD,ESQ1,JS,JP,DEL,W,R,H,OT,ANGI,
     1PV,SV,VP,VS,EPIPR
      PJ5=JP(K-2,J)
      PJ5=PJ5/10.
      PJ6=JP(K+2,J)
      PJ6=PJ6/10.
      PJ7=JP(K-2,J+1)
      PJ7=PJ7/10.
      PJ8=JP(K+2,J+1)
```

```
      PJ8=PJ8/10.
      G1=PJ6-PJ5
      G2=PJ8-PJ7
      IF(J-1)500,500,501
  500 G=G1+(G2-G1)*H/33.
      GO TO 502
  501 G=G2+(G1-G2)*R/63.38
  502 C=G*VP*6371./((DEL(K+2)-DEL(K-2))*111.195*(6371.-H))
      Y = ABS(C)
      IF(Y-1.)510,515,515
  510 PAN = ATAN(Y/SQRT(1.-Y*Y))
      GO TO 518
  515 PAN=1.5708
  518 PAN=PAN*57.2958
      RETURN
      END

      SUBROUTINE GEOMS(GSP,FRAT,ANGS,Q,DIFN,D)
      DIMENSION JP(120,14),JS(122,14) ,DEL(122)
      DIMENSION PV(14),SV(14)
      DIMENSION STN(150),STNP(150),STNL(150)
      COMMON STN,STNP,STNL,EPILC,EPIPC,RAD,ESQ1,JS,JP,DEL,W,R,H,OT,ANGI,
     1PV,SV,VP,VS,EPI,FR
      QQ=Q*RAD
      S=7.706*(6371.-H)*SIN(QQ)/(VP*6338.)
      S = ABS(S)
      IF(S-1.)10,15,15
   15 OI=1.57
      GO TO 20
   10 CONTINUE
      C = SQRT(1.-S*S)
      OI = ATAN(S/C)
      DD=D*RAD
      HI=3.141-QQ
      GSP=(SQRT(ABS(SIN(HI)*DIFN/(C*SIN(DD)))))/6338.
      FRAT=.816752*ABS(SIN(HI-OI)/SIN(HI))
      GO TO 21
   20 GSP=0.0
      FRAT=0.
   21 CONTINUE
      PS=5.6*(6371.-H)*SIN(QQ)/(VP*6371.)
      PS = ABS(PS)
      IF(PS-1.)25,30,30
   30 ANGS=1.57
      GO TO 35
   25 CONTINUE
      CS = SQRT(1.-PS*PS)
      ANGS=ATAN(PS/CS)
   35 ANGS=ANGS*57.2958
      RETURN
```

```
      END
```

-76	-46	93	190	275	354	429	503	574	639	704	764	824	884
-4	3	114	202	283	360	434	507	577	642	706	766	826	886
68	54	135	214	291	366	439	511	580	645	708	768	828	888
140	105	156	226	299	372	444	515	583	648	710	770	830	890
211	177	204	258	323	391	459	527	593	657	718	777	836	895
282	248	267	306	360	423	484	548	610	672	731	788	846	903
354	320	329	360	406	458	516	576	634	692	748	803	859	915
426	391	398	421	457	503	554	609	663	718	771	823	877	930
497	463	467	484	513	552	597	646	697	748	798	847	898	949
568	534	536	548	571	604	644	689	734	781	828	875	923	972
639	605	604	613	632	660	694	734	775	817	862	906	951	997
710	676	672	678	694	717	747	782	819	857	897	937	983	1024
781	747	741	744	756	775	801	833	865	899	935	973	1014	1054
852	817	809	810	820	835	857	884	913	943	976	1009	1049	1086
922	887	877	876	883	895	914	937	963	989	1018	1048	1082	1119
993	958	946	943	947	956	972	992	1014	1036	1061	1089	1120	1153
1063	1028	1016	1010	1011	1018	1031	1048	1065	1084	1106	1131	1159	1189
1133	1098	1084	1077	1075	1080	1090	1104	1118	1133	1152	1174	1199	1226
1203	1167	1152	1143	1140	1142	1149	1161	1171	1183	1198	1217	1240	1265
1273	1237	1220	1209	1205	1204	1208	1218	1225	1233	1245	1262	1282	1305
1342	1306	1287	1275	1269	1266	1268	1275	1279	1284	1293	1307	1325	1345
1411	1375	1355	1341	1333	1328	1328	1332	1333	1335	1341	1353	1368	1386
1480	1444	1422	1406	1397	1390	1388	1390	1386	1386	1389	1399	1412	1427
1617	1581	1556	1537	1525	1514	1508	1506	1493	1488	1487	1491	1500	1512
1753	1716	1689	1667	1651	1638	1628	1618	1599	1589	1586	1586	1590	1598
1887	1850	1821	1796	1776	1760	1747	1729	1705	1691	1685	1681	1681	1685
2019	1981	1950	1923	1900	1881	1863	1836	1809	1792	1782	1776	1772	1773
2150	2112	2079	2049	2023	2001	1970	1940	1911	1892	1879	1871	1864	1862
2280	2241	2205	2173	2144	2113	2076	2041	2012	1990	1975	1964	1955	1951
2407	2367	2329	2295	2260	2219	2180	2142	2112	2087	2069	2055	2045	2040
2532	2492	2452	2411	2365	2322	2281	2243	2211	2184	2163	2147	2135	2128
2655	2615	2565	2516	2467	2423	2381	2341	2308	2279	2256	2238	2225	2216
2770	2725	2671	2619	2569	2522	2479	2438	2403	2373	2348	2328	2313	2303
2874	2829	2773	2719	2668	2620	2576	2534	2497	2465	2439	2418	2402	2390
2975	2929	2872	2817	2765	2717	2672	2629	2590	2557	2530	2508	2490	2477
3074	3028	2969	2914	2862	2812	2765	2720	2681	2647	2619	2596	2577	2563
3171	3125	3065	3010	2956	2905	2857	2811	2771	2737	2708	2684	2664	2649
3268	3222	3162	3104	3049	2996	2947	2901	2861	2826	2796	2771	2750	2734
3362	3316	3255	3197	3141	3087	3038	2991	2950	2914	2884	2858	2836	2819
3454	3408	3347	3288	3232	3178	3128	3080	3039	3002	2971	2944	2921	2903
3545	3499	3438	3379	3322	3268	3217	3168	3126	3090	3057	3029	3006	2987
3635	3588	3527	3468	3411	3356	3305	3255	3214	3176	3143	3114	3090	3071
3725	3677	3616	3557	3499	3444	3392	3342	3300	3262	3228	3199	3174	3154
3813	3766	3704	3645	3586	3531	3478	3428	3386	3347	3313	3283	3257	3237
3901	3854	3791	3732	3673	3617	3564	3514	3471	3432	3397	3367	3341	3319
3988	3941	3878	3818	3759	3703	3649	3599	3555	3516	3481	3450	3423	3401
4075	4027	3964	3903	3844	3788	3734	3684	3639	3600	3564	3533	3505	3482
4161	4113	4049	3986	3929	3872	3818	3768	3723	3683	3647	3615	3587	3563
4246	4198	4134	4072	4013	3956	3902	3852	3806	3766	3729	3697	3668	3644
4330	4282	4218	4156	4097	4040	3985	3935	3889	3848	3811	3779	3749	3724

4414	4366	4301	4240	4180	4123	4068	4017	3971	3929	3893	3860	3830	3804
4498	4449	4384	4323	4263	4205	4150	4099	4053	4010	3974	3940	3910	3883
4581	4532	4467	4405	4345	4287	4232	4181	4134	4091	4054	4020	3989	3961
4663	4615	4549	4487	4427	4369	4313	4262	4215	4171	4134	4099	4067	4038
4745	4697	4631	4569	4508	4450	4394	4342	4295	4251	4213	4178	4145	4115
4827	4779	4713	4650	4589	4530	4474	4422	4374	4330	4291	4255	4222	4191
4908	4860	4794	4730	4669	4610	4554	4501	4453	4408	4369	4333	4298	4267
4989	4940	4874	4810	4748	4689	4633	4580	4531	4486	4446	4409	4374	4342
5068	5020	4953	4889	4827	4767	4711	4658	4608	4563	4522	4485	4449	4417
5147	5098	5032	4967	4904	4845	4788	4735	4685	4639	4598	4560	4524	4491
5226	5177	5110	5045	4982	4922	4865	4811	4761	4715	4673	4634	4598	4564
5303	5254	5187	5122	5058	4998	4941	4887	4836	4790	4748	4708	4671	4637
5380	5331	5264	5198	5134	5073	5016	4962	4911	4864	4821	4781	4744	4709
5456	5407	5340	5274	5209	5147	5090	5036	4985	4937	4894	4853	4816	4780
5532	5482	5415	5349	5283	5221	5164	5110	5058	5010	4965	4924	4886	4850
5607	5557	5490	5423	5357	5294	5237	5183	5130	5081	5036	4995	4956	4919
5680	5631	5563	5496	5430	5366	5309	5255	5201	5152	5106	5065	5026	4988
5754	5704	5636	5569	5502	5438	5380	5326	5272	5222	5176	5134	5094	5056
5826	5776	5708	5641	5573	5509	5451	5396	5342	5291	5245	5202	5162	5123
5898	5848	5779	5711	5644	5579	5520	5465	5410	5360	5313	5270	5229	5190
5968	5918	5849	5781	5714	5649	5589	5533	5478	5428	5381	5337	5295	5256
6038	5988	5918	5851	5783	5718	5658	5600	5545	5495	5448	5403	5361	5321
6107	6057	5987	5919	5851	5786	5725	5667	5612	5561	5514	5469	5426	5386
6175	6125	6055	5987	5918	5853	5791	5733	5678	5627	5579	5534	5490	5450
6243	6192	6122	6054	5985	5919	5857	5799	5744	5692	5644	5598	5554	5514
6309	6259	6189	6120	6051	5984	5922	5864	5809	5756	5708	5662	5618	5576
6375	6324	6254	6185	6116	6049	5986	5928	5873	5820	5771	5725	5680	5639
6440	6389	6319	6250	6180	6113	6050	5992	5936	5883	5834	5787	5742	5700
6504	6453	6383	6314	6244	6176	6113	6055	5998	5945	5896	5849	5803	5761
6568	6516	6446	6377	6307	6239	6176	6117	6060	6007	5957	5909	5864	5821
6631	6579	6508	6439	6369	6301	6237	6178	6121	6068	6017	5970	5924	5880
6693	6641	6570	6500	6430	6362	6298	6239	6181	6128	6077	6029	5983	5939
6754	6702	6631	6561	6491	6423	6359	6299	6241	6187	6136	6088	6042	5997
6815	6763	6691	6621	6551	6483	6419	6358	6300	6246	6194	6146	6100	6054
6875	6822	6751	6681	6611	6543	6478	6417	6358	6304	6252	6203	6157	6111
6934	6882	6809	6739	6670	6602	6537	6475	6416	6361	6309	6260	6213	6166
6992	6940	6868	6797	6728	6660	6595	6532	6473	6417	6365	6316	6268	6222
7050	6998	6925	6854	6785	6717	6652	6588	6529	6473	6421	6371	6323	6276
7107	7055	6982	6910	6841	6773	6708	6644	6584	6528	6476	6426	6377	6330
7163	7112	7038	6966	6896	6828	6763	6699	6639	6582	6530	6479	6431	6383
7218	7167	7093	7021	6951	6883	6817	6753	6693	6636	6583	6533	6483	6435
7273	7222	7148	7075	7005	6936	6870	6806	6746	6689	6636	6585	6536	6487
7327	7276	7202	7129	7058	6989	6923	6859	6798	6741	6688	6637	6587	6538
7380	7329	7255	7182	7111	7041	6975	6911	6850	6793	6739	6688	6638	6588
7432	7381	7307	7234	7162	7093	7027	6962	6901	6843	6790	6739	6688	6638
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7585	7533	7458	7385	7314	7244	7177	7112	7050	6992	6938	6886	6834	6784
7635	7582	7507	7434	7363	7293	7225	7160	7098	7040	6986	6933	6881	6831
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8057	8004	7928	7854	7782	7712	7644	7578	7515	7456	7400	7348	7296	7244
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8193	8140	8064	7990	7918	7848	7780	7715	7651	7592	7535	7483	7431	7380
8238	8185	8110	8036	7964	7894	7826	7760	7696	7637	7580	7528	7476	7425
8284	8231	8155	8081	8009	7939	7871	7804	7741	7682	7626	7573	7521	7470
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8462	8409	8332	8258	8186	8116	8047	7980	7917	7858	7802	7749	7697	7646
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107	92	236	377	515	651	783	912	1036	1155	1269	1379	1486	1590
234	181	275	400	530	663	792	920	1043	1160	1274	1383	1490	1594
361	305	358	457	574	697	819	942	1063	1176	1289	1396	1502	1604
488	435	466	541	639	748	863	979	1094	1203	1312	1417	1521	1621
615	561	572	638	719	815	920	1028	1136	1241	1344	1446	1546	1644
742	686	695	744	811	895	987	1087	1188	1287	1384	1482	1578	1673
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996	942	941	969	1014	1076	1149	1230	1315	1400	1486	1572	1660	1746
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1249	1195	1187	1201	1232	1278	1333	1397	1466	1536	1610	1684	1762	1841
1375	1321	1311	1319	1344	1382	1430	1486	1549	1612	1678	1748	1820	1894
1501	1447	1434	1438	1457	1489	1530	1578	1635	1691	1751	1813	1881	1950
1626	1572	1557	1557	1571	1597	1632	1674	1724	1774	1827	1883	1946	2009
1751	1697	1680	1676	1686	1707	1736	1774	1816	1859	1906	1956	2009	2070
1876	1821	1802	1796	1801	1817	1841	1875	1909	1946	1987	2031	2082	2134
2001	1946	1925	1916	1916	1928	1947	1976	2004	2035	2071	2108	2154	2200
2126	2070	2047	2035	2032	2039	2054	2077	2100	2125	2156	2188	2228	2269
2251	2195	2169	2154	2147	2150	2161	2180	2197	2216	2242	2269	2304	2340
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AAM   42,2833 -83,7333      ANN ARBOR                              MICHIGAN
ALE   82,4833-62,4000
ALQ   34,9416-106,4583
ATL   33,4333-084,3375
BLA   37,211  -080,421
BLC   64,3167-96,0167
BLO   39,1716 -86,5183
COL   64,9000-147,7933
CPSO  35,600  -85,569
DAL   32,8462 -96,7838
DUG   40,1950-112,8133
EDM   53,2217-113,3500
FCC   58,792  -94,0867
FFC   54,7666-102,0000
FRB   63,7467-68,5467
FSJ   54,4333-124,50
GOL   39,7003-105,3711
INK   68,2916 -133,5
JCT   30,4790-99,082
LHC   48,4166-89,2666
LUB   33,5833-101,8666
MBC   76,2333 -119,3333
MNT   45,5025 -73,6238
 MSO  46,8292-113,9406
OGD   41,0666 -74,6166
 ORT  35,9235-84,3118
OTT   45,3938 -75,7158
OXF   34,514  -089,411
PAL    41,007- 73,909
PHC    50,700 -127,433
PNT   49,3167-119,6167
RES    74,686  -94,900
ROL    37,917- 91,868
SCH   54,8166 -66,6833
SCP   40,8098 -77,8693
SES   50,3958-111,4167
SFA   47,1233 -70,8266
SHA   30,6947 -88,1397
SLM   38,6361 -90,2361
STJ   47,572  -52,733
TUC   32,2466-110,8350
TUL    35,910- 95,792
YKC   62,4601 -114,4601
WES   42,3846 -71,3220
     111,
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EPICENTER INDENT, NO, IS WTEX DAY 60 MONTH 16 YEAR 78
LOCATION 33,000 LAT, -100,700 LONG,
DEPTH OF FOCUS= 10, KM ORIGIN TIME= 11 HOUR 46 MIN 53,2 SEC GMT

NO,STA	EPIDIST KM,	EPIDIST DEG	P WAVE H	M	S	S WAVE H	M	S	AZ DEG	BAZ DEG	ID P DEG	IO P DEG	GEOM SPREAD P	ATTEN FACTOR P	ID S DEG	IO S DEG	GEOM SPREAD S	ATTEN FACTOR S
1AAM	1812,5	16,3	11	50	48,8	11	53	44,7	50,5	240,9	54,5	40,2	0,0005471	0,8818020	57,7	47,0	0,000678	1,194446
2ALE	5713,1	51,4	11	56	0,2	12	3	18,3	6,0	221,8	28,8	22,5	0,0000738	1,4801917	30,1	25,7	0,000068	2,491559
3ALQ	573,9	5,2	11	48	12,6	11	49	13,1	293,6	110,4	63,9	45,4	0,0009399	0,5021092	66,3	52,4	0.	0,
4ATL	1524,4	13,7	11	50	14,1	11	52	43,7	83,7	272,7	57,7	42,1	0,0005184	0,7733148	60,9	49,1	0,001474	0,822624
5BLA	1902,9	17,1	11	50	54,1	11	54	3,4	70,1	261,8	53,2	39,4	0,0005449	0,9200548	56,6	46,3	0,000669	1,273667
6BLC	3500,0	31,5	11	53	17,3	11	58	24,2	3,9	187,6	34,1	26,4	0,0001090	1,3872745	34,9	29,7	0,000101	2,333764
7BLO	1447,0	13,0	11	50	,9	11	52	27,0	57,8	246,1	57,7	42,1	0,0005184	0,7733148	60,9	49,1	0,001474	0,822624
8COL	4753,8	42,8	11	54	58,4	12	1	16,0	332,6	114,9	31,3	24,3	0,0000731	1,4382157	32,4	27,6	0,000084	2,418640
9CPSO	1420,9	12,8	11	49	57,8	11	52	21,4	74,1	262,6	58,8	42,7	0,0005640	0,7359537	61,7	49,7	0.	0,
10DAL	366,6	3,3	11	47	46,1	11	48	26,0	91,6	273,7	64,9	45,9	0,0021292	0,4042187	67,2	53,0	0.	0,
11DUG	1344,2	12,1	11	49	49,6	11	52	4,7	309,9	122,6	58,8	42,7	0,0005640	0,7359537	61,7	49,7	0.	0,
12EDM	2463,8	22,2	11	51	50,9	11	55	50,0	339,6	150,8	39,5	30,3	0,0003272	1,2759209	42,6	35,9	0,000405	2,030851
13FCC	2910,8	26,2	11	52	23,6	11	56	59,4	7,8	192,7	36,4	28,1	0,0001693	1,3411518	37,0	31,4	0,000209	2,256562
14FFC	2421,8	21,8	11	51	47,1	11	55	43,0	358,8	177,1	41,5	31,7	0,0003689	1,2314679	46,0	38,5	0,000454	1,876764
15FRB	4079,4	36,7	11	54	2,1	11	59	45,0	23,3	228,5	32,6	25,3	0,0000854	1,4157390	34,0	29,0	0,000079	2,362970
16FSJ	3028,4	27,2	11	52	31,3	11	57	16,7	329,0	132,2	35,6	27,5	0,0001550	1,3576789	36,4	30,9	0,000176	2,278949
17GOL	853,3	7,7	11	48	47,9	11	50	16,0	331,9	149,2	62,7	44,8	0,0008028	0,5716105	65,2	51,8	0.	0,
18INK	4448,9	40,0	11	54	29,9	12	0	35,4	341,7	134,9	31,7	24,6	0,0000732	1,4312361	33,0	28,1	0,000087	2,398235
19JCT	318,7	2,9	11	47	40,0	11	48	15,1	150,8	331,7	65,3	46,1	0.	0.	67,4	53,0	0.	0,
20LHC	1961,4	17,6	11	51	0,7	11	54	15,4	25,8	213,3	53,2	39,4	0,0005449	0,9200548	56,6	46,3	0,000669	1,273667
21LUB	126,4	1,1	11	47	15,2	11	47	31,2	301,1	120,4	62,8	44,8	0,0053289	0,5667062	64,4	51,3	0.	0,
22MBC	4914,2	44,2	11	55	6,1	12	1	37,0	353,7	157,3	30,9	24,0	0,0000755	1,4461977	31,8	27,1	0,000080	2,437157
23MNT	2699,4	24,3	11	52	11,6	11	56	27,5	51,1	248,5	37,9	29,2	0,0002447	1,3103685	39,0	33,1	0,000306	2,177818
24 MSO	1902,5	17,1	11	50	54,1	11	54	3,3	327,7	139,1	53,2	39,4	0,0005449	0,9200548	56,6	46,3	0,000669	1,273667
25OGD	2476,0	22,3	11	51	52,0	11	55	52,0	61,3	257,2	39,5	30,3	0,0003272	1,2759209	42,6	35,9	0,000405	2,030851
26 ORT	1538,3	13,8	11	50	11,8	11	52	46,6	73,3	262,6	57,7	42,1	0,0005184	0,7733148	60,9	49,1	0,001474	0,822624
27OTT	2543,7	22,9	11	51	56,0	11	56	3,0	50,0	245,9	39,5	30,3	0,0003272	1,2759209	42,6	35,9	0,000405	2,030851
28OXF	1058,6	9,5	11	49	13,5	11	51	1,9	77,8	264,0	60,9	43,9	0,0006738	0,6507455	63,6	50,8	0.	0,
29PAL	2532,7	22,8	11	51	57,0	11	56	1,3	61,8	258,1	39,5	30,3	0,0003272	1,2759209	42,6	35,9	0,000405	2,030851
30PHC	2937,0	26,4	11	52	31,8	11	57	3,2	320,0	121,8	36,4	28,1	0,0001693	1,3411518	37,0	31,4	0,000209	2,256562
31PNT	2396,3	21,6	11	51	44,8	11	55	38,7	324,7	132,1	41,5	31,7	0,0003689	1,2314679	46,0	38,5	0,000454	1,876764
32RES	4654,9	41,9	11	54	45,1	12	1	2,9	2,3	187,3	31,5	24,5	0,0000743	1,4344539	32,7	27,9	0,000086	2,407699
33ROL	969,0	8,7	11	49	4,4	11	50	41,9	53,3	238,4	61,9	44,4	0,0007139	0,6091725	64,8	51,6	0.	0,
34SCH	3592,6	32,3	11	53	24,6	11	58	37,2	37,3	241,6	33,8	26,1	0,0001030	1,3935221	34,6	29,5	0,000091	2,342652
35SCP	2203,5	19,8	11	51	26,8	11	55	4,3	60,3	254,1	47,7	35,9	0,0004539	1,0783057	52,7	43,5	0,000580	1,524639
36SES	2123,7	19,1	11	51	16,6	11	54	48,4	338,7	151,5	47,7	35,9	0,0004539	1,0783057	52,7	43,5	0,000580	1,524639
37SFA	2965,8	26,7	11	52	34,2	11	57	7,5	49,3	248,8	36,4	28,1	0,0001693	1,3411518	37,0	31,4	0,000209	2,256562
38SHA	1215,0	10,9	11	49	32,8	11	51	36,4	98,8	285,4	60,4	43,6	0,0006439	0,6722177	63,0	50,5	0.	0,
39SLM	1132,6	10,2	11	49	22,6	11	51	18,2	53,6	239,7	60,4	43,6	0,0006439	0,6722177	63,0	50,5	0.	0,
40STJ	4309,0	38,8	11	54	19,4	12	0	16,4	53,5	265,7	32,1	24,9	0,0000789	1,4241422	33,5	28,6	0,000084	2,379415
41TUC	954,3	8,6	11	49	0,5	11	50	38,6	267,7	82,3	61,9	44,4	0,0007139	0,6091725	64,8	51,6	0.	0,
42TUL	554,5	5,0	11	48	14,1	11	49	8,7	53,0	235,8	64,3	45,6	0,0012293	0,4713241	66,6	52,6	0.	0,
43YKC	3420,1	30,8	11	53	10,9	11	58	12,9	347,5	157,0	34,4	26,6	0,0001209	1,3815873	35,2	29,9	0,000112	2,323209
44WES	2775,6	25,0	11	52	18,2	11	56	39,1	59,5	257,7	37,9	29,2	0,0002447	1,3103685	39,0	33,1	0,000306	2,177818

VII. LISTER

PROGRAMMER: R. B. HERRMANN / Jan 1977

PURPOSE:

This program lists a check of cards in a format of 55 lines per page and numbers the pages. It was used for all listings of programs and data sets in this volume. 72 columns of card data are duplicated.

INPUT/OUTPUT

Input is from the card reader. Output is on the on-line printer.

INPUT DATA

Card Sequance	Column	Name	Format	Explanation
A. Page Header.				
	1-4	JTL	A4	End program JTL = //// Otherwise
	5-8	KTL	A4	JTL and KTL form the header
B. Deck to be copies.				
	1-72	ITTL	12A6	List card unless ITTL(1) = ******. In this case return to Point A.

```
C      THIS PROGRAM LISTS A DECK IN A FORMAT OF 55 LINES PER PAGE AND
C      NUMBERS THE PAGES
       CHARACTER JTL,KTL,ITTL(13)
 9998  CONTINUE
       READ 10,JTL,KTL
   10  FORMAT(2A4)
       IF(JTL.EQ.4H////) GO TO 9999
       PRINT 1
    1  FORMAT(1H1)
       IPAGE = 1
  200  CONTINUE
       PRINT 2,JTL,KTL,IPAGE
    2  FORMAT(1H1,10X,2A4,5H PAGE,I3///)
       IPAGE = IPAGE + 1
       LINE = 0
  250  CONTINUE
       LINE = LINE + 1
       READ 3,(ITTL(I),I=1,13)
    3  FORMAT(13A6)
       IF(ITTL(1).EQ.6H******) GO TO 9998
       IF(ITTL(2).EQ.6HSUBROU) LINE = LINE + 1
       IF(ITTL(2).EQ.6HSUBROU) PRINT 4
       IF(ITTL(2).EQ.6HFUNCTI) PRINT 4
       IF(ITTL(2).EQ.6HFUNCTI) LINE = LINE + 1
    4  FORMAT(1H )
       PRINT 5,(ITTL(I),I=1,13)
    5  FORMAT(1H ,10X,13A6)
       IF(LINE.GE.50) GO TO 200
       GO TO 250
 9999  CONTINUE
       STOP
       END
```

VIII. PLTSEIS

PROGRAMMER: R. B. HERRMANN / Aug 1977

PURPOSE:

This program reads in and plots a digitized seismogram. Amplitudes are normalized to a peak magnification of 3000. If horizontal data are entered, the transverse and radial components of ground motion are formed and plotted. The plots have an x-axis equivalent to 30 mm/min. Software for filtering is included. The program accepts without change the data sets from EXSPEC, SPSPEC for a 15-100 WWSSN, a 30-100 WWSSN, a 6824-13 LRSM or a 6824-2 LRSM systems. Punched card output from WIGGLE is useable without change.

INPUT/OUTPUT

Input is from card on FILE 60, printer output is through a PRINT statement, and FILE 10 is used for the off-line CALCOMP plotter tape.

THEORY

The convention on record displacements for coordinate rotation is that N and E be positive. After transformation, radial is positive away from the source and transverse is positive clockwise about the source.

PROGRAM DESCRIPTION

PROGRAM PLTSEIS : This is the main control line. It is almost identical to the main routine of EXSPEC. All plot calls and rotation is done in this routine.

SUBROUTINE FILT: This is an example of a low-pass filter routine. The normal data card for EXSPEC or output card from WIGGLE has IFILT = blank, which causes this subroutine not to be called. The purpose behind the subroutine is to low-pass filter real data so that they have the same low-pass limitations of theoretical seismograms.

SUBROUTINE PLOTEM: This is the plot routine.

SUBROUTINE TREND: Permits the removal of DC offsets and linear trends from the digitized data.

SUBROUTINE CARDIN: Reads in either equally spaced data or X,Y coordinates of data which are then linearly interpolated to form an evenly spaced time series.

SUBROUTINE FOUR: Fast Fourier transform for use by FILT subroutine.

INPUT DATA

Card Sequence	Column	Name	Format	Explanation
A.	1-5	ICONTRL	I5	LE.0 end program
	6-10	IDATA	I5	EQ.1 one component read in EQ.2 EW read in first then NS, E and N are positive displacements on seismogram. W and S are negative. The UT amd UR are formed. Both must have the same TO and DT. UT is positive clockwise about the source; UR is positive away from the source.
	11-15	ITAPE	I5	Not used.
	16-20	IPRNT	I5	Not used.
	21-25	ITREND	I5	0 or neg bypass TREND 1 DC offset removed 2 DC offset and linear trend removed.
	26-30	INTYP	I5	NE.2 Y values entered for evenly spaced time increments. Terminated by a +9999 punch after last data value EQ.2 Array of X,Y pairs which will be evenly spaced at interval of DT by CARDIN. Data set terminated by a -9999-9999 pair.

Card Sequence	Column	Name	Format	Explanation
A. (cont'd)	31-35	IFILT	I5	GE.1 Filter input series.
B.			79H	An identification card. Usually blank.
C.	1-4	STA	A4	Station identifier.
	5-8	COMP	A4	Component identifier
	11-20	DIST	F10.5	Station distance from epicenter in kilometers.
	21-30	DEG	F10.5	Station distance from epicenter in degrees.
	31-40	BACKAZ	F10.5	Azimuth from station to epicenter, measured clockwise from north.
	41-50	TO	F10.5	Time digitizing began in seconds after origin time.
	51-60	DT	F10.5	Digitizing interval used or desired.
	61-70	CPMM	F10.5	Digitizer counts per millimeter of original record. (counts per minute/millimeters per minute)
	71-80	PEAK	F10.5	Peak instrument response.

Card Sequence	Column	Name	Format	Explanation
D.	1-12	IDATE (3)	3A4	Date of event
	16-25	SLOPE	F10.5	Not used.
	26-35	TMAX	F10.5	When INTYP=2, total length desired for evenly spaced seismograms. Note, TMAX must be less than 1024 DT.
	36-45	CPM	F10.5	Counts per minute. Used to convert counts to time.

E. Digitized Data.

INTYP .NE.2.	DUMMY(I)	12(F5.0,1X)	Digitized trace for equispaced time values. End of trace signified by +9999.
INTYP .EQ.2	X(I), Y(I)	16F5.0	X,Y pairs. These will be linearly interpolated to form a trace of amplitude for equispaced time series of length TMAX and spacing DT. The first pair must be +0000+0000 and the last -9999-9999.

At this point the program returns to Point B if IDATA .EQ.2 in order to read in both EW and NS seismograms, or to Point C if IDATA.EQ.1 or if both EW and NS seismograms have bean read in.

The plotted output consists of the ditigized traces and also the rotated displacements when horizontal data are entered.

```
CPLTSEI
C       THIS PROGRAM READS IN AND PLOTS A DIGITIZED SEISMOGRAM FOR A WWSS
C       15-100 SYSTEM.  AMPLITUDES ARE NORMALIZED TO A GAIN OF 3K.  IF
C       HORIZONTAL DATA ARE ENTERED, THE TRANSVERSE AND RADIAL COMPONENTS
C       GROUND MOTION ARE FORMED AND PLOTTED..    PLOTS ARE MAGNIFUED 2 X
C       DATA CARDS ARE EXACTLY AS FOR EXSPEC OR SPSPEC.
        DIMENSION DATA(1026),DATUM(1026),IBUF(1000)
        DIMENSION T(1026)
        DIMENSION IDATE(3)
        CALL PLOTS(IBUF,1000,10)
        CALL PLOT(0.0,-11.0,-3)
        CALL PLOT(0.0,3.0,-3)
  303   READ(60,63)ICONTRL,IDATA,ITAPE,IPRNT,ITREND,INTYP,IFILT
C       IFILT = IFILT + 1
     63 FORMAT(7I5)
        IF(ICONTRL.LE.0) GO TO 1000
        DO 100 ITYPE=1,IDATA
        READ(60,2)
        PRINT 2
      2 FORMAT(79H
     1                                                                 )
        READ(60,10)STA,COMP,DIST,DEG,BACKAZ,TO,DT,CPMM,PEAK
     10 FORMAT(2A4,2X,7F10.5)
        READ(60,11) IDATE(1),IDATE(2),IDATE(3),SLOPE,TMAX,CPM
     11 FORMAT(3A4,3X,3F10.5)
        CPS = CPM/60.
        PRINT 6
        PRINT 7,STA,COMP,DIST,DEG,BACKAZ,TO,DT,CPMM,PEAK
      6 FORMAT(1H ,8OH STA     COMP     DIST KM     DEG    BACKAZ     TO       DT
     1      CPMM     PEAKMAG                                              )
      7 FORMAT(1H ,A4,4X,A4,3X,F10.2,2F7.2,F7.1,F8.3,F9.2,F8.0)
        PRINT 8
        PRINT 9,IDATE(1),IDATE(2),IDATE(3),SLOPE,TMAX,CPM
      8 FORMAT(1H0,4X,4HDATE,12X,5HSLOPE,6X,4HTMAX,7X,3HCPM)
      9 FORMAT(1H ,3A4,3X,F10.4,2F10.2)
        PRINT 3
      3 FORMAT(//)
        CALL CARDIN(DATA,NPTS,CPM,DT,TMAX)
C       CONVERT TO CENTIMETERS PER COUNT
        CONFAC = 0.1/CPMM
C       PLOT AT 30 MM/MIN
        CMSEC = 0.05
C       ADJUST FOR INSTRUMENT TO NORMALIZE TO A 3K INSTRUMENT
        CONFAC = CONFAC * (3000./PEAK)
        DO 115 I = 1,NPTS
        T(I) = (I-1) * DT
        DATA(I) = DATA(I)*CONFAC    /2.54
        T(I) = T(I) * CMSEC    /2.54
  115   CONTINUE
        IF(ITREND.GE.1) CALL TREND(DATA,NPTS,ITREND)
```

```
      CALL PLOTEM(T,DATA,NPTS)
      IF(ITYPE.EQ.IDATA) GO TO 100
      DO 125 I = 1,NPTS
  125 DATUM(I) = DATA(I)
C      DATA = NS AND DATUM = EW
  100 CONTINUE
C     FORMATION OF RADIAL AND TRANSVERSE COMPONENTS IF IDATA.EQ.2
      IF(IDATA.NE.2) GO TO 200
      BACKAZ = BACKAZ * 0.0174533
      A = SIN(BACKAZ)
      B = COS(BACKAZ)
      DO 110 I = 1,NPTS
      TRANS = DATA(I)*A - DATUM(I)*B
      RADIAL =-DATA(I)*B - DATUM(I)*A
C     DATA = TRANS = + CLOCKWISE FROM ERIC
C     DATUM = RADIAL = + AWAT FROM EPIC
      DATA(I) = TRANS
  110 DATUM(I) = RADIAL
      CALL PLOTEM(T,DATA,NPTS)
      CALL PLOTEM(T,DATUM,NPTS)
  200 CONTINUE
C     FILTER SIGNAL AS DONE FOR SYNTHETICS
      IF(IFILT.GE.1) CALL FILT(DATA ,NPTS,DT)
      IF(IFILT.GE.1.AND.IDATA.EQ.2) CALL FILT(DATUM,NPTS,DT)
      IF(IFILT.GE.1) CALL PLOTEM(T,DATA,NPTS)
      IF(IFILT.GE.1.AND.IDATA.EQ.2) CALL PLOTEM(T,DATUM,NPTS)
      CALL PLOT(3.0,0.0,-3)
      GO TO 303
 1000 CONTINUE
      CALL PLOT(8.0,0.0,999)
 1002 CONTINUE
      STOP
      END

      SUBROUTINE FILT(Y,N,DT)
      COMMON/DTA/DATA(2,1024)
      DIMENSION Y(1)
      DO 100 I = 1,2
      DO 100 J = 1,1024
  100 DATA(I,J) = 0.0
      DO 101 I = 1,N
  101 DATA(1,I) = Y(I)
      CALL FOUR(DATA,1024,-1,DT,DF)
      DO 200 I = 2,513
      J = 1024 + 2 - I
      T = 1./((I-1)*DF)
      IF(T.GE.3.0) GO TO 200
      IF(T.GE.2.5.AND.T.LT.3.0) FAC = 0.8+0.4*(T-2.5)
      IF(T.GE.2.0.AND.T.LT.2.5) FAC = 0.5+0.6*(T-2.0)
      IF(T.LT.2.0) FAC = 0.0
```

```
      DATA(1,I) = FAC*DATA(1,I)
      DATA(2,I) = FAC*DATA(2,I)
      DATA(1,J) = FAC*DATA(1,J)
      DATA(2,J) = FAC*DATA(2,J)
  200 CONTINUE
      CALL FOUR(DATA,1024,+1,DT,DF)
      DO 300 I = 1,N
  300 Y(I) = DATA(1,I)
      RETURN
      END

      SUBROUTINE PLOTEM(X,Y,N)
      DIMENSION X(1),Y(1)
      X(N+1) = X(1)
      X(N+2) = 1.0
      Y(N+1) = 0.0
      Y(N+2) = -1.0
      CALL LINE(Y,X,N,1,0,0)
      CALL PLOT(4.0,0.0,-3)
      RETURN
      END

      SUBROUTINE TREND(X,NPTS,ITREND)
      DIMENSION X(1)
C     ITREND = 1   DC COMPONENT REMOVED
C     ITREND = 2   LINEAR COMPONENT REMOVED
      SUM2 = 0.0
      SUM1 = 0.0
      N1 = NPTS/2
      DO 1 I = 1,N1
    1 SUM1 = SUM1 + X(I)
      N21 = N1 + 1
      DO 2 I = N21,NPTS
    2 SUM2 = SUM2 + X(I)
      N2 = NPTS - N1
      DC = (SUM1 + SUM2)/NPTS
      IF(ITREND - 1)6,6,7
    6 B = DC
      SLP = 0.0
      GO TO 8
    7 CONTINUE
      SLP = 2.*((SUM2/N2) - (SUM1/N1))/NPTS
      B = (SUM1/N1) - 0.5*N21*SLP
    8 CONTINUE
      DO 3 I = 1,NPTS
      XI = I
    3 X(I) = X(I) - B - SLP*XI
      PRINT 5,DC,SLP
    5 FORMAT(1H ,4HDC = , E11.4,4X,7HSLOPE = , E11.4)
      RETURN
```

```
      END

      SUBROUTINE CARDIN( DUMMY,NPTS,CPM,DT,TMAX)
      COMMON/DTA/X(1024),Y(1024)
      DIMENSION DUMMY(1)
      DIMENSION XJUMP(11)
      XJUMP(1) = 0.
      XJUMP(2) = 10000.
      XJUMP(3) = 20000.
      XJUMP(4) = 30000.
      XJUMP(5) = 40000.
      XJUMP(6) = 50000.
      XJUMP(7) = 60000.
      XJUMP(8) = 70000.
      XJUMP(9) = 80000.
      XJUMP(10) = 90000.
      XJUMP(11) = 100000.
      CPS = CPM/60.
      DO 110 I = 1,2048,8
      J = I + 7
      READ(60,111) ((X(K),Y(K)),K=I,J)
      PRINT 112,((X(K),Y(K)),K=I,J)
  111 FORMAT(16F5.0)
  112 FORMAT(1H ,16F7.0)
      DO 110 K = I,J
      IF(X(K)+9999.) 115,115,110
  110 CONTINUE
  115 NUM = K - 1
      PRINT 907,NUM
  907 FORMAT(1H ,6H NUM =  ,I5)
      JUMP = 1
      DO 200 I = 2,NUM
      Q = X(I) + XJUMP(JUMP)
      IF(ABS(Q - X(I-1)).GT.9000.) JUMP = JUMP + 1
      X(I) = X(I) + XJUMP(JUMP)
  200 CONTINUE
      PRINT 908,JUMP
  908 FORMAT(1H , 6HJUMP =  ,I5)
      TIME1 = 0.0
      NPTS = 1
      DO 300 I = 2,NUM
  305 CONTINUE
      TIME = TIME1 * CPS
      JUMP = 1
      IF(TIME.LT.X(I).AND.TIME.GE.X(I-1)) JUMP = 2
      GO TO (301,302),JUMP
  302 DUMMY(NPTS) = Y(I) + (TIME-X(I))*((Y(I)-Y(I-1))/(X(I)-X(I-1)))
      NPTS = NPTS + 1
      TIME1 = TIME1 + DT
      IF(TIME1.GT.TMAX) GO TO 500
```

```
      GO TO 305
  301 CONTINUE
  300 CONTINUE
  500 NPTS = NPTS - 1
      PRINT 909,NPTS
  909 FORMAT(1H ,6HNPTS = ,I5)
      RETURN
      END

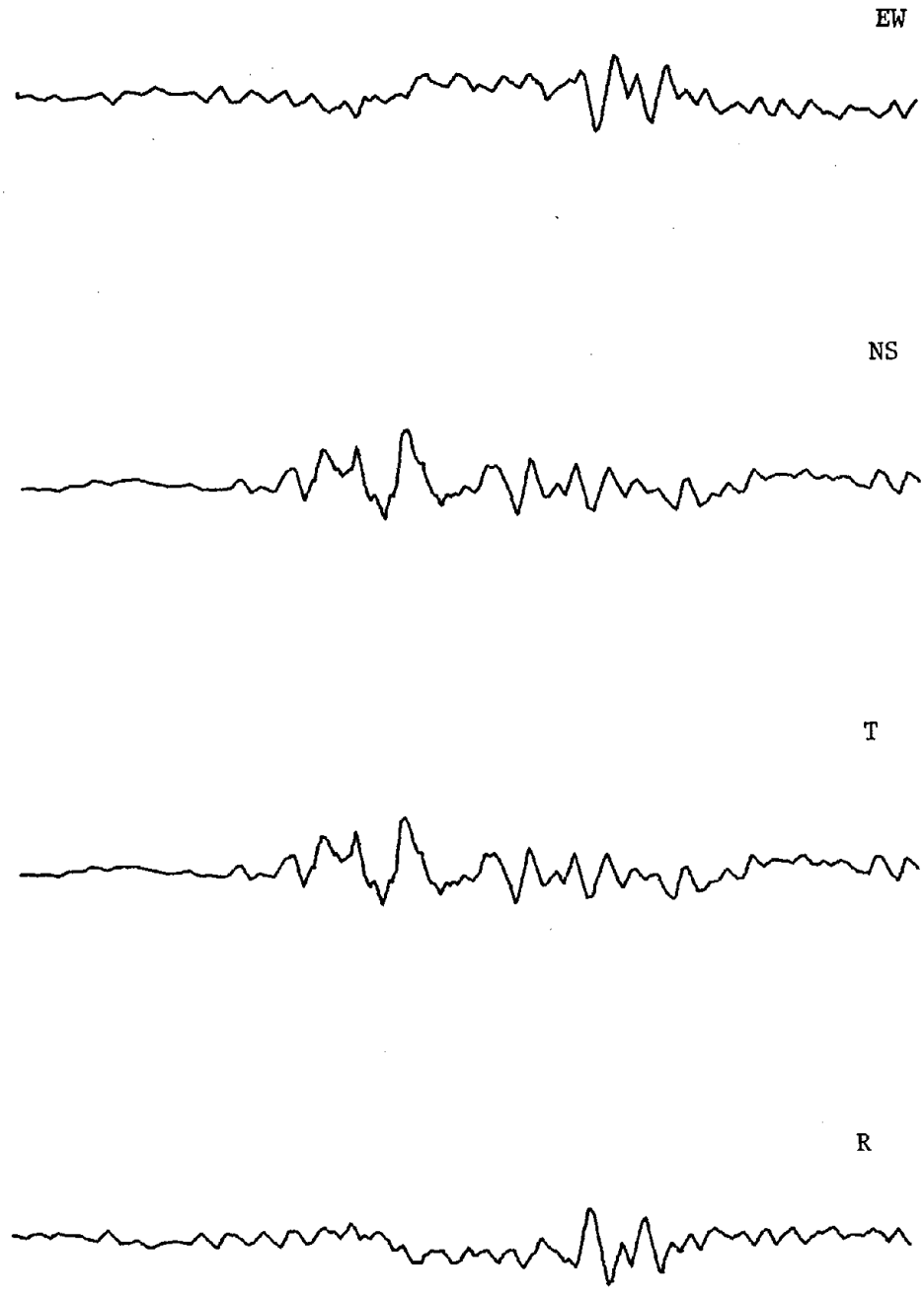
      SUBROUTINE FOUR(DATA,NN,ISIGN,DT,DF)
C     THE COOLEY-TOOKEY FAST FOURIER TRANSFORM IN USASI BASIC FORTRAN
C     TRANSFORM(J) = SUM(DATA(I)*W**((I-1)(J-1)), WHERE I AND J RUN
C     FROM 1 TO NN AND W = EXP(ISIGN*2*PI*SQRT(-1)/NN).  DATA IS A ONE-
C     DIMENSIONAL COMPLEX ARRAY (I.E., THE REAL AND IMAGINARY PARTS OF
C     DATA ARE LOCATED IMMEDIATELY ADJACENT IN STORAGE, SUCH AS FORTRAN
C     PLACES THEM) WHOSE LENGTH NN IS A POWER OF TWO.  ISIGN
C     IS +1 OR -1, GIVING THE SIGN OF THE TRANSFORM.  TRANSFORM VALUES
C     ARE RETURNED IN ARRAY DATA, REPLACING THE INPUT DATA.  THE TIME IS
C     PROPORTIONAL TO N*LOG2(N), RATHER THAN THE USUAL N**2
C     RMS RESOLUTION ERROR BEING BOUNDED BY 6*SQRT(I)*LOG2(NN)*2**(-B),
C     B IS THE NUMBER OF BITS IN THE FLOATING POINT FRACTION.
C     PROGRAM AUTOMATICALLY DIVIDES TRANSFORM BY NN FOR INVERSE TRANSFOR
      DIMENSION DATA(1)
      N = 2 * NN
      IF(DT.EQ.0.0) DT = 1./(NN*DF)
      IF(DF.EQ.0.0) DF = 1./(NN*DT)
      IF(DT.NE.(1./(NN*DF))) DF = 1./(NN*DT)
      J = 1
      DO 5 I=1,N,2
      IF(I-J)1,2,2
    1 TEMPR = DATA(J)
      TEMPI = DATA(J+1)
      DATA(J) = DATA(I)
      DATA(J+1)=DATA(I+1)
      DATA(I) = TEMPR
      DATA(I+1) = TEMPI
    2 M = N/2
    3 IF(J-M) 5,5,4
    4 J = J-M
      M = M/2
      IF(M-2)5,3,3
    5 J=J+M
      MMAX = 2
    6 IF(MMAX-N) 7,10,10
    7 ISTEP= 2 *MMAX
      THETA = 6.283185307/FLOAT(ISIGN*MMAX)
      SINTH=SIN(THETA/2.)
      WSTPR=-2.*SINTH*SINTH
      WSTPI=SIN(THETA)
      WR=1.0
```

```
      WI=0.0
      DO 9 M=1,MMAX,2
      DO 8 I=M,N,ISTEP
      J=I+MMAX
      TEMPR=WR*DATA(J)-WI*DATA(J+1)
      TEMPI=WR*DATA(J+1)+WI*DATA(J)
      DATA(J)=DATA(I)-TEMPR
      DATA(J+1)=DATA(I+1)-TEMPI
      DATA(I)=DATA(I)+TEMPR
    8 DATA(I+1) = DATA(I+1)+TEMPI
      TEMPR = WR
      WR = WR*WSTPR-WI*WSTPI + WR
    9 WI = WI*WSTPR+TEMPR*WSTPI + WI
      MMAX = ISTEP
      GO TO 6
   10 CONTINUE
      IF(ISIGN.LT.0) GO TO 1002
C     FREQUENCY TO TIME DOMAIN
      DO 1001 IIII = 1,N
 1001 DATA(IIII) = DATA(IIII) * DF
      RETURN
 1002 CONTINUE
C     TIME TO FREQUENCY DOMAIN
      DO 1003 IIII = 1,N
 1003 DATA(IIII) = DATA(IIII) * DT
      RETURN
      END
```

```
 1    2    1    1    2    2

ALQ UE     1455.8      13.1        82.4        338.9       0.25        30.4267    3000.
25 MAR 76                  240.        456.4
0000 0000 0028 0012 0039-0004 0056-0009 0076 0012 0092-0008 0111-0002 0135 00
0171 0023 0193-0021 0217 0030 0240 0026 0252 0019 0282 0051 0312 0027 0337 00
0360 0036 0383-0005 0404 0038 0415 0057 0433-0006 0451-0003 0476 0044 0490 00
0508-0006 0525 0019 0544 0043 0561-0017 0575-0008 0584 0001 0597 0034 0607 00
0623-0031 0633-0039 0649-0017 0654-0020 0666 0008 0687-0060 0693-0040 0706 00
0714 001  0727 0030 0745 0002 0751 0010 0769 0034 0780 0037 0791 0026 0811 01
0833 0122 0837 0096 0851 0084 0859 0078 0875 0072 0894 0124 0907 0114 0911 01
0926 0059 0937 0084 0955 0064 0965 0057 0986 0120 0999 0098 1019 0073 1039 01
1056 0092 1062 0088 1075 0024 1094 0068 1108 0086 1122 0108 1132 0101 1145 01
1151 0127 1172-0101 1180-0090 1185-0068 1211 0213 1217 0204 1240 0039 1250 00
1259 0136 1280-0043 1287-0061 1316 0170 1322 0173 1327 0116 1341 0040 1357 00
1380 0014 1397 0082 1415 0004 1428-0019 1443-0000 1463 0027 1488-0015 1509 00
1528-0019 1539-0018 1553 0043 1571 0000 1586-0032 1612 0042 1637-0008 1647-00
1670-0030 1691 0021 1707 0006 1729 0012 1750-0023 1770 0005 1783 0046 1802-00
1831 0062 1843 0019 1919 0019-9999-9999

ALQ UN     1455.8      13.1        82.4        338.9       0.25        30.44      3000.
25 MAR 76                  240.        456.6
0000 0000 0022 0006 0033-0000 0053 0003 0074-0005 0097 0014 0124 0015 0143 00
0160 0033 0178 0023 0189 0038 0211 0041 0232 0044 0263 0032 0294 0019 0322 00
0344 0027 0366 0007 0389 0005 0401 0005 0425 0013 0437 0040 0446 0048 0466-00
0485 0019 0501 0004 0515 0002 0524 0036 0537 0081 0553 0097 0557 0085 0565 00
0575-0036 0591 0050 0596 0047 0601 0107 0611 0173 0619 0163 0631 0115 0638 00
0642 0105 0651 0064 0665 0091 0671 0095 0681 0188 0699 0009 0709-0032 0718-00
0736-0107 0749-0005 0754-0015 0764 0049 0772 0238 0781 0259 0788 0229 0797 01
0807 0119 0814 0121 0822 0054 0834-0004 0844-0011 0853-0054 0864-0004 0871-00
0881 0000 0889-0006 0901 0032 0910 0021 0919 0006 0926 0017 0932 0039 0944 01
0955 0109 0964 0118 0973 0092 0988 0019 0990 0009 0996-0020 1007-0086 1015-00
1033 0145 1038 0133 1050 0047 1061-0013 1071-0008 1089 0045 1103-0006 1126 01
1151-0053 1163-0065 1173 0006 1193 0117 1208 0056 1225-0009 1240 0048 1252 00
1271 0009 1276 0015 1294 0029 1310-0019 1328-0054 1332-0048 1345 0061 1354 00
1378-0043 1391-0025 1402 0009 1418 0002 1436 0053 1437 0051 1457 0019 1469 00
1488 0111 1512 0074 1533 0095 1541 0093 1563 0094 1571 0083 1586 0105 1595 01
1611 0082 1624 0081 1634 0093 1650 0073 1670 0090 1683 0086 1699 0054 1707 00
1725 0042 1741 0114 1755 0104 1771 0041 1786 0019 1803 0108 1823 0081 1832 00
1867 0081 1879 0077-9999-9999
-1
```


EW
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STA	COMP	DIST KM	DEG	BACKAZ	TO	DT	CPMM	PEAKMAG
ALQ	UE	1455.80	13.10	82.40	338.9	0.250	30.43	3000.

DATE	SLOPE	TMAX	CPM
25 MAR 76	0.	240.00	456.40

0.	0.	28.	12.	39.	-4.	56.	-9.	76.	12.	92.	-8.	111.	-2.	135.	0.
171.	23.	193.	-21.	217.	30.	240.	26.	252.	19.	282.	51.	312.	27.	337.	25.
360.	36.	383.	-5.	404.	38.	415.	57.	433.	-6.	451.	-3.	476.	44.	490.	30.
508.	-6.	525.	19.	544.	43.	561.	-17.	575.	-8.	584.	1.	597.	34.	607.	15.
623.	-31.	633.	-39.	649.	-17.	654.	-20.	666.	8.	687.	-60.	693.	-40.	706.	29.
714.	10.	727.	30.	745.	2.	751.	10.	769.	34.	780.	37.	791.	26.	811.	104.
833.	122.	837.	96.	851.	84.	859.	78.	875.	72.	894.	124.	907.	114.	911.	113.
926.	59.	937.	84.	955.	64.	965.	57.	986.	120.	999.	98.	1019.	73.	1039.	130.
1056.	92.	1062.	88.	1075.	24.	1094.	68.	1108.	86.	1122.	108.	1132.	101.	1145.	146.
1151.	127.	1172.	-101.	1180.	-90.	1185.	-68.	1211.	213.	1217.	204.	1240.	39.	1250.	88.
1259.	136.	1280.	-43.	1287.	-61.	1316.	170.	1322.	173.	1327.	116.	1341.	40.	1357.	76.
1380.	14.	1397.	82.	1415.	4.	1428.	-19.	1443.	0.	1463.	27.	1488.	-15.	1509.	49.
1528.	-19.	1539.	-18.	1553.	43.	1571.	0.	1586.	-32.	1612.	42.	1637.	-8.	1647.	-2.
1670.	-30.	1691.	21.	1707.	6.	1729.	12.	1750.	-23.	1770.	5.	1783.	46.	1802.	-26.
1831.	62.	1843.	19.	1919.	19.	-9999.	-9999.	0.	0.	0.	0.	0.	0.	0.	0.

NUM = 115
JUMP = 1
NPTS = 961
DC = 0.4129E-01 SLOPE = 0.5221E-04

STA	COMP	DIST KM	DEG	BACKAZ	TO	DT	CPMM	PEAKMAG
ALQ	UN	1455.80	13.10	82.40	338.9	0.250	30.44	3000.

DATE	SLOPE	TMAX	CPM
25 MAR 76	0.	240.00	456.60

0.	0.	22.	6.	33.	0.	53.	3.	74.	-5.	97.	14.	124.	15.	143.	37.
160.	33.	178.	23.	189.	33.	211.	41.	232.	44.	263.	32.	294.	19.	322.	19.
344.	27.	366.	7.	389.	5.	401.	5.	425.	13.	437.	40.	446.	48.	466.	-5.
485.	19.	501.	4.	515.	2.	524.	36.	537.	81.	553.	97.	557.	85.	565.	20.
575.	-36.	591.	50.	596.	47.	601.	107.	611.	173.	619.	163.	631.	115.	638.	91.
642.	105.	651.	64.	665.	91.	671.	95.	681.	188.	699.	9.	709.	-32.	718.	-7.
736.	-107.	749.	-5.	764.	-15.	764.	49.	772.	238.	781.	259.	788.	229.	797.	154.
807.	119.	814.	121.	822.	54.	834.	44.	844.	-11.	853.	-54.	864.	-4.	871.	-16.
881.	0.	889.	-6.	901.	32.	910.	21.	919.	6.	926.	17.	932.	39.	944.	113.
955.	109.	964.	118.	973.	92.	988.	19.	990.	9.	996.	-20.	1007.	-86.	1015.	-33.
1033.	145.	1036.	133.	1050.	47.	1061.	-13.	1071.	-8.	1089.	45.	1103.	-6.	1126.	129.
1151.	-53.	1163.	-65.	1173.	6.	1193.	117.	1208.	56.	1225.	-9.	1240.	48.	1252.	67.
1271.	9.	1276.	15.	1294.	29.	1310.	-19.	1328.	-54.	1332.	-48.	1345.	61.	1354.	73.
1378.	-43.	1391.	-25.	1402.	9.	1418.	2.	1436.	53.	1437.	51.	1457.	19.	1469.	22.
1488.	111.	1512.	74.	1533.	95.	1541.	93.	1563.	94.	1571.	83.	1586.	105.	1595.	114.
1611.	82.	1624.	81.	1634.	93.	1650.	73.	1670.	90.	1683.	86.	1699.	54.	1707.	50.
1725.	42.	1741.	114.	1755.	104.	1771.	41.	1786.	19.	1803.	108.	1823.	81.	1832.	58.
1867.	81.	1879.	77.	-9999.	-9999.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NUM = 138
JUMP = 1
NPTS = 961
DC = 0.5401E-01 SLOPE = 0.3554E-04

IX. HILBERT

PROGRAMMER: P. LUH / Jan 1976; R. B. Herrmann / Feb 1976

PURPOSE:

This program determines the phase response of a minimum seismogram system given the amplitude response by using a Hilbert transform. As part of the output, the time response of the system to an impulse in ground displacement, an impulse in ground velocity, impulse in ground acceleration and a step in ground acceleration are plotted so that the last can be compared to an observed step calibration response and the first can be checked for noise.

INPUT/OUTPUT

Card input is through a READ statement, printer output is through a PRINT statement, and offline CALCOMP is through FILE 10.

THEORY

The application of a Hilbert transform to the problem of determining a seismograph phase response given the amplitude response was made by Bolduc et al (1972). Luh (1977) wrote the basic part of this program. The paper by Herrmann (1977) shows the use of the program.

PROGRAM DESCRIPTION

PROGRAM IMPULSE: This is the main control link. The phase response list as well as plotting are done in this routine.

FUNCTION TANH : A function to determine the hyperbolic tangent.

SUBROUTINE FOUR: A fast Fourier transform which numerically approximates the Fourier integral.

SUBROUTINE INTVAL : This establishes a comb of abscissa for the numerical integration.

SUBROUTINE AMPRIME : Seismograph amplitude response is read in as a function of period, natural logarithms are taken and the logarithmic response is fit by a cubic spline. The log amplitude response and slope of the response are determined at points of the comb specified by SUBROUTINE INTVAL.

When entering the data, add enough points at the extremes of the data set so that the low and high frequency

asymptotic slopes are well specified. This can be checked from the output. If the response varies as FREQ**K at either high or low frequencies, then the phase response is K * 90 degrees.

SUBROUTINE ASHIFT: This subroutine determines the amplitude response of a given frequency and shifts the slope of the response according to the given frequency.

SUBROUTINE LNCOTH: This determines the natural logarithm of the hyperbolic cosine.

SUBROUTINE DOT: Numerical integration routine.

SUBROUTINE SPLINC: Determines cubic spline interpolation coefficients.

REFERENCES

Bolduc, P. M., R. M. Ellis and R. D. Russell (1972). Determination of the seismograph phase response from the amplitude response, Bull. Seism. Soc. Am. 62, 1665-1672.

Herrmann, R. B. (1977). On the determination of the impulse response seismograph systems with emphasis on the SRO system, Earthquake Notes 48, 3-23.

Luh, P. C (1977). A scheme for expressing instrumental responses parametrically, Bull. Seism. Soc. Am. 67, 957-969.

INPUT DATA

Card Sequence	Column	Name	Format	Explanation
A.	1-10	X1	F10.3	Lower comb limit.
	11-20	X2	F10.3	Upper comb limit.
	21-30	H	F10.3	Comb spacing
	(The values used X1=-7, X2=+7, H=0.2 work. Smaller X1 or larger X2 may lead to word overflow.)			
B.	1-10	DT	F10.3	Digitizing interval for plot.
		MMMIN	F10.3	Millimeters per minute for plot
C. Amplitude Response (in order of increasing period).				
	1-10	F	F10.0	Period in seconds EQ.0 Terminate program
		Y	F10.0	Amplitude response
		K	I1	GT.0 signify end of data set

After one data set, program returns to Point C for another.

```
C       PROGRAM IMPULSE
        COMMON /ONE/DATA(2,1024)
        COMMON /TWO/F(37)
        DIMENSION IBUF(1000),X(1026),Y(1026)
        DIMENSION V(200),A(200),B(200),C(200),D(200)
        REAL  MMMIN
        PI = 3.1415927
        PII = 1./PI
        PIH = PI/2.
        RAD = 180./PI
        DO 44 I = 1,9
        XX = I
        DO 44 J = 1,4
        IF(J.EQ.1) YY = 0.001
        IF(J.EQ.2) YY = 0.01
        IF(J.EQ.3) YY = 0.1
        IF(J.EQ.4) YY = 1.0
        L = (J-1)*9 + I
   44 F(L) = XX*YY
        F(37) = 10.
        NF = 37
        CALL PLOTS(IBUF,1000,10)
        READ 10,X1,X2,H
        PRINT 10,X1,X2,H
   10 FORMAT(3F10.3)
        CALL INTVAL(V,X1,X2,H,M)
        CALL LNCOTH(V,C,M,H)
   25 CONTINUE
        READ 10,DT,MMMIN
        PRINT 1
    1 FORMAT(1H1)
        CALL AMPRIME(A,V,D,M,H,KJUMP)
        IF(KJUMP.EQ.1) GO TO 9999
        CALL PLOT(0.0,-11.0,-3)
        CALL PLOT(0.0,4.0,-3)
        DO 30 I = 1,NF
        W = F(I)
        CALL ASHIFT(A,B,V,H,W,M,YYY,D,Z)
        FASE = PII*DOT(B,C,V,M,H) + YYY*PIH
        PHASE = FASE * RAD
        IF(I.EQ.1) PRINT 43
   43 FORMAT(1H1/1H0,20X,10HFREQ (HZ)  ,11X,9HPHI (DEG),9X,13HMAGNIFICAT
      1ION //)
        PRINT 41 ,W,PHASE,Z
   41 FORMAT(1H ,10X,E20.5,F20.5,E20.5)
   30 CONTINUE
        DO 50 IP = 1,4
        N = 1024
        DF = 1./(N*DT)
        MM = 501
```

```
      NP = 512
      NP1 = 513
      DO 100 J=1,2
      DO 100 I=1,1024
  100 DATA(J,I)=0.0
      DATA(1,82) = 1./(4.*DT)
      DATA(1,83) = 1./(2.*DT)
      DATA(1,84) = 1./(4.*DT)
      CALL FOUR(DATA,N,-1,DT,DF)
      DATA(1,1) = 0.0
      DATA(2,1) = 0.0
      DO 200 I = 2,NP1
      W = (I-1) * DF
      CALL ASHIFT(A,B,V,H,W,M,YYY,D,Z)
      FASE = PII*DOT(B,C,V,M,E) + YYY*PIH
      IF(I.EQ.2) FASESV= FASE
      XR = Z * COS(FASE)
      XI = Z * SIN(FASE)
      TR = DATA(1,I)
      TI = DATA(2,I)
      DATA(1,I) = XR*TR-XI*TI
      DATA(2,I) = XR*TI+XI*TR
      XR = 0.0
      XI = 0.0
      WW = 2. * PI * W
      IF(IP.EQ.1) XR = 1.0
      IF(IP.EQ.2) XI = -1./WW
      IF(IP.EQ.3) XR = -1./(WW*WW)
      IF(IP.EQ.4) XI = 1./(WW*WW*WW)
      TR = DATA(1,I)
      TI = DATA(2,I)
      DATA(1,I) = XR*TR-XI*TI
      DATA(2,I) = XR*TI+XI*TR
  200 CONTINUE
      DO 202 I = NP1,N
      J = N+2-I
      DATA(1,I) = DATA(1,J)
      DATA(2,I) = -DATA(2,J)
  202 CONTINUE
      DATA(2,NP1) = 0.0
      IF(IP.EQ.4.AND.ABS(FASESV-270.).LT.10.) DATA(1,1) = DATA(1,2)
      CALL FOUR(DATA,N,+1,DT,DF)
      AMAX = 0.0
      DO 400 I = 1,N
      Y(I) = DATA(1,I)
      IF(ABS(Y(I)).GT.AMAX) AMAX = ABS(Y(I))
      X(I) = (I-1) * DT
  400 CONTINUE
      PRINT 42,AMAX
   42 FORMAT(///////// 1H ,E20.5)
```

```
      DO 500 I = 1,MM
      Y(I) = Y(I) / AMAX
  500 X(I) = X(I)*MMMIN/(60.*25.4)
      J = MM+1
      K = MM+2
      X(J) = 0.0
      Y(J) = 0.0
      X(K) = 1.0
      Y(K) = -1.0
      CALL LINE(Y,X,MM,1,0,0)
      CALL PLOT(3.0,0.0,-3)
   50 CONTINUE
      CALL PLOT(12.0,0.0,-3)
      GO TO 25
 9999 CONTINUE
      CALL PLOT(0.0,0.0,999)
      STOP
      END

      FUNCTION TANH(X)
      IF(X.GT.9.0) GO TO 9
      IF(X.LT.-9.0) GO TO 10
      Y = EXP(X)
      W = 1./Y
      TANH = (Y-W)/(Y+W)
      RETURN
    9 TANH = 1.0
      RETURN
   10 TANH = -1.0
      RETURN
      END

      SUBROUTINE FOUR(DATA,NN,ISIGN,DT,DF)
C     IT IS BETTER TO PRESET DF = 0 OR TO TRUE VALUE SOME COMP DF = INDE
C     THE COOLEY-TOOKEY FAST FOURIER TRANSFORM IN USASI BASIC FORTRAN
C     TRANSFORM(J) = SUM(DATA(I)*W**((I-1)(J-1)), WHERE I AND J RUN
C     FROM 1 TO NN AND W = EXP(ISIGN*2*PI*SQRT(-1)/NN).  DATA IS A ONE-
C     DIMENSIONAL COMPLEX ARRAY (I.E., THE REAL AND IMAGINARY PARTS OF
C     DATA ARE LOCATED IMMEDIATELY ADJACENT IN STORAGE, SUCH AS FORTRAN
C     PLACES THEM) WHOSE LENGTH NN IS A POWER OF TWO.  ISIGN
C     IS +1 OR -1, GIVING THE SIGN OF THE TRANSFORM.  TRANSFORM VALUES
C     ARE RETURNED IN ARRAY DATA, REPLACING THE INPUT DATA.  THE TIME IS
C     PROPORTIONAL TO N*LOG2(N), RATHER THAN THE USUAL N**2
C     RMS RESOLUTION ERROR BEING BOUNDED BY 6*SQRT(I)*LOG2(NN)*2**(-B),
C     B IS THE NUMBER OF BITS IN THE FLOATING POINT FRACTION.
      DIMENSION DATA(1)
      N = 2 * NN
      IF(DT.EQ.0.0) DT=1./(NN*DF)
      IF(DF.EQ.0.0) DF=1./(NN*DT)
      IF(DT.NE.(NN*DF)) DF = 1./(NN*DT)
```

```
      J = 1
      DO 5 I=1,N,2
      IF(I-J)1,2,2
    1 TEMPR = DATA(J)
      TEMPI = DATA(J+1)
      DATA(J) = DATA(I)
      DATA(J+1)=DATA(I+1)
      DATA(I) = TEMPR
      DATA(I+1) = TEMPI
    2 M = N/2
    3 IF(J-M) 5,5,4
    4 J = J-M
      M = M/2
      IF(M-2)5,3,3
    5 J=J+M
      MMAX = 2
    6 IF(MMAX-N) 7,10,10
    7 ISTEP= 2 *MMAX
      THETA = 6.283185307/FLOAT(ISIGN*MMAX)
      SINTH=SIN(THETA/2.)
      WSTPR=-2.*SINTH*SINTH
      WSTPI=SIN(THETA)
      WR=1.0
      WI=0.0
      DO 9 M=1,MMAX,2
      DO 8 I=M,N,ISTEP
      J=I+MMAX
      TEMPR=WR*DATA(J)-WI*DATA(J+1)
      TEMPI=WR*DATA(J+1)+WI*DATA(J)
      DATA(J)=DATA(I)-TEMPR
      DATA(J+1)=DATA(I+1)-TEMPI
      DATA(I)=DATA(I)+TEMPR
    8 DATA(I+1) = DATA(I+1)+TEMPI
      TEMPR = WR
      WR = WR*WSTPR-WI*WSTPI + WR
    9 WI = WI*WSTPR+TEMPR*WSTPI + WI
      MMAX = ISTEP
      GO TO 6
   10 CONTINUE
      IF(ISIGN.LT.0) GO TO 1002
C     FREQUENCY TO TIME DOMAIN
      DO 1001 IIII=1,N
 1001 DATA(IIII)=DATA(IIII)*DF
      RETURN
 1002 CONTINUE
C     TIME TO FREQUENCY DOMAIN
      DO 1003 IIII=1,N
 1003 DATA(IIII)=DATA(IIII)*DT
      RETURN
      END
```

```
      SUBROUTINE INTVAL(X,X1,X2,H,M)
      DIMENSION X(1)
C        X1 .LT. 0
      M1=-X1/H+2.
      M1=M1+1-MOD(M1,2)
      M =X2/H+2.
      M=M1+M +1-MOD(M ,2)
      X(1)=-(M1-0.5)*H
      DO 10 I=2,M
   10 X(I)=X(I-1)+H
      RETURN
      END

      SUBROUTINE AMPRIME(W,X,A,M,H,KJUMP)
      DIMENSION A(1),X(1),W(1),F(200),Y(200),B(200),C(200),D(200)
      KJUMP = 0
      DO 10 I=1,200
C     READ IN PERIOD,AMPLITUDE PAIRS IN ORDER OF INCREASING PERIOD
      READ 5,F(I),Y(I),K
    5 FORMAT(2F10.0,I1)
      IF(F(I).EQ.0.0) KJUMP = 1
      IF(F(I).EQ.0.0) RETURN
      Y(I)=ALOG(Y(I))
      F(I)=-ALOG(F(I))
      IF(K.NE.0) GO TO 15
   10 CONTINUE
   15 N=I
      NH=N/2
      K=N+1
      DO 20 I=1,NH
      J=K-I
      Z=F(I)
      F(I)=F(J)
      F(J)=Z
      Z=Y(I)
      Y(I)=Y(J)
   20 Y(J)=Z
      CALL SPLINE(1,N,F,Y,B,C,D)
      NL=(F(1)-X(1))/H+1.
      NH=M-1.-(X(M)-F(N))/H
      Z=1.05*B(1)
      Z=B(1)
      K=NL+1
      DO 25 I=1,NL
      J=K-I
      W(J)=Z
   25 A(J)=Y(1)+Z*(X(J)-F(1))
      Z=1.05*B(N)
      Z=B(N)
```

```
      DO 30 I=NH,M
      W(I)=Z
   30 A(I)=Y(N)+Z*(X(I)-F(N))
      NH=NH-1
      J=1
      DO 45 I=K,NH
   35 IF(X(I).LT.F(J)) GO TO 40
      J=J+1
      GO TO 35
   40 L=J-1
      Z=X(I)-F(L)
      W(I)=B(L)+Z*(2.*C(L)+3.*Z*D(L))
   45 A(I)=Y(L)+Z*(B(L)+Z*(C(L)+Z*D(L)))
      Z=0.5/H
      DO 50 I=K,NH
   50 W(I)=Z*(A(I+1)-A(I-1))
      PRINT 1,NH,NL,M
    1 FORMAT(1H ,4HNH =,I5,4HNL =,I5,4HM = ,I5)
      RETURN
      END

      SUBROUTINE ASHIFT(A,B,X,H,W,M,Y,C,E)
      DIMENSION A(1),B(1),X(1),C(1)
      D=ALOG(W)
      Z=ABS(D)/H
      ID=Z
      Z=Z-ID
      Y=(D-X(1))/H+1
      N=Y
      Y=Y-N
      E=EXP(C(N)+Y*(C(N+1)-C(N)))
      Y=A(N)+Y*(A(N+1)-A(N))
      IF(D.LT.0.) GO TO 30
      N=N-1-ID
      DO 10 I=1,N
      J=I+ID
   10 B(I)=A(J)+Z*(A(J+1)-A(J))-Y
      N=N+1
      DO 20 I=N,M
   20 B(I)=A(M)-Y
      RETURN
   30 Z=1.-Z
      ID=ID+1
      N=ID+1
      DO 40 I=1,ID
   40 B(I)=A(1)-Y
      DO 50 I=N,M
      J=I-ID
   50 B(I)=A(J)+Z*(A(J+1)-A(J))-Y
      RETURN
```

```
      END

      SUBROUTINE LNCOTH(X,C,M,H)
      DIMENSION X(1),C(1)
      IF(X(M).GT.-X(1)) GO TO 30
      N=-(X(1)+X(M))/H
      IF(ABS(N*H+X(M)+X(1)),GT.1.E-4) N=N+1
      DO 10 I=1,N
   10 C(I)=-ALOG(TANH(-0.5*X(I)))
      J=M+1
      K=X(M)/H+1.+N
      N=N+1
      DO 20 I=N,K
      J=J-1
      C(J)=-ALOG(TANH(-0.5*X(I)))
      C(I)=C(J)
   20 CONTINUE
      RETURN
   30 N=(X(M)+X(1))/H
      IF(ABS(N*H-X(1)-X(M)),GT.1.E-4) N=N+1
      K=-X(1)/H+1.
      J=K+K+1
      DO 40 I=1,K
      J=J-1
      C(J)=-ALOG(TANH(-0.5*X(I)))
   40 C(I)=C(J)
      K=K+1
      DO 50 I=K,M
   50 C(I)=-ALOG(TANH(0.5*X(I)))
      RETURN
      END

      FUNCTION DOT(A,B,X,N,H)
      DIMENSION A(1),B(1),X(1)
      DO 10 I=1,N
   10 A(I)=A(I)*B(I)
      M=-X(1)/H+1.
      DOT=A(1)
      DO 20 I=3,M,2
   20 DOT=DOT+4.*A(I-1)+2.*A(I)
      DOT=DOT-A(M)+A(M+1)
      M=M+3
      DO 30 I=M,N,2
   30 DOT=DOT+4.*A(I-1)+2.*A(I)
      DOT=H*(DOT-A(N))/3.
      RETURN
      END

      SUBROUTINE SPLINC(N1,N2,X,Y,B,C,D)
      DIMENSION X(1),Y(1),B(1),C(1),D(1)
```

```
      M1=N1+1
      M2=N2-1
      M3=M1+M2
      S=0.
      DO 10 K=N1,M2
      D(K)=X(K+1)-X(K)
      R=(Y(K+1)-Y(K))/D(K)
      C(K) = R - S
   10 S=R
      R=0.0
      S=0.0
      C(N1)=0.0
      C(N2)=0.0
      DO 20 K=M1,M2
      C(K) = C(K)*R*C(K-1)
      B(K)=1./((X(K-1)-X(K+1))*2.-R*S)
      S=D(K)
   20 R=S*B(K)
      DO 30 K=M1,M2
      L=M3-K
   30 C(L)=B(L)*(D(L)*C(L+1)-C(L))
      DO 40 K=N1,M2
      B(K)=(Y(K+1)-Y(K))/D(K)-(C(K)*2.+C(K+1))*D(K)
      D(K)=(C(K+1)-C(K))/D(K)
   40 C(K)=3.*C(K)
      R=X(N2)-X(M2)
      B(N2)=B(M2)+R*(2.*C(M2)+3.*R*D(M2))
      C(N2)=0.
      D(N2) = 0.0
      RETURN
      END
```

DATA PAGE 1

```
     -7.          7.        0.2
  0.25        7.5
 2.5          0.0703
 5.0          1.125
 6.67         3.56
 10.          18.
 12.5         45.
 14.29        75.
 16.67        135.
 20.          240.
 22.22        300.
 25.          360.
 28.57        370.
 33.33        320.
 40.          195.
 50.          100.
 66.66        34.
 100.         6.716
 111.11       4.406
 125.         2.751
 142.86       1.613
 166.67       0.8704
 333.333      .05439
 500.        .010746
1000.        .0006716  1
```

Impulse Displacement

Impulse Acceleration

Impulse Velocity

Step Acceleration

FREQ (HZ)	PHI (DEG)	MAGNIFICATION
0.10000E-02	351.44586	0.67160E-03
0.20000E-02	342.72147	0.10746E-01
0.30000E-02	333.97441	0.54390E-01
0.40000E-02	325.07655	0.17187E 00
0.50000E-02	316.23960	0.41964E 00
0.60000E-02	307.35212	0.87048E 00
0.70000E-02	298.48943	0.16129E 01
0.80000E-02	289.59594	0.27512E 01
0.90000E-02	280.26886	0.44059E 01
0.10000E-01	271.50561	0.67159E 01
0.20000E-01	169.03246	0.99546E 02
0.30000E-01	63.32208	0.31807E 03
0.40000E-01	-35.34685	0.34130E 03
0.50000E-01	-107.13589	0.23110E 03
0.60000E-01	-156.19694	0.13271E 03
0.70000E-01	-190.64494	0.74935E 02
0.80000E-01	-214.54080	0.44868E 02
0.90000E-01	-232.90682	0.27801E 02
0.10000E 00	-246.63725	0.18000E 02
0.20000E 00	-304.25502	0.11251E 01
0.30000E 00	-322.92178	0.22191E 00
0.40000E 00	-332.02555	0.70300E-01
0.50000E 00	-337.59146	0.28822E-01
0.60000E 00	-341.29862	0.13911E-01
0.70000E 00	-343.97775	0.75135E-02
0.80000E 00	-345.96515	0.44068E-02
0.90000E 00	-347.47298	0.27525E-02
0.10000E 01	-348.76815	0.18067E-02
0.20000E 01	-354.26057	0.11326E-03
0.30000E 01	-356.11110	0.22411E-04
0.40000E 01	-357.04558	0.70996E-05
0.50000E 01	-357.60168	0.29108E-05
0.60000E 01	-357.96860	0.14048E-05
0.70000E 01	-358.22774	0.75879E-06
0.80000E 01	-358.42483	0.44504E-06
0.90000E 01	-358.58372	0.27798E-06
0.10000E 02	-358.70178	0.18246E-06

0.20249E 02

0.92551E 02

X. HASKELL

PROGRAMMER : R. B. HERRMANN / Mar 1975

PURPOSE:

This program uses the Haskell-Thompson formalism to synthesize teleseismic P and S wave time histories for any of a set of seismic source force equivalents. The options include source crust response, receiver crust response, anelastic attenuation, and instrument response.

INPUT/OUTPUT

Card input is from FILE 60, printer output is in FILE 61, and FILE 10 is used for the off-line CALCOMP plotter tape.

THEORY

The theory is described by Hudson (1969). An example of the use of the program can be found in Herrmann (1976a,b).

PROGRAM DESCRIPTION

PROGRAM HASKELL: Main input-output routine.

SUBROUTINE SIGNAL: Computes the theoretical spectra and seismograms.

SUBROUTINE FOURIER: Performs an inverse Fourier transform of a spectra.

SUBROUTINE SPEC: Takes spectra and plots on a 2 & 3 log-log plot.

SUBROUTINE TRANS: Converts from DIP, STK and SLIP into orientation of x,y axes or P and T axes.

SUBROUTINE RESP: Takes spectra of input pulse and includes non-causal anelastic attenuation and/or instrument effect. Also delays signal for P wave studies so that time is relative to direct arrival, no matter what the focal depth is.

SUBROUTINE PULDLY: Gives the P wave delay time for use in RESP.

SUBROUTINE MODELIN: Reads in receiver and source crust models. Both must be read in.

SUBROUTINE RAD: Gives theoretical far-field P, SV, or SH amplitudes from a double-couple source. Used to determine theoretical S polarization angle.

SUBROUTINE MINMAX: Searches an array for minimum and maximum values, prints these values out and then adjusts the values for the use of EZPLOT2.

SUBROUTINE SEISMAG : Hagiwara's formula for the system response of a 15-100 WWSSN LP seismograph. The sign of the output is such that a unit positive impulse will give an initial positive output.

SUBROUTINE FOUR2 : This computes a FFT. This is really FOUR1 of Brenner.

SUBROUTINE PULSE : This generates a trapezoid of unit area which is used as the source input signal. The beginning of the signal is delayed by DT1 + DT2 + DT3 to avoid some aliasing problems in the time domain.

SUBROUTINE DELSV: Haskell formulation of response at surface of plane-layered halfspace to an incident P or SV wave. Vertical and radial spectra are determined.

SUBROUTINE DELSH : Haskell formulation of response at surface of a plane-layered halfspace to an incident SH wave.

SUBROUTINE SHSRC: Response of source crust upon teleseismic SH for source within the crust.

SUBROUTINE SHEXC : Excitation of SH by various types of sources - HASKELL uses only ISRC = 5 or 6. These are really multipole coefficients.

SUBROUTINE SVSRC : Spectra of teleseismic P or SV due to source in a layered source crust.

SUBROUTINE COEF: Generation of the layer matrix BB used by SVSRC.

SUBROUTINE SVEXC: Multipole coefficients for point sources for SVSRC. HASKELL uses only ISRC = 5 or 6.

SUBROUTINE DETER : Gives the determinant of a 3 x 3 matrix.

SUBROUTINE DOEF : Generation of the source layer matrix DP used by SVSRC.

REFERENCES

Haskell, N. A. (1964). Radiation pattern of surface waves from point sources in a multi-layered medium, Bull. Seism Soc. Am. 54, 377-393.

Herrmann, R. B. (1976a). Some more complexity in S-wave particle motion, Bull. Seism. Soc. Am. 66, 625-632.

Herrmann, R. B. (1976b). Focal depth determination from the signal character of long-period P waves, Bull. Seism. Soc. Am. 66, 1221-1232.

Hudson, J. A. (1969). A quantitative evaluation of seismic signals at teleseismic distances-II. Body waves and surface waves from an extended source, Geophys. J. R. astr.Soc. 18, 353-370.

(Note: there is a small error in Hudson's equation 3.5. The expression defining h_r^{nc} is in fact not h_r^{nc} but rather - $F(\omega)\ K_1$ as can be verified by a solution of equation 2.5 using equation 2.7)

INPUT DATA

Card Sequence	Column	Name	Format	Explanation
A.	1-5	MMAXS	I5	Number of layers of source crust including half-space
B. Source Model (MMAXS cards)				
	1-10	DS	F10.3	Layer thickness in km
	11-20	AS	F10.4	Source layer P vel km/sec
	21-30	BS	F10.4	Source layer S vel km/sec
	31-40	RHOS	F10.4	Source layer density gm/cc
C.	1-5	MMAXR	I5	Number of layers of receiver crust, including halfspace.
D. Receiver model (MMAXR cards)				
	1-10	DR	F10.4	Layer thickness in km of receiver crust
	11-20	AR	F10.4	Layer P vel km/sec
	21-30	BR	F10.4	Layer S vel km/sec
	31-40	RHOR	F10.4	Layer density gm/cc
	(Note MMAXR and MMAXS can be no greater than 10).			
D.	1-10	TMMN	F10.3	Minimum time value for time history plots (LE. 0)

D. Cont'd)

Card Sequence	Column	Name	Format	Explanation
	11-20	TMMX	F10.3	Maximum time value for time history plot
	21-30	FMIN	F10.3	Minimum frequency for spectra plot
	31-40	FMAX	F10.3	Maximum frequency for abscissa of spectra plot
E.	1-5	NN	I5	Number of points to be used in synthesizing the input time series. The plotted output time series varies from t = 0 sec to t = (NN-1)*DT sec NN.LE.256.
	11-20	DT	F10.5	Digitizing interval 256*DT sec are synthesized while NN*DT sec are outputted.
	21-25	IEQEX	I5	LE.0 double couple earthquake source GT.0 center of compression used for source
F.	1-10	H	F10.3	Focal depth in km. Must not be in halfspace of model. e.g. must be within a layer. (LE.0 terminate program)
	11-20	DIP	F10.3	Dip of fault plane in degrees (0^{o},90^{o})
	21-30	STK	F10.3	Strike of fault plane. Fault dips to right when looking along strike. Measured clockwise from N.

F. (cont.d)

Card Sequence	Column	Name	Format	Explanation
	31-40	SLIP	F10.3	Angle of slip on fault plane. Measured from direction of strike. SLIP (0^{o},180^{o}) center of focal sphere = compression (-0^{o},-180^{o})center of focal sphere = dilatation.
	41-50	DT1	F10.3	Duration of positive slope of trapezoidal source pulse.
	51-60	DT2	F10.3	Duration of zero slope of trapezoidal source pulse
	61-70	DT3	F10.3	Duration of negative slope of trapezoidal source pulse.
	71-80	XMOM	E10.3	Seismic moment in dyne-cm
G.	1-5	IFORM	I5	LE.0 go to Point F for new source EQ.1 P wave synthesis EQ.2 S wave synthesis
	6-10	ITYP	I5	.EQ.1 Response of source and receiver system together .EQ.2 Response of source crust only. Only teleseismic P or S returned. .EQ.3 Response of receiver crust to a unit incident teleseismic P or S wave.

G. Cont'd)

Card Sequence	Column	Name	Format	Explanation
	11-15	ISPEC	I5	GT.1 Ground motion output LE.1 seismograph output (at present 15-100 WWSSN)
	16-20	IATTEN	I5	GE.1 attenuation (non-causal included) LT.1 not included
	21-25	IZ	I5	LE.0 skip GT.0. and .LE.2 seismogram GT.2 spectra of Z component (for ITYP=2 this equals mantle P or SV according to IFORM)
	26-30	IN	I5	LE.0 slip North-south output GT.0. and .LE.2 seismogram GT.2 spectra of NS component
	31-35	IE	I5	LE.0 skip east-west output GT.0. and LE.2 seismogram GT.2 spectra of EW comp.
	36-40	IR	I5	LE.0 skip radial output GT.0. and.LE.2 seismogram GT.2 spectra of radial comp.
	41-45	IT	I5	LE.0 skip transverse output GT.0.and .LE.2 seismogram GT.2 spectra of transverse component (SH)

G. (Cont'd)

Card Sequence	Column	Name	Format	Explanation
	46-50	IPOL	I5	LE.0 do nothing GT.0 plot SH vs SV particle motions when IFORM = 2.
H.	2-5	ISTA	A4	Identifier--control returns to Point G when ISTA=HALT
	11-20	DEL	F10.3	Azimuth of station w.r.t. source
	21-30	BAZ	F10.3	Back azimuth from station to source. Used in making N and E time histories from R and T
	31-40	C	E10.3	Phase velocity of arrival (km/sec) determined from travel time curves.
	41-50	GEOM	E10.3	Geometrical spreading factor for P wave--see Bullen or EDABAC.
	51-60	GEOMS	E10.3	Geometrical spreading factor for S wave.
	61-70	BETSS	F10.5	S-wave takeoff angle, used for determination of theoretical S-wave polarization angle.

The program calculates the desired quantities and reads another ISTA card until it finds one for which ISTA = HALT.

```
C     PROGRAM HASKELL(INPUT,OUTPUT,TAPE60=INPUT,TAPE61=OUTPUT,FILMPL)
C     THIS PROGRAM GENERATES P OR S WAVE GROUND OR SEISMOGRAM TIME
C     HISTORIES FOR A PARTICULAR SET OF SOURCE PARAMETERS
      CHARACTER XL,YL,TL,YLS,SHL,SVL,FL,IOU1,IOU2,IOU3,IST
      COMMON / SRCMOD / DS(10), AS(10), BS(10), RHOS(10), MMAXS
        COMMON / RECMOD / DR(10), AR(10), BR(10), RHOR(10), MMAXR
      COMMON / CONTROL / IFORM,ITYP,ISPEC,IATTEN,IZ,IR,IT
      COMMON / SOURCE / SAVE1(  258),C,H,DIP,STK,SLIP,DCF(3),DCN(3),ISRC
      COMMON / PULS  / X(258),Y(258),NN
      COMMON / FOUR/ DATA(  512),N,DT,DF
      COMMON /PLTLIM / TMMN,TMMX,FMIN,FMAX
      COMMON / PLTTTL / XL(8),YL(8),TL(8),FL(8),YLS(8),SHL(8),SVL(8)
      DIMENSION Z(258),UN(258),UE(258),R(258),T(258),USV(258)
      DIMENSION IBUF(1000)
      DIMENSION XX(4),YY(4)
      CALL PLOTS(IBUF,1000,10)
      CALL MODELIN
      DO 33 I = 1,56
   33 XL(I) =  6H
      FL(2) =       6HFREQUE
      FL(3) =  6HNCY (H
      FL(4) = 6HZ)
      YL(1) = 6HAMPLIT
      YL(2) = 6HUDE SP
      YL(3) = 6HECTRUM
      YL(4) = 6HCM-SEC
      XL(1) = 6H     TI
      XL(2) = 6HME (SE
      XL(3) = 6HC)
      YLS(1) = 6H AMPLI
      YLS(2) = 6HTUDE C
      YLS(3) = 6HCM)
      SHL(2) = 6H  SH
      SVL(2) = 6H  SV
      DEGRAD = 0.017452329
      READ(60,1) TMMN,TMMX,FMIN,FMAX
    1 FORMAT(7F10.3,E10.3)
      XMIN = TMMN
                        XMAX = TMMX
      READ(60,4) NN,DT,IEQEX
    4 FORMAT(I5,5X,F10.5,2I5)
      ISRC = 5
                     IF(IEQEX.GT.0) ISRC = 6
      IF(IEQEX.GT.0) IOU1 = 4HEXPL
      IF(IEQEX.GT.0) IOU2 = 4HOSIO
      IF(IEQEX.GT.0) IOU3 = 4HN
      IF(IEQEX.LE.0) IOU1 = 4HEART
      IF(IEQEX.LE.0) IOU2 = 4HHQUA
      IF(IEQEX.LE.0) IOU3 = 4HKE
      WRITE(61,14) NN,DT,IOU1,IOU2,IOU3
```

```
   14 FORMAT(1H0,4HNN = ,I5,5X,4HDT = ,F7.2,5X,3A4/)
 4002 CONTINUE
      READ(60,1) H,DIP,STK,SLIP,DT1,DT2,DT3,XMOM
      IF(H.LE.0) GO TO 9999
      WRITE(61,11) H,DIP,STK,SLIP,DT1,DT2,DT3,XMOM
   11 FORMAT(1H0,3HH = ,F7.2,4X,5HDIP = ,F7.2,4X,5HSTK = ,F7.2,4X,6HSLIP
     1 = ,F7.2,4X,5HDT1 = ,F7.2,4X,5HDT2 = ,F7.2,4X,5HDT3 = ,F7.2,4X,
     25HMOM = ,E10.3/)
      H = H * 1.0E+5
      CALL TRANS
 4001 CONTINUE
      READ(60,2)  IFORM,ITYP,ISPEC,IATTEN,IZ,IN,IE,IR,IT,IPOL
    2 FORMAT(10I5)
      IF(IFORM.LE.0) GO TO 4002
      IF(IFORM.NE.2) IPOL = 0
      WRITE(61,12)IFORM,ITYP,ISPEC,IATTEN,IZ,IN,IE,IR,IT,IPOL
   12 FORMAT(1H ,10I5/)
C     IFORM = 1 P WAVE SYNTHESIS  = 2 S WAVE SYNTHESIS
C     ITYP  .EQ. 1   RESPONSE OF SOURCE AND RECEIVER CRUSTS
C           .EQ. 2   RESPONSE OF SOURCE CRUST ONLY -- TELESEISMIC P OR S
C           .EQ. 3   RESPONSE OF RECEIVER CRUST ONLY
C     ISPEC GT 1 GROUND MOTION OUTPUT
C           LE 1 SEISMOGRAPH OUTPUT
C     IATTEN .GE. 1 ATTENUATION INCLUDED   .LT. 1 NOT INCLUDED
C     IZ  Z   LE 0 SKIP LE 2 SEISMOGRAM GE 2 SPECTRA
C     IN  N   LE 0 SKIP LE 2 SEISMOGRAM GE 2 SPECTRA
C     IE  E   LE 0 SKIP LE 2 SEISMOGRAM GE 2 SPECTRA
C     IR  R   LE 0 SKIP LE 2 SEISMOGRAM GE 2 SPECTRA
C     IT  T   LE 0 SKIP LE 2 SEISMOGRAM GE 2 SPECTRA
C     IPOL . GT. 0  PLOT SH VERSUS SV
      N = 256
      CALL PULSE(X,Y,NN,DT,DT1,DT2,DT3,XMOM)
      CALL MINMAX( Y,NN,SMIN,SMAX)
      TL(2) = 6HSOURCE
      TL(3) =  6H PULSE
      CALL EZPLOT2(X, Y,NN,0,XMIN,XMAX,SMIN,SMAX,XL,YLS,TL,1,1)
      DF = 1./(N*DT)
 4003 CONTINUE
      READ(60,5)  IST,DEL,BAZ,C,GEOM,GEOMS,BETSS
    5 FORMAT(1H ,A4, 5X,3F10.3,2E10.3,F10.5)
      IF(IST.EQ.4HHALT) GO TO 4001
      WRITE(61,5) IST,DEL,BAZ,C,GEOM,GEOMS,BETSS
      C = C*1.0E+5
      TL(2) = IST
      IF(IFORM.EQ.1) SCALE = GEOM
      IF(IFORM.EQ.2) SCALE = GEOMS
      DELAY = 0.0
      IF(IFORM.EQ.1) CALL PULDLY(DELAY)
      N2 = N * 2
      DO 1000 I = 1,N2
```

```
1000 DATA(I) = 0.0
     DO 1005 I = 1,NN
1005 DATA(2*I-1) = Y(I) * DT
     CALL FOUR2(DATA,N,0,-1)
     CALL RESP(DATA,DF,N,IFORM,ISPEC,IATTEN,SCALE,DELAY)
     DO 2314 I = 1,258
2314 SAVE1(I) = DATA(I)
     CALL SIGNAL(Z,R,T,DEL)
     CB = COS(BAZ*DEGRAD)
                              SB = SIN(BAZ*DEGRAD)
     DO 7000 I = 1,NN
     UN(I) = - CB * R(I) + SB * T(I)
     UE(I) = - SB * R(I) - CB * T(I)
7000 CONTINUE
     IF(IPOL.LE.0) GO TO 5006
     DO 4006 I = 1,N
     IF(Z(I).NE.0.0) SGN = SIGN(1.0,Z(I))
     IF(Z(I).EQ.0.0) SGN = SIGN(-1.0,R(I))
4006 USV(I) = SGN * SQRT(Z(I)*Z(I) + R(I)*R(I))
     CALL MINMAX(USV,NN,SMIN,SMAX)
     CALL MINMAX(T  ,NN,SSIN,SSAX)
     DUM = ABS(SMAX)
                         IF(DUM.LT.ABS(SSAX)) DUM = ABS(SSAX)
     SMIN = - DUM
                       SMAX = DUM
     TL(1) = IST
     TL(2) = 6HS POLA
     TL(3) = 6HRIZATI
     TL(4) = 6HON
     CALL EZPLOT2(T,USV,NN,0,SMIN,SMAX,SMIN,SMAX,SHL,SVL,TL,1,3)
     CALL RAD(STK,DIP,SLIP,DEL,BETSS,D,3)
     CALL RAD(STK,DIP,SLIP,DEL,BETSS,E,2)
     SPOLANG = ATAN2(E,D)/DEGRAD
     WRITE(61,6) SPOLANG,E,D
   6 FORMAT(1H ,6HSPOL =,F6.1,5X,4HSH =,E10.3,5X,4HSV =,E10.3)
     SS = SIN(SPOLANG*DEGRAD)
                                    CC = COS(SPOLANG*DEGRAD)
     R1 = 0.75 * SMAX
                            R2 = 0.95 * SMAX
     XX(1) = R1 * SS
                         XX(2) = R2 * SS
                                              YY(1) = R1 * CC
                                                                YY(2) = R2
    1 * CC
     CALL NXCURV2(XX,YY,2,0)
     XX(1) = - XX(1)
                         XX(2) = - XX(2)
                                              YY(1) = - YY(1)
                                                              YY(2)=-YY(2)
     CALL NXCURV2(XX,YY,2,0)
```

```
      TL(1) = 6H
      TL(2) = IST
      TL(3) = 6H
      TL(4) = 6H
 5006 CONTINUE
      IF(IZ.LE.0) GO TO 5001
      TL(3) = 6HZ
      IF(ITYP.EQ.2.AND.IFORM.EQ.1) TL(3) = 6HP
      IF(ITYP.EQ.2.AND.IFORM.EQ.2) TL(3) = 6HSV
      IF(IZ.GT.2) GO TO 6001
      CALL MINMAX( Z,NN,SMIN,SMAX)
      CALL EZPLOT2(X, Z,NN,0,XMIN,XMAX,SMIN,SMAX,XL,YLS,TL,1,1)
 6001 CONTINUE
 5001 CONTINUE
      IF(IN.LE.0) GO TO 5002
      TL(3) = 6HN
      IF(IN.GT.2) GO TO 6002
      CALL MINMAX(UN,NN,SMIN,SMAX)
      CALL EZPLOT2(X,UN,NN,0,XMIN,XMAX,SMIN,SMAX,XL,YLS,TL,1,1)
 6002 CONTINUE
 5002 CONTINUE
      IF(IE.LE.0) GO TO 5003
      TL(3) = 6HE
      IF(IE.GT.2) GO TO 6003
      CALL MINMAX(UE,NN,SMIN,SMAX)
      CALL EZPLOT2(X,UE,NN,0,XMIN,XMAX,SMIN,SMAX,XL,YLS,TL,1,1)
 6003 CONTINUE
 5003 CONTINUE
      IF(IR.LE.0) GO TO 5004
      TL(3) = 6HR
      IF(ITYP.EQ.2.AND.IFORM.EQ.1) TL(3) = 6HP
      IF(ITYP.EQ.2.AND.IFORM.EQ.2) TL(3) = 6HSV
      IF(IR.GT.2) GO TO 6004
      CALL MINMAX( R,NN,SMIN,SMAX)
      CALL EZPLOT2(X, R,NN,0,XMIN,XMAX,SMIN,SMAX,XL,YLS,TL,1,1)
 6004 CONTINUE
 5004 CONTINUE
      IF(IT.LE.0) GO TO 5005
      TL(3) = 6HT
      IF(IT.GT.2) GO TO 6005
      CALL MINMAX( T,NN,SMIN,SMAX)
      CALL EZPLOT2(X, T,NN,0,XMIN,XMAX,SMIN,SMAX,XL,YLS,TL,1,1)
 6005 CONTINUE
 5005 CONTINUE
      GO TO 4003
 9999 CONTINUE
      CALL PLOT(12.0,0.0,999)
      STOP
      END

      SUBROUTINE SIGNAL(Z,R,T,PHI)
```

```
      CHARACTER XL,YL,TL,YLS,SHL,SVL,FL
      COMMON / CONTROL / IFORM,ITYP,ISPEC,IATTEN,IZ,IR,IT
      COMMON / SOURCE / SAVE1(  258),C,H,DIP,STK,SLIP,DCF(3),DCN(3),ISRC
      COMMON / FOUR/ DATA(  512),N,DT,DF
      COMMON /PLTLIM / TMMN,TMMX,FMIN,FMAX
      COMMON / PLTTTL / XL(8),YL(8),TL(8),FL(8),YLS(8),SHL(8),SVL(8)
      COMMON / SAVE / SAVE2(258),SAVE3(258)
      DIMENSION Z(258),R(258),T(258)
      NP1 = N/2 + 1
      N2 = N + 2
      DO 100 I = 1,N2
      SAVE2(I) = 0.0
                        SAVE3(I) = 0.0
                                          Z(I) = 0.0
                                                    R(I) = 0.0
                                                              T(I) =
     1 0.0
  100 CONTINUE
      IF(ITYP.EQ.3) GO TO 1001
      DO 1000 INDEX = 1,2
C     INDEX = 1 P WAVE SOURCE     INDEX = 2 S WAVE SOURCE
      IF(IFORM.NE.INDEX) GO TO 1000
      DO 999 I = 1,NP1
      FREQ = (I-1) * DF
      J = 2 * I - 1
      K = 2 * I
      IF(FREQ.EQ.0.0) FREQ = 1.0E-05
      IF(IZ.LE.0.AND.IR.LE.0) GO TO  994
      CALL SVSRC(FREQ,C,AR,AI,DCF,DCN,ISRC,H,PHI,INDEX)
      SAVE2(J) = SAVE1(J) * AR - SAVE1(K) * AI
      SAVE2(K) = SAVE1(K) * AR + SAVE1(J) * AI
  994 CONTINUE
      IF(INDEX.EQ.1) GO TO 999
      IF(IT.LE.0) GO TO 999
      CALL SHSRC(FREQ,C,AR,AI,DCF,DCN,ISRC,H,PHI)
      SAVE3(J) = SAVE1(J) * AR - SAVE1(K) * AI
      SAVE3(K) = SAVE1(K) * AR + SAVE1(J) * AI
  999 CONTINUE
 1000 CONTINUE
C     AT THIS POINT SAVE2 = MANTLE P OR SV AND SAVE3 = MANTLE SH
      IF(ITYP.EQ.2) GO TO 3001
 1001 CONTINUE
      DO 2000 INDEX = 1,2
      IF(IFORM.NE.INDEX) GO TO 2000
      DO 1999 I = 1,NP1
      J = 2 * I - 1
      K = 2 * I
      FREQ = (I-1) * DF
      IF(FREQ.EQ.0.0) FREQ = 1.0E-05
      IF(IZ.LE.0.AND.IR.LE.0) GO TO 1994
```

```
      CALL DELSV(FREQ,C,AUR,AUI,AWR,AWI,INDEX)
      GO TO (1991,1991,1993),ITYP
 1991 Z(J) = SAVE2(J) * AWR - SAVE2(K) * AWI
      Z(K) = SAVE2(K) * AWR + SAVE2(J) * AWI
      R(J) = SAVE2(J) * AUR - SAVE2(K) * AUI
      R(K) = SAVE2(K) * AUR + SAVE2(J) * AUI
      GO TO 1994
 1993 Z(J) = SAVE1(J) * AWR - SAVE1(K) * AWI
      Z(K) = SAVE1(K) * AWR + SAVE1(J) * AWI
      R(J) = SAVE1(J) * AUR - SAVE1(K) * AUI
      R(K) = SAVE1(K) * AUR + SAVE1(J) * AUI
 1994 CONTINUE
      IF(INDEX.EQ.1) GO TO 1999
      IF(IT.LE.0) GO TO 1999
      CALL DELSH(FREQ,C,AR,AI)
      GO TO (1981,1981,1983),ITYP
 1981 T(J) = SAVE3(J) * AR - SAVE3(K) * AI
      T(K) = SAVE3(K) * AR + SAVE3(J) * AI
      GO TO 1984
 1983 T(J) = SAVE1(J) * AR - SAVE1(K) * AI
      T(K) = SAVE1(K) * AR + SAVE1(J) * AI
 1984 CONTINUE
 1999 CONTINUE
 2000 CONTINUE
      GO TO 3002
 3001 DO 2999 I = 1,N2
      Z(I) = SAVE2(I)
                        R(I) = SAVE2(I)
                                              T(I) = SAVE3(I)
 2999 CONTINUE
 3002 CONTINUE
C     SPECTRA PLOTTED IF SO CALLED FOR
      IF(IZ.LT.2) GO TO 3011
      TL(3) = 6HZ
      IF(ITYP.EQ.2.AND.IFORM.EQ.1) TL(3) = 6HP
      IF(ITYP.EQ.2.AND.IFORM.EQ.2) TL(3) = 6HSV
      CALL SPEC(DF,N,Z)
 3011 IF(IR.LT.2) GO TO 3012
      TL(3) = 6HR
      IF(ITYP.EQ.2.AND.IFORM.EQ.1) TL(3) = 6HP
      IF(ITYP.EQ.2.AND.IFORM.EQ.2) TL(3) = 6HSV
      CALL SPEC(DF,N,R)
 3012 IF(IT.LT.2) GO TO 3013
      TL(3) = 6HT
      CALL SPEC(DF,N,T)
 3013 CONTINUE
C     SEISMOGRAMS NOW DETERMINED FROM THE SPECTRA
      IF(IZ.LE.2.AND.IZ.GT.0) CALL FOURTR(Z)
      IF(IR.LE.2.AND.IR.GT.0) CALL FOURTR(R)
      IF(IT.LE.2.AND.IT.GT.0) CALL FOURTR(T)
```

```
      RETURN
      END

      SUBROUTINE FOURTR(X)
      COMMON / FOUR/ DATA(  512),N,DT,DF
      DIMENSION X(1)
      N2 = N + 2
      DO 100 I = 1,N2
  100 DATA(I) = X(I)
      MM = N/2 + 1
      DO 1015 I = MM,N
      J = N + 2 - I
      DATA(2*I-1) = DATA(2*J-1)
 1015 DATA(2*I) = - DATA(2*J)
      DATA(2*MM) = 0.0
      DATA(2) = 0.0
      CALL FOUR2(DATA,N,0,+1)
      DO 1020 I = 1,N
      J = 2 * I - 1
 1020 X(I) = DATA(J) * DF
      RETURN
               END

      SUBROUTINE TRANS
      COMMON / SOURCE / SAVE1(  258),C,H,DIP,STK,SLIP,DCF(3),DCN(3),ISRC
      DO 100 I = 1,3
      DCF(I) = 0.0
  100 DCN(I) = 0.0
      IF(ISRC.LT.4.OR.ISRC.GT.5) RETURN
C     ISRC .EQ. 4  DCF = ORIENTATION OF X-AXIS
C                  DCN = ORIENTATION OF Y-AXIS
C     ISRC .EQ. 5  DCF = ORIENTATION OF T-AXIS
C                  DCN = ORIENTATION OF P-AXIS
   10 FORMAT(1H0,     5HX = (,F10.7,1H,,F10.7,1H,,F10.7,1H)     ,
     1 5X    ,        5HY = (,F10.7,1H,,F10.7,1H,,F10.7,1H)     ,
     2 5X    ,        5HZ = (,F10.7,1H,,F10.7,1H,,F10.7,1H)     )
   11 FORMAT(1H ,5HT = (, F10.7,1H,,F10.7,1H,,F10.7,1H)    ,
     1 5X  ,     5HP = (, F10.7,1H,,F10.7,1H,,F10.7,1H)  /)
      DEGRAD = 0.01745329
      SINS = SIN(STK*DEGRAD)
      COSS = COS(STK*DEGRAD)
      SIND = SIN(DIP*DEGRAD)
      COSD = COS(DIP*DEGRAD)
      SINF = SIN(SLIP*DEGRAD)
      COSF = COS(SLIP*DEGRAD)
      A11 = COSF*COSS + SINF*COSD*SINS
      A12 = COSF*SINS - SINF*COSD*COSS
      A13 = - SINF*SIND
      A21 = - SINS*SIND
      A22 = COSS * SIND
```

```
      A23 = - COSD
      A31 = COSS*SINF - COSD*COSF*SINS
      A32 = COSD*COSF*COSS + SINF*SINS
      A33 = COSF*SIND
      WRITE(61,10) A11,A12,A13,A21,A22,A23,A31,A32,A33
      IF(ISRC.EQ.5) GO TO 1005
      DCF(1) = A11
                       DCF(2) = A12
                                        DCF(3) = A13
      DCN(1) = A21
                       DCN(2) = A22
                                        DCN(3) = A23
      RETURN
 1005 CONTINUE
      T1 = A11 + A21
                         T2 = A12 + A22
                                          T3 = A13 + A23
      TNORM = SQRT(T1*T1 + T2*T2 + T3*T3)
      IF(T3.LT.0.0) TNORM = -TNORM
      DCF(1) = T1/TNORM
                         DCF(2) = T2/TNORM
                                            DCF(3) = T3/TNORM
      P1 = A11 - A21
                         P2 = A12 - A22
                                          P3 = A13 - A23
      PNORM = SQRT(P1*P1 + P2*P2 + P3*P3)
      IF(P3.LT.0.0) PNORM = - PNORM
      DCN(1) = P1/PNORM
                         DCN(2) = P2/PNORM
                                            DCN(3) = P3/PNORM
      WRITE(61,11)DCF(1),DCF(2),DCF(3),DCN(1),DCN(2),DCN(3)
      RETURN
            END

      SUBROUTINE RESP(DATA,DF,N,IFORM,ISPEC,IATTEN,SCALE,DELAY)
      DIMENSION DATA(1)
      IF(IFORM.EQ.1) TQ = 1.0
C     T/Q = 1.0 FOR P WAVES (=ELMBERGER)
      IF(IFORM.EQ.2) TQ = 3.0
C     T/Q = 3.0 FOR S WAVES (=ELMBERGER)
      M = N/2 + 1
      DO 10 I = 1,M
      XI = I - 1
      FREQ = XI * DF
      ARG = 6.283185307 * FREQ * DELAY
      FAC = 1.0
      IF(IATTEN.LT.1) GO TO 99
      FAC = EXP(-3.1415927 * TQ * FREQ )
   99 CONTINUE
      J = 2 * I - 1
```

```
      K = 2 * I
      IF(ISPEC.GT.1) GO TO 100
      IF(FREQ.EQ.0.0) FREQ = 1.0E-5
      CALL SEISMAG(FREQ,3000.,XR,XI)
      GO TO 101
  100 XR = 1.0
                  XI = 0.0
  101 CONTINUE
      TEMPR = XR*DATA(J) - XI*DATA(K)
      TEMPI = XR*DATA(K) + XI*DATA(J)
      DATA(K) = TEMPI * SCALE
      DATA(J) = TEMPR * SCALE
      CF = COS(ARG)
                        SF = SIN(ARG)
      TEMPR = DATA(J) * CF - DATA(K) * SF
      TEMPI = DATA(K) * CF + DATA(J) * SF
      DATA(J) = TEMPR * FAC
   10 DATA(K) = TEMPI * FAC
      RETURN
      END

      SUBROUTINE PULDLY(DELAY)
C     THIS SUBROUTINE GIVES THE DELAY TIME.  IT IS ONLY VALID FOR
C     C .GT. THE MAXIMUM P VELOCITY
      COMMON / CONTROL/ IFORM,ITYP,ISPEC,IATTEN,IZ,IR,IT
      COMMON /SOURCE / SAVE1(  258),C,H,DIP,STK,SLIP,DCF(3),DCN(3),ISRC
      COMMON / SRCMOD / DS(10),AS(10),BS(10),RHOS(10),MMAXS
      COMMON / RECMOD / DR(10),AR(10),BR(10),RHOR(10),MMAXR
      NMAXR = MMAXR - 1
      DELAY = 0.0
      IF(ITYP.EQ.2) GO TO 101
      DO 100 I = 1,NMAXR
      SINB = AR(I) / C
  100 DELAY = DELAY + DR(I)*SQRT(ABS(1.-SINB*SINB))/AR(I)
  101 CONTINUE
      IF(ITYP.EQ.3) GO TO 201
      DEP = 0.0
      NMAXS = MMAXS - 1
      DO 200 I = 1,NMAXS
      DDUM = DS(I)
      DPM = DEP
      DEP = DEP + DDUM
      IF(H.GT.DEP) GO TO 200
      IF(H.GE.DPM.AND.H.LE.DEP) DDUM = DEP  - H
      SINB = AS(I) / C
      DELAY = DELAY + DDUM * SQRT(ABS(1. - SINB*SINB))/AS(I)
  200 CONTINUE
  201 CONTINUE
      RETURN
            END
```

```
      SUBROUTINE MODELIN
      COMMON /RECMOD / DR(10),AR(10),BR(10),RHOR(10),MMAXR
      COMMON / SRCMOD/ DS(10),AS(10),BS(10),RHOS(10),MMAXS
      WRITE(61,20)
    4 FORMAT(1H ,40X,4F10.4)
    5 FORMAT(1H ,50X,3F10.4)
   20 FORMAT(1H1,/,1H ,51X,20HSOURCE CRUSTAL MODEL      ,/1H )
   21 FORMAT(1H ,42X,40H   THICK    P  VEL    S  VEL    DENSITY   /1H0)
   19 FORMAT(1H0,/,1H ,50X,22HRECEIVER CRUSTAL MODEL          ,/1H0)
   44 FORMAT(4F10.4)
   55 FORMAT(10X,3F10.4)
      WRITE(61,21)
      READ(60,1) MMAXS
    1 FORMAT(I5)
      L = MMAXS - 1
      DO 30 I = 1,L
      READ(60,44) DS(I),AS(I),BS(I),RHOS(I)
      WRITE(61,4) DS(I),AS(I),BS(I),RHOS(I)
   30 CONTINUE
      READ(60,55) AS(MMAXS),BS(MMAXS),RHOS(MMAXS)
      WRITE(61,5) AS(MMAXS),BS(MMAXS),RHOS(MMAXS)
      WRITE(61,19)
      WRITE(61,21)
      READ(60,1) MMAXR
      L = MMAXR - 1
      DO 40 I = 1,L
      READ(60,44) DR(I),AR(I),BR(I),RHOR(I)
      WRITE(61,4) DR(I),AR(I),BR(I),RHOR(I)
   40 CONTINUE
      READ(60,55) AR(MMAXR),BR(MMAXR),RHOR(MMAXR)
      WRITE(61,5) AR(MMAXR),BR(MMAXR),RHOR(MMAXR)
      DR(MMAXR) = 0.0
                  DS(MMAXS) = 0.0
C     MODEL PARAMETERS CONVERTED TO CGS UNITS FROM MKS UNITS
      DO 100 I = 1,MMAXR
      DR(I) = DR(I) * 1.0E+5
      AR(I) = AR(I) * 1.0E+5
      BR(I) = BR(I) * 1.0E+5
  100 CONTINUE
      DO 101 I = 1,MMAXS
      DS(I) = DS(I) * 1.0E+5
      AS(I) = AS(I) * 1.0E+5
      BS(I) = BS(I) * 1.0E+5
  101 CONTINUE
      RETURN
            END

      SUBROUTINE RAD(STK,DIP,SLIP,DEL,BET,AMP,INDEX)
      DEGRAD = 0.017452329
```

```
      SINS = SIN(STK*DEGRAD)
      COSS = COS(STK*DEGRAD)
      SIND = SIN(DIP*DEGRAD)
      COSD = COS(DIP*DEGRAD)
      SINF = SIN(SLIP*DEGRAD)
      COSF = COS(SLIP*DEGRAD)
      SINB = SIN(BET*DEGRAD)
      COSB = COS(BET*DEGRAD)
      SINDL = SIN(DEL*DEGRAD)
      COSDL = COS(DEL*DEGRAD)
      A11 = COSF*COSS + SINF*COSD*SINS
      A12 = COSF*SINS - SINF*COSD*COSS
      A13 = - SINF*SIND
      A21 = - SINS*SIND
      A22 = COSS * SIND
      A23 = - COSD
      A31 = COSS*SINF - COSD*COSF*SINS
      A32 = COSD*COSF*COSS + SINF*SINS
      A33 = COSF*SIND
      XP = SINB*COSDL
      YP = SINB*SINDL
      ZP = COSB
      X = A11*XP + A12*YP + A13*ZP
      Y = A21*XP + A22*YP + A23*ZP
      Z = A31*XP + A32*YP + A33*ZP
      R2 = X*X + Y*Y + Z*Z
      GO TO (1,2,3),INDEX
C     P AMPLITUDE
    1 AMP = 2.*X*Y/R2
      RETURN
C     SH AMPLITUDE
    2 AMP = -5.196*((A11*Y+A21*X)*SINDL - (A12*Y+A22*X)*COSDL)/R2
      RETURN
C     SV
    3 IF(SINB.EQ.0.0) GO TO 30
      AMP = 5.196*(2.*X*Y*COSB - A13*Y - A23*X)/(R2*SINB)
      RETURN
   30 AMP = 5.196 *((A23*A11+A21*A13)*COSDL + (A12*A23+A13*A22)*SINDL)/
     1 R2
      RETURN
      END

      SUBROUTINE MINMAX(X,N,XMIN,XMAX)
      DIMENSION X(1)
      XMAX = -1.0E+38
                              XMIN = +1.0E+38
      DO 100 I = 1,N
      IF(X(I).GT.XMAX) XMAX = X(I)
      IF(X(I).LT.XMIN) XMIN = X(I)
  100 CONTINUE
```

```
      WRITE(61,1) XMAX , XMIN
    1 FORMAT(1H ,6HXMAX = , E10.3,5X,6HXMIN = , E10.3)
      IF(XMAX.EQ.0.0.AND.XMIN.EQ.0.0) XMAX = 0.001
      IF(XMAX.EQ.XMIN) XMIN = - XMAX
      YMAX = XMAX
                      IF(ABS(XMIN).GT.YMAX) YMAX = ABS(XMIN)
      XMAX = 2.0 * YMAX
                           XMIN = - 2.0 * YMAX
                                                  RETURN
                                                       END

      SUBROUTINE SEISMAG(FREQ,PEAK,XR,XI)
C     THIS RESPONSE GIVES A POSITIVE DISPLACEMNET FOR A POSITIVE IMPULSE
C     15-100 SYSTEM
C     PEAK MAGNIFICATIONS ARE 350,700,1400,2800,5600
      WE = 6.2831853*FREQ
                                INDEX = (PEAK+1.)/375.
      GO TO(1,2,2,3,3,3,3,4,4,4,4,4,4,4,4,5),INDEX
    1 FMAG = 278.
                     SIGMA = 0.003
                                     GO TO 6
    2 FMAG = 556.0
                      SIGMA = 0.013
                                     GO TO 6
    3 FMAG = 1110.
                      SIGMA = 0.047
                                      GO TO 6
    4 FMAG = 2190.
                      SIGMA = 0.204
                                      GO TO 6
    5 FMAG = 3950.
                      SIGMA = 0.805
    6 ZETA=0.93
                ZETA1=1.
                           WN=.418879
                                     WN1=.062831853
      AR= (WE*WE-WN*WN)*(WE*WE-WN1*WN1)*4.*ZETA*ZETA1*WN*WN1*(1.-SIGMA)
     1*WE*WE
            AI=2.*WE*(ZETA1*WN1*(WN*WN-WE*WE)+ZETA*WN*(WN1*WN1-WE*WE))
      FACTOR = FMAG*WE*WE*WE / (AI*AI + AR*AR)
      XR = - AI * FACTOR
                                XI = - FACTOR * AR
      RETURN
      END

      SUBROUTINE FOUR2(DATA,NN,IDUM,ISIGN)
      DIMENSION DATA(1)
      N = 2 * NN
      J = 1
      DO 5 I=1,N,2
```

```
      IF(I-J)1,2,2
    1 TEMPR = DATA(J)
      TEMPI = DATA(J+1)
      DATA(J) = DATA(I)
      DATA(J+1)=DATA(I+1)
      DATA(I) = TEMPR
      DATA(I+1) = TEMPI
    2 M = N/2
    3 IF(J-M) 5,5,4
    4 J = J-M
      M = M/2
      IF(M-2)5,3,3
    5 J=J+M
      MMAX = 2
    6 IF(MMAX-N) 7,10,10
    7 ISTEP= 2 *MMAX
      THETA = 6.28318307/FLOAT(ISIGN*MMAX)
      SINTH=SIN(THETA/2.)
      WSTPR=-2.*SINTH*SINTH
      WSTPI=SIN(THETA)
      WR=1.0
      WI=0.0
      DO 9 M=1,MMAX,2
      DO 8 I=M,N,ISTEP
      J=I+MMAX
      TEMPR=WR*DATA(J)-WI*DATA(J+1)
      TEMPI=WR*DATA(J+1)+WI*DATA(J)
      DATA(J)=DATA(I)-TEMPR
      DATA(J+1)=DATA(I+1)-TEMPI
      DATA(I)=DATA(I)+TEMPR
    8 DATA(I+1) = DATA(I+1)+TEMPI
      TEMPR = WR
      WR = WR*WSTPR-WI*WSTPI + WR
    9 WI = WI*WSTPR+TEMPR*WSTPI + WI
      MMAX = ISTEP
      GO TO 6
   10 RETURN
      END

      SUBROUTINE PULSE(X,Y,NN,DT,DT1,DT2,DT3,XMOM)
C     THIS SUBROUTINE GENERATES A TRAPEZOID OF AREA XMOM
      DIMENSION X(1),Y(1)
      T = - DT
      T0 = DT1 + DT2 + DT3
                              T1 = T0 + DT1
                                                  T2 = T1 + DT2
      T3 = T2 + DT3
      AREA = 0.5 * ( DT1 + DT2 + DT2 + DT3)
      HT = XMOM / AREA
      DO 100 I = 1,NN
```

```
      T = T + DT
      X(I) = T
      IF(T.LE.T0) Y(I) = 0.0
      IF(T.GT.T0.AND.T.LE.T1) Y(I) = HT*(T-T0)/DT1
      IF(T.GT.T1.AND.T.LE.T2) Y(I) = HT
      IF(T.GT.T2.AND.T.LE.T3) Y(I) = HT * (1. - (T-T2)/DT3)
      IF(T.GT.T3) Y(I) = 0.0
  100 CONTINUE
                  RETURN
                        END

      SUBROUTINE DELSV(FREQ,C,AUR,AUI,AWR,AWI,INDEX)
C     HASKELL FORMULATION OF RESPONSE AT SURFACE OF LAYERED HALFSPACE
C     TO INCIDENT PLANE P WAVE (INDEX=1) OR TO INCIDENT PLANE SV WAVE
C     (INDEX=2)
      COMMON / RECMOD / D(10), A(10), B(10), RHO(10), MMAX
       WVNO = 6.26318529 * FREQ / C
      A11 = 1.0
      A12 = 0.0
      A21 = 0.0
      A22 = 1.0
      A31 = 0.0
      A32 = 0.0
      A41 = 0.0
      A42 = 0.0
      DO 1346 M = 1,MMAX
      COVA = C/A(M)
      COVB = C/B(M)
      GAM = 2./COVB**2
      GAMM1 = GAM - 1.
      RA = SQRT(ABS(COVA*COVA - 1.)) + 0.0000001
      RB = SQRT(ABS(COVB*COVB - 1.)) + 0.0000001
      H = RHO(M) * C * C
      IF(M-MMAX) 7001,7002,7002
 7001 P = WVNO*D(M)*RA
      Q = WVNO * D(M) * RB
      IF(C-B(M)) 1211,1221,1231
 1231 SINQ = SIN(Q)
      Y = SINQ/RB
      Z = RB * SINQ
      COSQ = COS(Q)
      GO TO 1242
 1221 Y = WVNO*D(M)
      Z = 0
      COSQ = 1.0
      GO TO 1241
 1211 EXQP = EXP(Q)
      EXQM = 1./EXQP
      Y = (EXQP-EXQM)/(2.*RB)
      Z = RB * (EXQM-EXQP)/2.
```

```
      COSQ = (EXQP+EXQM)/2.
 1241 EXPP = EXP(P)
      EXPM = 1./EXPP
      W = (EXPP-EXPM)/(2.*RA)
      X = RA * (EXPM-EXPP)/2.
      COSP = (EXPP+EXPM)/2.
      GO TO 124
 1242 IF(C-A(M))1241,122,123
  123 SINP = SIN(P)
      W = SINP/RA
      X = RA * SINP
      COSP = COS(P)
      GO TO 124
  122 W = WVNO*D(M)
      X = 0
      COSP = 1
  124 B11 = GAM*COSP - GAMM1*COSQ
      B12 = GAMM1*W + GAM*Z
      B13 = -(COSP-COSQ)/H
      B14 = (W+Z)/H
      B21 = GAM*X + GAMM1*Y
      B22 = -GAMM1*COSP + GAM*COSQ
      B23 = -(X+Y)/H
      B31 = H*GAM*GAMM1*(COSP-COSQ)
      B32 = H*(GAMM1*GAMM1*W + GAM*GAM*Z)
      B41 = -H*(GAM*GAM*X + GAMM1*GAMM1*Y)
      EA11 = B11*A11 + B12*A21 + B13*A31 + B14*A41
      EA12 = B11*A12 + B12*A22 + B13*A32 + B14*A42
      EA21 = B21*A11 + B22*A21 + B23*A31 + B13*A41
      EA22 = B21*A12 + B22*A22 + B23*A32 + B13*A42
      EA31 = B31*A11 + B32*A21 + B22*A31 + B12*A41
      EA32 = B31*A12 + B32*A22 + B22*A32 + B12*A42
      EA41 = B41*A11 + B31*A21 + B21*A31 + B11*A41
      EA42 = B41*A12 + B31*A22 + B21*A32 + B11*A42
      A11 = EA11
      A12 = EA12
      A21 = EA21
      A22 = EA22
      A31 = EA31
      A32 = EA32
      A41 = EA41
 1346 A42 = EA42
 7002 E11 = -GAM*COVA*COVA
      E13 = 1./(RHO(MMAX)*A(MMAX)*A(MMAX))
      E22 = GAMM1*COVA*COVA/RA
      E24 = E13/RA
      E44 = 1./(H*GAM)
      E33 = - E44/RB
      E31 = - E33*GAMM1*H
      E42 = 1.
```

```
      EJ11 = E11*A11 + E13*A31
      EJ12 = E11*A12 + E13*A32
      EJ21 = E22*A21 + E24*A41
      EJ22 = E22*A22 + E24*A42
      EJ31 = E31*A11 + E33*A31
      EJ32 = E31*A12 + E33*A32
      EJ41 = E42*A21 + E44*A41
      EJ42 = E42*A22 + E44*A42
      IF(COVA.GT.1.0) GO TO 5000
      AA = EJ11 - EJ21
      BB = 0.0
      EE = 0.0
      FF = EJ12 - EJ22
      GO TO 5001
 5000 CONTINUE
      AA = EJ11
      BB = EJ21
      EE = -EJ22
      FF = EJ12
 5003 CC = - EJ42
      DD = EJ32
      GG = EJ31
      HH = EJ41
      GO TO 5002
 5001 IF(COVB.GT.1.0) GO TO 5003
      CC = - EJ32 - EJ42
      DD = 0.0
      GG = 0.0
      HH = EJ31 + EJ41
 5002 CONTINUE
      XR = AA*CC - BB*DD - EE*GG + FF*HH
      XI = AA*DD + BB*CC - EE*HH - FF*GG
      DINVR = XR/(XR*XR+XI*XI)
      DINVI = -XI/(XR*XR+XI*XI)
      XR = DINVR
                    XI = DINVI
      GO TO (6001,6002),INDEX
 6001 AUR = -2.*COVA*(CC*XR-DD*XI)
      AUI = -2.*COVA*(CC*XI+DD*XR)
      AWR = -2.*COVA*(GG*XR-HH*XI)
      AWI = -2.*COVA*(GG*XI+HH*XR)
      RETURN
 6002 AUR =-COVB*(EE*XR-FF*XI)
      AUI =-COVB*(EE*XI+FF*XR)
      AWR = -COVB*(AA*XR-BB*XI)
      AWI = -COVB*(AA*XI+BB*XR)
      RETURN
      END

      SUBROUTINE DELSH(FREQ,CAR,AI)
```

```
C       HASKELL FORMULATION OF RESPONSE AT SURFACE OF LAYERED HALFSPACE TO
C       AN INCIDENT PLANE SH WAVE IN THE HALFSPACE
        COMMON / RECMOD / D(10), A(10), B(10), RHO(10), MMAX
        WVNO = 6.28318527 * FREQ / C
        A11 = 1
        A21 = 0.0
        DO 1340 M = 1,MMAX
        COVB = C/B(M)
        RB = SQRT(ABS(COVB*COVB - 1.))
        H = RHO(M) * B(M) * B(M)
        IF(M-MMAX) 7001,7002,7002
 7001   Q = WVNO*D(M)*RB
        IF(C-B(M))1211,1221,1231
 1231   SINQ = SIN(Q)
        Y = SINQ/RB
        Z = RB * SINQ
        COSQ = COS(Q)
        GO TO 1242
 1221   Y = WVNO*D(M)
        Z = 0
        COSQ = 1
        GO TO 1242
 1211   EXQP = EXP(Q)
        EXQM = 1./EXQP
        Y = (EXQP-EXQM)/(2.*RB)
        Z = RB*(EXQM-EXQP)/2.
        COSQ = (EXQP+EXQM)/2.
 1242   EA11 = COSQ*A11 - Y*A21/H
        EA21 = H*Z*A11 + COSQ*A21
        A11 = EA11
 1340   A21 = EA21
 7002   FAC = H*RB
        DENOM = FAC*FAC*A11*A11 + A21*A21
        AR = 2.*FAC*FAC*A11/DENOM
        AI = - 2.*FAC*A21/DENOM
        RETURN
        END

        SUBROUTINE SHSRC(FREQ,C,AR,AI,DCF,DCN,ISRC,DEPTH,PHI)
        COMMON / SRCMOD / D(10), A(10), B(10), RHO(10), MMAX
        COMPLEX SUM,SC(3,2),SS(3,2),EIP(3)
        COMPLEX FL,HS(3),HC(3)
        COMPLEX DM11,DM12,DM21,DM22
        COMPLEX EJ11,EJ21,EI11,EI22,EL11,EL12,EL21,EL22
        COMPLEX EYE
        DIMENSION DCF(3),DCN(3)
        DEGRAD = 0.017452329
        EIP(1) = CMPLX(1.0,0.0)
        EIP(2) = CMPLX(0.0,1.0)
        EIP(3) = CMPLX(-1.0,0.0)
```

```
      EYE = CMPLX(0.0,1.0)
      PH = PHI * DEGRAD
      IF(FREQ.EQ.0.0) GO TO 9669
      WVNO = 6.28318527 * FREQ / C
      A11 = 1.0
                  A21 = 0.0
      AP11 = 1.0
                   AP21 = 0.0
                               AP12 = 0.0
                                           AP22 = 1.0
      DEP = 0.0
      DO 1340 M = 1,MMAX
      COVB = C / B(M)
      RB = WVNO *(SQRT(ABS(COVB*COVB-1.)) + 0.0000001  )
      GAM = 2./COVB**2
      FAC = RHO(M) * GAM/(2.*WVNO*WVNO)
      IF(M-MMAX) 7001,7002,7002
 7001 Q = RB * D(M)
      DPM = DEP
      DEP = DEP + D(M)
      IF(DEPTH.GE.DPM.AND.DEPTH.LT.DEP) LSAVE = M
      IF(DEPTH.GE.DPM.AND.DEPTH.LT.DEP) DEPM = DEP - DEPTH
      IF(C-B(M)) 1211,1221,1231
 1211 EXQP = EXP(Q)
      EXQM = 1./EXQP
      COSQ = 0.5 * (EXQP+EXQM)
      SINQ = (EXQP-EXQM)/2.
      Y = SINQ/(RB*FAC)
      Z = RB*FAC*SINQ
      GO TO 1242
 1221 COSQ = 1.0
      Y = D(M) / FAC
      Z = 0.0
      GO TO 1242
 1231 COSQ = COS(Q)
      SINQ = SIN(Q)
      Y = SINQ/(RB*FAC)
      Z = -RB * FAC * SINQ
 1242 CONTINUE
      EA11 = COSQ * A11 + Y * A21
C     EA12 = COSQ * A12 + Y * A22
      EA21 = Z * A11 + COSQ * A21
C     EA22 = Z * A12 + COSQ * A22
      A11 = EA11
C     A12 = EA12
      A21 = EA21
C     A22 = EA22
      IF(DEPTH.GT.DPM) GO TO 1340
      EA11 = COSQ * AP11 + Y * AP21
      EA12 = COSQ * AP12 + Y * AP22
```

```
      EA21 = Z * AP11 + COSQ * AP21
      EA22 = Z * AP12 + COSQ * AP22
      AP11 = EA11
      AP12 = EA12
      AP21 = EA21
      AP22 = EA22
 1340 CONTINUE
 7002 CONTINUE
      COBM = C/B(LSAVE)
      RB = WVNO*(SQRT(ABS(COBM*COBM-1.)) + 0.0000001)
      GAM = 2./COBM**2
      FAC = GAM/(2.*WVNO*WVNO)
      Q = RB * DEPM
      IF(C-B(LSAVE)) 1411,1421,1431
 1411 EXQP = EXP(Q)
      EXQM = 1./EXQP
      COSQ = 0.5 * (EXQP+EXQM)
      SINQ = 0.5*(EXQP-EXQM)
      D11R = COSQ/RHO(LSAVE)
      D12I = 0.0
                    D22I = 0.0
      D12R = -SINQ/RHO(LSAVE)
      D21R = FAC*RB*SINQ
      D22R = -FAC*RB*COSQ
      GO TO 1442
 1421 D11R = 1.0/RHO(LSAVE)
      D12R = 0.0
             D21R = 0.0
                    D12I = 0.0
                           D22R = 0.0
                                  D22I = 0.0
      GO TO 1442
 1431 COSQ = COS(Q)
      SINQ = SIN(Q)
      D11R= COSQ/RHO(LSAVE)
      D12R = 0.0
      D12I = - SINQ/RHO(LSAVE)
      D21R = - RB*FAC*SINQ
      D22R = 0.0
      D22I = - RB*FAC*COSQ
 1442 CONTINUE
      DM11 = CMPLX(D11R,0.0)
      DM12 = CMPLX(D12R,D12I)
      DM21 = CMPLX(D21R,0.0)
      DM22 = CMPLX(D22R,D22I)
      SINT = B(MMAX)/C
      COST = SQRT(ABS(1.-SINT*SINT))
      SINT = 6.2831853*FREQ/B(MMAX)
      COST = RHO(MMAX) * COST
      EA11 = A11 * COST
```

```
      EA21 = A21 * SINT
      EJ11 = CMPLX(EA11,0.0)
      EJ21 = CMPLX(0.0,EA21)
      FL = EJ11 - EJ21
      EI11 = CMPLX(COST,0.0)
      EI22 = CMPLX (0.0,SINT)
      EL11 = AP11*DM11 + AP12*DM21
      EL12 = AP11 * DM12 + AP12 * DM22
      EL21 = AP21 * DM11 + AP22 * DM21
      EL22 = AP21 * DM12 + AP22 * DM22
      DM11 = EL11
                    DM12 = EL12
                                  DM21 = EL21
                                                DM22 = EL22
      EL11 = EI11 * DM11
      EL12 = EI11 * DM12
      EL21 = EI22 * DM21
      EL22 = EI22 * DM22
      RBB = SQRT(ABS((1./(C*C))-(1./(B(LSAVE)*B(LSAVE))))) + 0.0000001
      CALL SHEXC(FREQ,WVNO,RBB,DCF,DCN,ISRC,A(LSAVE),B(LSAVE),C,SC,SS)
      DO 8700 N = 1,3
      HS(N) = (EJ11*EL21-EJ21*EL11)*SS(N,1)
     1 + (EJ11*EL22 - EJ21*EL12) * SS(N,2)
      HC(N) = (EJ11*EL21-EJ21*EL11)*SC(N,1)
     1 + (EJ11*EL22 - EJ21*EL12) * SC(N,2)
 8700 CONTINUE
      SUM = CMPLX(0.0,0.0)
      DO 8750 N = 1,3
      ANG = (N-1) * PH
      SUM = SUM + (HC(N)*SIN(ANG)-HS(N)*COS(ANG))*EIP(N)
 8750 CONTINUE
      SUM = SUM/(RHO(MMAX)*B(MMAX)*FL*EYE)
      AR = REAL(SUM)
      AI = AIMAG(SUM)
      RETURN
 9669 CONTINUE
      LSAVE = MMAX
      RBB = SQRT(ABS((1./(C*C))-(1./(B(LSAVE)*B(LSAVE))))) + 0.0000001
      CALL SHEXC(FREQ,WVNO,RBB,DCF,DCN,ISRC,A(LSAVE),B(LSAVE),C,SC,SS)
      SUM = CMPLX(0.0,0.0)
      DO 9700 N = 1,3
      ANG = (N-1) * PH
      SUM = SUM + (SC(N,2)*SIN(ANG) - SS(N,2)*COS(ANG))*EIP(N)
 9700 CONTINUE
      AR =-REAL(SUM)/(RHO(MMAX)*B(MMAX)*B(MMAX))
      AI = 0.0
      RETURN
      END

      SUBROUTINE SHEXC(FREQ,WVNO,RB,F,N,ISRC,ALP,BET,C,SC,SS)
```

```
      COMPLEX SC(3,2),SS(3,2)
      COMPLEX VB
      COMPLEX EYE,ONE
      REAL N
      DIMENSION F(3),N(3)
C     ISRC = 1 SINGLE FORCE IN DIRECTION (F1,F2,F3)
C     ISRC = 2 DIPOLE IN DIRECTION (F1,F2,F3)
C     ISRC = 3 SINGLE COUPLE FORCE (F1,F2,F3) OFFSET (N1,N2,N3)
C     ISRC = 4 DOUBLE COUPLE WITHOUT MOMENT X-AXIS (F1,F2,F3)
C                                          Y-AXIS (N1,N2,N3)
C     ISRC = 5 DOUBLE DIPOLE  T-AXIS (F1,F2,F3) P-AXIS (N1,N2,N3)
C     ISRC = 6 PURE COMPRESSIONAL SOURCE
      EYE = CMPLX(0.0,1.0)
      ONE = CMPLX(1.0,0.0)
      PI4 = 12.5663706
      PI4C = PI4*C
      FAC = 1./(BET*BET*12.5663706)
      WV = 1./C
      DO 100 I = 1,2
      DO 100 NN = 1,3
      SC(NN,I) = CMPLX(0.0,0.0)
  100 SS(NN,I) = CMPLX(0.0,0.0)
      IF(FREQ.EQ.0.0) GO TO 200
      IF(C.GT.BET) VB = CMPLX(0.0,RB)
      IF(C.LE.BET) VB = CMPLX(RB,0.0)
      GO TO (1,2,3,4,5,6),ISRC
    1 CONTINUE
      SC(2,2) = (-2.*F(1)*FAC) * EYE / VB
      SS(2,2) = (-2.*FAC*F(2)) * EYE / VB
      RETURN
    2 SC(2,1) = (-2.*FAC*F(1)*F(3))*ONE
      SS(2,1) = (-2.*F(2)*F(3)*FAC)*ONE
      SC(3,2) =(FAC*(F(2)**2-F(1)**2)*WV  )/VB
      SS(3,2) = (-2.*FAC*WV  *F(1)*F(2))/VB
      RETURN
    3 SS(1,2) = (FAC*WV  *(F(2)*N(1)-F(1)*N(2)))/VB
      SC(2,1) =(-2.*FAC*F(1)*N(3))*ONE
      SS(2,1) = (-2.*FAC*F(2)*N(3))*ONE
      SC(3,2) = (WV  *FAC*(F(2)*N(2)-F(1)*N(1)))/VB
      SS(3,2) = (-FAC*WV  *(F(1)*N(2)+F(2)*N(1)))/VB
      RETURN
    4 SC(2,1) = (-2.*FAC*(F(1)*N(3)+F(3)*N(1)))*ONE
      SS(2,1) = (-2.*FAC*(F(2)*N(3)+F(3)*N(2)))*ONE
      SC(3,2) = (2.*FAC*WV  *(F(2)*N(2)-F(1)*N(1)))/VB
      SS(3,2) = (-2.*FAC*WV  *(F(1)*N(2)+F(2)*N(1)))/VB
      RETURN
    5 SC(2,1) = (-2.*FAC*(F(1)*F(3)-N(1)*N(3)))*ONE
      SS(2,1) = (-2.*FAC*(F(2)*F(3)-N(2)*N(3)))*ONE
      SC(3,2) = (FAC*WV  *(F(2)**2-F(1)**2-N(2)**2+N(1)**2))/VB
      SS(3,2) = (-2.*FAC*WV  *(F(1)*F(2)-N(1)*N(2)))/VB
```

```
      RETURN
    6 RETURN
  200 GO TO (11,12,13,14,15,16),ISRC
   11 SC(2,2) = (-2.*F(1)/PI4)*EYE
      SS(2,2) = (-2.*F(2)/PI4)*EYE
      RETURN
   12 SC(3,2) = ((F(2)**2 - F(1)**2)/PI4C)*ONE
      SS(3,2) = (-2.*F(1)*F(2)/PI4C)*ONE
      RETURN
   13 SS(1,2) = ((F(2)*N(1)-F(1)*N(2))/PI4C) * ONE
      SC(3,2) = ((F(2)*N(2)-F(1)*N(1))/PI4C) * ONE
      SS(3,2) = (-(F(1)*N(2)+F(2)*N(1))/PI4C) * ONE
      RETURN
   14 SC(3,2) = (2.*(F(2)*N(2)-F(1)*N(1))/PI4C) * ONE
      SS(3,2) = (-2.*(F(1)*N(2)+F(2)*N(1))/PI4C) * ONE
      RETURN
   15 SC(3,2) = ((F(2)**2-F(1)**2-N(2)**2+N(1)**2)/PI4C) * ONE
      SS(3,2) = (-2.*(F(1)*F(2)-N(1)*N(2))/PI4C) * ONE
      RETURN
   16 RETURN
      END

      SUBROUTINE SVSRC(FREQ,C,AR,AI,DCF,DCN,ISRC,DEPTH,PHI,INDEX)
      COMMON / SRCMOD / D(10), A(10), B(10), RHO(10), MMAX
      COMPLEX SC(3,4),SS(3,4),SUM,EIP(3)
      COMPLEX ZERO,F1,F2,F3,F4,FR,HS(3),HC(3)
      COMPLEX VB
      COMPLEX EJ(4,2),EL(4,4),DP(4,4),EI(4,4)
      COMPLEX EYE,ONE
      DIMENSION AA(4,2),AF(4,4),BB(4,4)
      DIMENSION EA(4,4)
      DIMENSION DCF(3),DCN(3)
      DEGRAD = 0.017452329
      EIP(1) = CMPLX(1.0,0.0)
      EIP(2) = CMPLX(0.0,1.0)
      EIP(3) = CMPLX(-1.0,0.0)
      ONE = EIP(1)
                        EYE = EIP(2)
      ZERO = CMPLX(0.0,0.0)
      PH = PHI * DEGRAD
      OMEGA = 6.28318527 * FREQ
                                      WVNO = OMEGA / C
      DO 101 J = 1,2
      DO 100 I = 1,4
  100 AA(I,J) = 0.0
  101 AA(J,J) = 1.0
      DO 102 I = 1,4
      DO 103 J = 1,4
  103 AF(I,J) = 0.0
  102 AF(1,I) = 1.0
```

```
      DEP = 0.0
                  DO 1346 M = 1,MMAX
      ALP = A(M)
                   BET = B(M)
                                DEN = RHO(M)
                                                    DM = D(M)
      DPM = DEP
                  DEP = DEP + D(M)
      COVB = C/BET
      GAM = 2./COVB**2
      GAMM1 = GAM - 1.
      RA = SQRT(ABS(1./(C*C) - 1./(ALP*ALP))) + 0.0000001
      RB = SQRT(ABS(1./(C*C) - 1./(BET*BET))) + 0.0000001
      IF(DEPTH.GE.DPM.AND.DEPTH.LT.DEP) LSAVE = M
      IF(DEPTH.GE.DPM.AND.DEPTH.LT.DEP) DEPM = DEP - DEPTH
      IF(M-MMAX) 7001,7002,7002
 7001 CONTINUE
      CALL COEF(OMEGA,C,WVNO,ALP,BET,DEN,DM,RA,RB,GAM,GAMM1,BB)
      DO 6052 I = 1,4
      DO 6052 J = 1,2
      EA(I,J) = 0.0
      DO 6052 K = 1,4
 6052 EA(I,J) = EA(I,J) + BB(I,K)*AA(K,J)
      DO 6053 I = 1,4
      DO 6053 J = 1,2
 6053 AA(I,J) = EA(I,J)
      IF(DEPTH.GT.DPM) GO TO 1346
      DO 6054 I = 1,4
      DO 6054 J = 1,4
      EA(I,J) = 0.0
      DO 6054 K = 1,4
 6054 EA(I,J) = EA(I,J) +BB(I,K)*AP(K,J)
      DO 6055 I = 1,4
      DO 6055 J = 1,4
 6055 AP(I,J) = EA(I,J)
 1346 CONTINUE
 7002 CONTINUE
      IF(C.LE.B(MMAX)) VB = CMPLX(OMEGA*RB,0.0)
      IF(C.GT.B(MMAX)) VB = CMPLX(0.0,OMEGA*RB)
      DO 6049 I = 1,4
      DO 6049 J = 1,4
 6049 EI(I,J) = ZERO
      E11 = -DEN*GAM
      E42 = DEN*GAM/(WVNO*WVNO)
      E22 = -DEN*GAMM1/(OMEGA*RA)
      E24 = WVNO*WVNO/(OMEGA*RA)
      E31 = DEN*GAMM1/(OMEGA*RB)
      E33 = -1./(OMEGA*RB)
      EI(1,1) = CMPLX(E11,0.0)
      EI(1,3) = ONE
```

```
      EI(4,2) = CMPLX(E42,0.0)
      EI(4,4) = CMPLX(-1.0,0.0)
      IF(C.GT.ALP) GO TO 6331
      EI(2,2) = CMPLX(E22,0.0)
      EI(2,4) = CMPLX(E24,0.0)
      GO TO 6332
 6331 EI(2,2) = CMPLX(0.0,-E22)
      EI(2,4) = CMPLX(0.0,-E24)
 6332 IF(C.GT.BET) GO TO 6333
      EI(3,1) = CMPLX(E31,0.0)
      EI(3,3) = CMPLX(E33,0.0)
      GO TO 6334
 6333 EI(3,1) = CMPLX(0.0,-E31)
      EI(3,3) = CMPLX(0.0,-E33)
 6334 CONTINUE
      ALP = A(LSAVE)
                        BET = B(LSAVE)
                                              DEN = RHO(LSAVE)
      COVB = C/BET
                      GAM = 2./COVB**2
                                              GAMM1 = GAM - 1.
      RA = SQRT(ABS(1./(C*C)-1./(ALP*ALP))) + 0.0000001
      RB = SQRT(ABS(1./(C*C)-1./(BET*BET))) + 0.0000001
      CALL DOEF(OMEGA,C,WVNO,ALP,BET,DEN,DEPM,RA,RB,GAM,GAMM1,DP)
      CALL SVEXC(OMEGA,WVNO,RB,RA,DCF,DCN,ISRC,ALP,BET,C,SC,SS)
      DO 6051 I = 1,4
      DO 6051 J = 1,2
      EJ(I,J) = ZERO
      DO 6051 K = 1,4
 6051 EJ(I,J) = EJ(I,J) + EI(I,K) * AA(K,J)
      DO 6050 I = 1,4
      DO 6050 J = 1,4
      EL(I,J) = ZERO
      DO 6050 K = 1,4
 6050 EL(I,J) = EL(I,J) + AP(I,K) * DP(K,J)
      DO 6056 I = 1,4
      DO 6056 J = 1,4
 6056 DP(I,J) = EL(I,J)
      DO 6057 I = 1,4
      DO 6057 J = 1,4
      EL(I,J) = ZERO
      DO 6057 K = 1,4
 6057 EL(I,J) = EL(I,J) + EI(I,K)*DP(K,J)
      GO TO (6041,6042),INDEX
 6041 CONTINUE
      CALL DETER(F1,EL(1,1),EJ(1,1),EJ(1,2),EL(2,1),EJ(2,1),EJ(2,2),
     1 EL(3,1)-EL(4,1),EJ(3,1)-EJ(4,1),EJ(3,2)-EJ(4,2))
      CALL DETER(F2,EL(1,2),EJ(1,1),EJ(1,2),EL(2,2),EJ(2,1),EJ(2,2),
     1 EL(3,2)-EL(4,2),EJ(3,1)-EJ(4,1),EJ(3,2)-EJ(4,2))
      CALL DETER(F3,EL(1,3),EJ(1,1),EJ(1,2),EL(2,3),EJ(2,1),EJ(2,2),
```

```
     1 EL(3,3)-EL(4,3),EJ(3,1)-EJ(4,1),EJ(3,2)-EJ(4,2))
       CALL DETER(F4,EL(1,4),EJ(1,1),EJ(1,2),EL(2,4),EJ(2,1),EJ(2,2),
     1 EL(3,4)-EL(4,4),EJ(3,1)-EJ(4,1),EJ(3,2)-EJ(4,2))
       GO TO 6043
 6042 CONTINUE
       CALL DETER(F1,EL(2,1)-EL(1,1),EJ(2,1)-EJ(1,1),EJ(2,2)-EJ(1,2),
     1EL(3,1),EJ(3,1),EJ(3,2),EL(4,1),EJ(4,1),EJ(4,2))
       CALL DETER(F2,EL(2,2)-EL(1,2),EJ(2,1)-EJ(1,1),EJ(2,2)-EJ(1,2),
     1EL(3,2),EJ(3,1),EJ(3,2),EL(4,2),EJ(4,1),EJ(4,2))
       CALL DETER(F3,EL(2,3)-EL(1,3),EJ(2,1)-EJ(1,1),EJ(2,2)-EJ(1,2),
     1EL(3,3),EJ(3,1),EJ(3,2),EL(4,3),EJ(4,1),EJ(4,2))
       CALL DETER(F4,EL(2,4)-EL(1,4),EJ(2,1)-EJ(1,1),EJ(2,2)-EJ(1,2),
     1EL(3,4),EJ(3,1),EJ(3,2),EL(4,4),EJ(4,1),EJ(4,2))
 6043 CONTINUE
       FR = (EJ(1,1)-EJ(2,1))*(EJ(3,2)-EJ(4,2))-(EJ(1,2)-EJ(2,2))*
     1 (EJ(3,1)-EJ(4,1))
       DO 8700 N = 1,3
       HS(N) = F1*SS(N,1) + F2*SS(N,2) + F3*SS(N,3) + F4*SS(N,4)
       HC(N) = F1*SC(N,1) + F2*SC(N,2) + F3*SC(N,3) + F4*SC(N,4)
 8700 CONTINUE
       SUM = CMPLX(0.0,0.0)
       DO 8750 N = 1,3
       ANG = (N-1)*PH
       SUM = SUM + (HC(N)*COS(ANG) + HS(N)*SIN(ANG) ) * EIP(N)
 8750 CONTINUE
       GO TO(9301,9302),INDEX
 9301 SINT = A(MMAX) / C
                                 COST = SQRT(ABS(1. - SINT*SINT))
       SUM = SUM*COST/(A(MMAX)*RHO(MMAX)*FR*EYE*SINT)
       AR = REAL(SUM)
                          AI = AIMAG(SUM)
                                                 RETURN
 9302 SUM = SUM * VB/(B(MMAX)*RHO(MMAX)*FR*EYE)
       AR = REAL(SUM)
                          AI = AIMAG(SUM)
                                                 RETURN
       END

       SUBROUTINE COEF(OMEGA,C,WVNO,ALP,BET,DEN,DM,RA,RB,GAM,GAMM1,BB)
       DIMENSION BB(4,4)
       WVNOSQ = WVNO*WVNO
       RBB = OMEGA * RB
       RAA = RA * OMEGA
       P = RAA * DM
       Q = RBB * DM
       IF(C-BET) 1211,1221,1231
 1231 SINQ = SIN(Q)
       COSQ = COS(Q)
       Y = SINQ/RBB
       Z = -RBB*SINQ
```

```
      GO TO 1242
 1221 COSQ = 1.0
      Y = DM
                Z = 0.0
                              GO TO 1241
 1211 EXQP = EXP(Q)
      EXQM = 1./EXQP
      COSQ = 0.5*(EXQP+EXQM)
      SINQ = 0.5*(EXQP-EXQM)
      Y = SINQ/RBB
      Z = RBB * SINQ
 1241 EXPP = EXP(P)
      EXPM = 1./EXPP
      COSP = 0.5*(EXPP+EXPM)
      SINP = 0.5*(EXPP-EXPM)
      W = SINP/RAA
      X = RAA * SINP
      GO TO 124
 1242 IF(C-ALP) 1241,122,123
  123 SINP = SIN(P)
      COSP = COS(P)
      W = SINP/RAA
      X = -RAA*SINP
      GO TO 124
  122 W = DM
      X = 0
               COSP = 1.0
                              GO TO 124
  124 CONTINUE
      BB(1,1) = GAM * COSP - GAMM1 * COSQ
      BB(1,2) = -GAMM1*W + GAM*Z/WVNOSQ
      BB(1,3) = -(COSP-COSQ)/DEN
      BB(1,4) = (WVNOSQ*W-Z)/DEN
      BB(2,1) = GAM*X - WVNOSQ*GAMM1*Y
      BB(2,2) = -GAMM1*COSP + GAM*COSQ
      BB(2,3) = (-X + WVNOSQ*Y)/DEN
      BB(2,4) = -WVNOSQ*BB(1,3)
      BB(3,1) = DEN*GAM*GAMM1*(COSP-COSQ)
      BB(3,2) = DEN*(-GAMM1*GAMM1*W + GAM*GAM*Z/WVNOSQ)
      BB(3,3) = BB(2,2)
      BB(3,4) = - WVNOSQ*BB(1,2)
      BB(4,1) = DEN*(GAM*GAM*X/WVNOSQ - GAMM1*GAMM1*Y)
      BB(4,2) = - BB(3,1)/WVNOSQ
      BB(4,3) = - BB(2,1)/WVNOSQ
      BB(4,4) = BB(1,1)
      RETURN
               END

      SUBROUTINE SVEXC(OMEGA,WVNO,RB,RA,P,N,ISRC,ALP,BET,C,SC,SS)
      COMPLEX SC(3,4),SS(3,4)
```

```
      COMPLEX VA,VB,ONE
      COMPLEX EYE
      REAL N
      DIMENSION F(3),N(3)
C     ISRC = 1 SINGLE FORCE IN DIRECTION (F1,F2,F3)
C     ISRC = 2 DIPOLE IN DIRECTION (F1,F2,F3)
C     ISRC = 3 SINGLE COUPLE FORCE (F1,F2,F3) OFFSET (N1,N2,N3)
C     ISRC = 4 DOUBLE COUPLE WITHOUT MOMENT X-AXIS (F1,F2,F3)
C                                          Y-AXIS (N1,N2,N3)
C     ISRC = 5 DOUBLE DIPOLE  T-AXIS (F1,F2,F3) P-AXIS (N1,N2,N3)
C     ISRC = 6 PURE COMPRESSIONAL SOURCE
      ONE = CMPLX(1.0,0.0)
      EYE = CMPLX(0.0,1.0)
      FAC = 1./12.5663706
      WV = 1./C
      PI4C = FAC * WV
      DO 100 II = 1,4
      DO 100 NN = 1,3
      SC(NN,II) = CMPLX(0.0,0.0)
  100 SS(NN,II) = CMPLX(0.0,0.0)
      IF(C.GT.ALP) VA = CMPLX(0.0,RA)
      IF(C.LE.ALP) VA = CMPLX(RA,0.0)
      IF(C.GT.BET) VB = CMPLX(0.0,RB)
      IF(C.LE.BET) VB = CMPLX(RB,0.0)
      GO TO (1,2,3,4,5,6),ISRC
    1 CONTINUE
      SC(1,1) = -2. * F(3) * PI4C * EYE
      SC(1,3) = 2. * F(3) * PI4C * EYE / VB
      SC(2,2) = -2. * F(1) * PI4C * WV * EYE / VA
      SS(2,2) = -2. * F(2) * PI4C * WV * EYE / VA
      SC(2,4) = 2. * F(1) * FAC * EYE/OMEGA
      SS(2,4) = 2. * F(2) * FAC * EYE / OMEGA
      RETURN
    2 CONTINUE
      SC(1,2) =PI4C*(WV*WV*(1.-3.*F(3)*F(3)) + 2.*F(3)*F(3)/(ALP*ALP))
     1 / VA
      SC(1,4) = -PI4C*(1.-3.*F(3)*F(3)) * ONE / OMEGA
      SS(2,1) = -4.*PI4C*WV*F(2)*F(3) * ONE
      SC(2,1) = -4.*PI4C*WV*F(1)*F(3) * ONE
      SC(2,3) = 2.*FAC*F(1)*F(3)*(RB + WV*WV/RB) / OMEGA
      SS(2,3) = 2.*FAC*F(2)*F(3)*(RB + WV*WV/RB) / OMEGA
      SC(3,2) =PI4C*WV*WV*(F(2)*F(2)-F(1)*F(1)) / VA
      SS(3,2) = -2.*F(1)*F(2)*PI4C*WV*WV / VA
      SC(3,4) = -PI4C*(F(2)*F(2) - F(1)*F(1)) * ONE / OMEGA
      SS(3,4) = 2.*F(1)*F(2)*PI4C* ONE / OMEGA
      RETURN
    3 CONTINUE
      SC(1,2) =PI4C*F(3)*N(3)*(2./(ALP*ALP)-3.*WV*WV) / VA
      SC(1,4) = 3.*F(3)*N(3)*PI4C * ONE / OMEGA
      SC(2,1) = -2.*PI4C*WV*(F(1)*N(3)+F(3)*N(1)) * ONE
```

```
      SS(2,1) = -2.*PI4C*WV*(F(2)*N(3)+F(3)*N(2)) * ONE
      SC(2,3) = 2.*FAC*(F(1)*N(3)*VB + F(3)*N(1)*WV*WV/VB) / OMEGA
      SS(2,3) = 2.*FAC*(F(2)*N(3)*VB + F(3)*N(2)*WV*WV/VB) / OMEGA
      SC(3,2) = PI4C*WV*WV*(F(2)*N(2)-F(1)*N(1)) / VA
      SS(3,2) =-PI4C*WV*WV*(F(1)*N(2)+F(2)*N(1)) / VA
      SC(3,4) = - PI4C*(F(2)*N(2)-F(1)*N(1)) * ONE / OMEGA
      SS(3,4) = PI4C * (F(1)*N(2)+F(2)*N(1)) * ONE / OMEGA
      RETURN
    4 CONTINUE
      SC(1,2) = 2.*PI4C*F(3)*N(3)*(2./(ALP*ALP) - 3.*WV*WV) / VA
      SC(1,4) = 6.*F(3)*N(3)*PI4C * ONE / OMEGA
      SC(2,1) = -4.*PI4C*WV*(F(1)*N(3)+F(3)*N(1)) * ONE
      SS(2,1) = -4.*PI4C*WV*(F(2)*N(3)+F(3)*N(2)) * ONE
      SC(2,3) = 2.*FAC*(F(1)*N(3)*F(3)*N(1))*(VB + WV*WV/VB) / OMEGA
      SS(2,3) = 2.*FAC*(F(2)*N(3)*F(3)*N(2))*(VB + WV*WV/VB) / OMEGA
      SC(3,2) = 2.*PI4C*WV*WV*(F(2)*N(2)-F(1)*N(1))/VA
      SS(3,2) = -2.*PI4C*WV*WV*(F(1)*N(2) + F(2)*N(1) ) / VA
      SC(3,4) = -2.*PI4C*(F(2)*N(2) - F(1)*N(1)) * ONE / OMEGA
      SS(3,4) = 2. * PI4C*(F(1)*N(2) + F(2)*N(1) ) * ONE / OMEGA
      RETURN
    5 CONTINUE
       SC(1,2) = PI4C*(F(3)*F(3)-N(3)*N(3))*(2./(ALP*ALP)-3.*WV*WV)/VA
      SC(1,4) = 3.*PI4C*(F(3)*F(3)-N(3)*N(3)) * ONE / OMEGA
      A = F(1)*F(3) - N(1)*N(3)
      B = F(3)*F(2) - N(2)*N(3)
      SC(2,1) = -4.*PI4C*WV*A*ONE
      SS(2,1) = -4.*PI4C*WV*B*ONE
      SC(2,3) = 2.*FAC*A*(VB + WV*WV/VB) / OMEGA
      SS(2,3) = 2.*FAC*B*(VB+WV*WV/VB) / OMEGA
      A = F(2)*F(2) - F(1)*F(1) - N(2)*N(2) + N(1)*N(1)
      B = F(1)*F(2) - N(1)*N(2)
      SC(3,2) = PI4C*WV*WV*A/VA
      SS(3,2) = -2.*PI4C*WV*WV*B/VA
      SC(3,4) = -PI4C*A*ONE/OMEGA
      SS(3,4) = 2.*PI4C*B*ONE/OMEGA
      RETURN
    6 CONTINUE
      SC(1,2) = 2.*PI4C /(ALP*ALP*VA)
      RETURN
      END

      SUBROUTINE DETER(F,A11,A12,A13,A21,A22,A23,A31,A32,A33)
      COMPLEX F,A11,A12,A13,A21,A22,A23,A31,A32,A33
      F = A11*(A22*A33-A32*A23) + A12*(A23*A31-A21*A33)
     1 + A13*(A21*A32-A22*A31)
      RETURN
               END

      SUBROUTINE DOEF(OMEGA,C,WVNO,ALP,BET,DEN,DM,RA,RB,GAM,GAMM1,DP)
      COMPLEX DP(4,4)
```

```
      COMPLEX ZERO
      ZERO = CMPLX(0.0,0.0)
      WVNOSQ = WVNO*WVNO
      RBB = OMEGA * RB
      RAA = RA * OMEGA
      P = RAA * DM
      Q = RBB * DM
      IF(C-BET) 1211,1221,1231
 1231 SINQ = SIN(Q)
      COSQ = COS(Q)
      Z = -RBB*SINQ
      GO TO 1242
 1221 COSQ = 1.0
      SINQ = 0.0
      Z = 0.0
                GO TO 1241
 1211 EXQP = EXP(Q)
      EXQM = 1./EXQP
      COSQ = 0.5*(EXQP+EXQM)
      SINQ = 0.5*(EXQP-EXQM)
      Z = RBB * SINQ
 1241 EXPP = EXP(P)
      EXPM = 1./EXPP
      COSP = 0.5*(EXPP+EXPM)
      SINP = 0.5*(EXPP-EXPM)
      X = RAA * SINP
      GO TO 124
 1242 IF(C-ALP) 1241,122,123
  123 SINP = SIN(P)
      COSP = COS(P)
      X = -RAA*SINP
      GO TO 124
  122 X = 0
              SINP = 0.0
                          COSP = 1.0
                                      GO TO 124
  124 CONTINUE
      P13 = -RBB*COSQ/DEN
      P23 = -WVNOSQ*SINQ/DEN
      P33 = -GAM*RBB*COSQ
      P43 = -GAMM1*SINQ
      P12 = SINP/DEN
                      P22 = RAA*COSP/DEN
                                  P32 = GAMM1*SINP
                                                  P42 =
     1 GAM*RAA*COSP/WVNOSQ
      IF(C-BET) 1411,1421,1431
 1411 DP(1,3) = CMPLX(P13,0.0)
                                 DP(2,3) = CMPLX(P23,0.0)
      DP(3,3) = CMPLX(P33,0.0)
```

```
                                        DP(4,3) = CMPLX(P43,0.0)
                                                          GO TO 1500
 1421 DP(1,3) = ZERO
              DP(2,3) = ZERO
                        DP(3,3) = ZERO
                                  DP(4,3) = ZERO
                                                    GO TO 1500
 1431 DP(1,3) = CMPLX(0.0,P13)
                                        DP(2,3) = CMPLX(0.0,P23)
      DP(3,3) = CMPLX(0.0,P33)
                                        DP(4,3) = CMPLX(0.0,P43)
 1500 IF(C-ALP) 1511,1521,1531
 1511 DP(1,2) = CMPLX(P12,0.0)
                                        DP(2,2) = CMPLX(P22,0.0)
      DP(3,2) = CMPLX(P32,0.0)
                                        DP(4,2) = CMPLX(P42,0.0)
                                                          GO TO 1600
 1521 DP(1,2) = ZERO
              DP(2,2) = ZERO
                        DP(3,2) = ZERO
                                  DP(4,2) = ZERO
                                                    GO TO 1600
 1531 DP(1,2) = CMPLX(0.0,P12)
                                        DP(2,2) = CMPLX(0.0,P22)
      DP(3,2) = CMPLX(0.0,P32)
                                        DP(4,2) = CMPLX(0.0,P42)
 1600 CONTINUE
      DP(1,1) = CMPLX(-COSP/DEN,0.0)
      DP(2,1) = CMPLX(-X/DEN,0.0)
      DP(3,1) = CMPLX(-GAMM1*COSP,0.0)
      DP(4,1) = CMPLX(-GAM*X/WVNOSQ,0.0)
      DP(1,4) = CMPLX(Z/DEN,0.0)
      DP(2,4) = CMPLX(WVNOSQ*COSQ/DEN,0.0)
      DP(3,4) = CMPLX(GAM*Z,0.0)
      DP(4,4) = CMPLX(GAMM1*COSQ,0.0)
      RETURN
              END

      SUBROUTINE SPEC(DF,M,DATA)
C     THIS SUBROUTINE PLOTS AMPLITUDE SPECTRA ON 2 X 3 CYCLE LOG-LOG
C     SCALE
      DIMENSION DATA(1),X(258),Y(258)
      CHARACTER XL,YL,TL,YLS,SHL,SVL
      COMMON /PLTLIM/ TMMN,TMMX,FMIN,FMAX
      COMMON /PLTTTL/ XL(8),YL(8),TL(8),FL(8),YLS(8),SHL(8),SVL(8)
      CALL PLOT(7.0,0.0,-3)
      CALL PLOT(0.0,-11.0,-3)
      CALL PLOT(0.0,2.0,-3)
      NP = M/2
      NP = NP + 1
```

```
      XMIN = FMIN
      XMAX = FMAX
      YMAX = 1.0E-38
      J = 0
C     THE ZERO FREQUENCY POINT IS NOT PLOTTED
      DO 5700 I = 2,NP
      J = J + 1
      X(J) = (I-1) * DF
      IF(X(J).LT.XMIN) X(J) = XMIN
      IF(X(J).GT.XMAX) X(J) = XMAX
      K = 2 * I - 1
      L = 2 * I
      Y(J) = SQRT(ABS(DATA(K)*DATA(K) + DATA(L)*DATA(L)))
      IF(Y(J).GT.YMAX) YMAX = Y(J)
 5700 CONTINUE
      YY = ALOG10(YMAX)
      LY = YY
      YY=LY
      IF(YY.GT.LY) YY = LY + 1
      YMIN = 10.**(YY - 4.)
       YMAX = 10.**YY
      N = J
      DO 5701 I = 1,N
      IF(Y(I).LT.YMIN) Y(I) = YMIN
 5701 CONTINUE
      XAXLEN = 4.0
      YAXLEN = 4.0
      DELTAX = 4./XAXLEN
      DELTAY = 4./YAXLEN
      X1 = ALOG10(FMIN)
      NOCX = 4
      NOCY = 4
      Y1 = YY - NOCY
      MTX = 24
      MTY = 24
      CALL ALOGAXES(XAXLEN,YAXLEN,NOCX,NOCY, FL , YL ,MTX,MTY,X1,Y1,
     1DELTAX,DELTAY)
      DO 5703 I = 1,N
      Y(I) = ALOG10(Y(I))
 5703 X(I) = ALOG10(X(I))
      X(N+1) = X1
      X(N+2) = DELTAX
      Y(N+1) = Y1
      Y(N+2) = DELTAY
      CALL LINE(X,Y,N,1,0,0)
      STTL = 0.035 * YAXLEN
      TTLP = - 0.20 * YAXLEN - 0.1
      XTL = (XAXLEN - 24. * STTL)/2.
      CALL SYMBOL(XTL,TTLP,STTL,TL,0.0,24)
      RETURN
```

```
      END

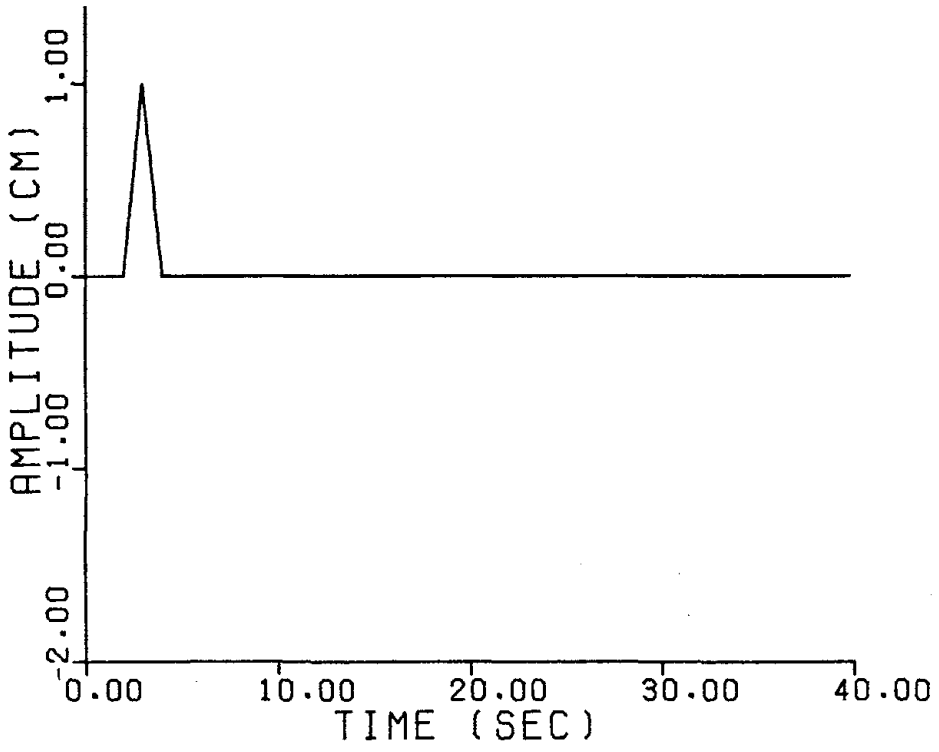
      SUBROUTINE ALOGAXES(XAXLEN,YAXLEN,NOCX,NOCY,TTLX,TTLY,MTX,MTY,X1,
     1Y1,DELTAX,DELTAY)
      CHARACTER TTLX(1),TTLY(1)
      SLT = 0.02*YAXLEN
      SST = 0.01 * YAXLEN
      SP = -0.06*YAXLEN
      SS = 0.035*YAXLEN
      SSP = SP + SS - 0.06
      TTLP = -0.11*YAXLEN - 0.1
      STTL = 0.035*YAXLEN
      XNUM = 1
      YL = Y1
      YU = Y1 + ANOCY
      IF(ABS(YL).GE.10. .OR. ABS(YU).GE.10. )XNUM = XNUM + 1.
      IF(ABS(YL).GE.100..OR. ABS(YU).GE.100.)XNUM = XNUM + 1.
      IF(Y1.LT.0) XNUM = XNUM + 1.0
      CALL PLOT(-SLT,0.0,2)
      CALL PLOT(0.0,-SLT,3)
      CALL PLOT(0.0,0.0,2)
      XPO = X1
      YPO = Y1
      IF(NOCX.EQ.0) GO TO 4
      ANOCX = NOCX
      FACTX = XAXLEN/ANOCX
      CALL SYMBOL(-.6*SS,SP,SS,2H10,0.0,2)
      CALL NUMBER(999.,SSP,0.6*SS,X1,0.0,-1)
      CALL PLOT(0.0,0.0,3)
      DO 3 J = 1,NOCX
      DO 2 I = 1,10
      X = I
      X = ALOG10(X) *FACTX + (J-1)*FACTX
      IF(I.EQ.1)GO TO 2
      CALL PLOT(X,0.0,2)
      CALL PLOT(X,-SST,2)
    2 CALL PLOT(X,0.0,3)
      CALL PLOT(X,-SLT,2)
      CALL SYMBOL(X-.6*SS,SP,SS,2H10,0.0,2)
      XPO = XPO + 1.0
      CALL NUMBER(999.,SSP,0.6*SS,XPO,0.0,-1)
    3 CALL PLOT(X,0.0,3)
      XTL = MTX
      XTL = (XAXLEN-XTL*STTL)/2.0
      CALL SYMBOL(XTL,TTLP,STTL,TTLX,0.0,MTX)
      GO TO 6
    4 CALL AXIS(0.0,0.0,TTLX,-MTX,XAXLEN,0.0,X1,DELTAX)
    6 CALL PLOT(0.0,0.0,3)
      IF(NOCY.EQ.0) GO TO 10
      ANOCY = NOCY
```

```
      SP = SP - (XNUM - 1.5) * 0.5 * SS
      TTLP = TTLP - (XNUM-1.)*0.5*SS
      FACTY = YAXLEN/ANOCY
      CALL SYMBOL(SP-0.4,-0.5*SS,SS,2H10,0.0,2)
      CALL NUMBER(999.,.5*SS-.06,.6*SS,Y1,0.0,-1)
      CALL PLOT(0.0,0.0,3)
      DO 9 J = 1,NOCY
      DO 8 I = 1,10
      Y = I
      Y = ALOG10(Y) * FACTY + (J-1)*FACTY
      IF(I.EQ.1)GO TO 8
      CALL PLOT(0.0,Y,2)
      CALL PLOT(-SST,Y,2)
    8 CALL PLOT(0.0,Y,3)
      CALL PLOT(-SLT,Y,2)
      CALL SYMBOL(SP-.4,Y-.5*SS,SS,2H10,0.0,2)
      YPO = YPO + 1
      CALL NUMBER(999.,Y+.5*SS-.06,.6*SS,YPO,0.0,-1)
    9 CALL PLOT(0.0,Y,3)
      YTL=MTY
      YTL = (YAXLEN-YTL*STTL)/2.0
      CALL SYMBOL(TTLP-.2,YTL,STTL,TTLY,90.,MTY)
      RETURN
   10 CALL AXIS(0.0,0.0,TTLY,MTY,YAXLEN,90.,Y1,DELTAY)
      RETURN
      END

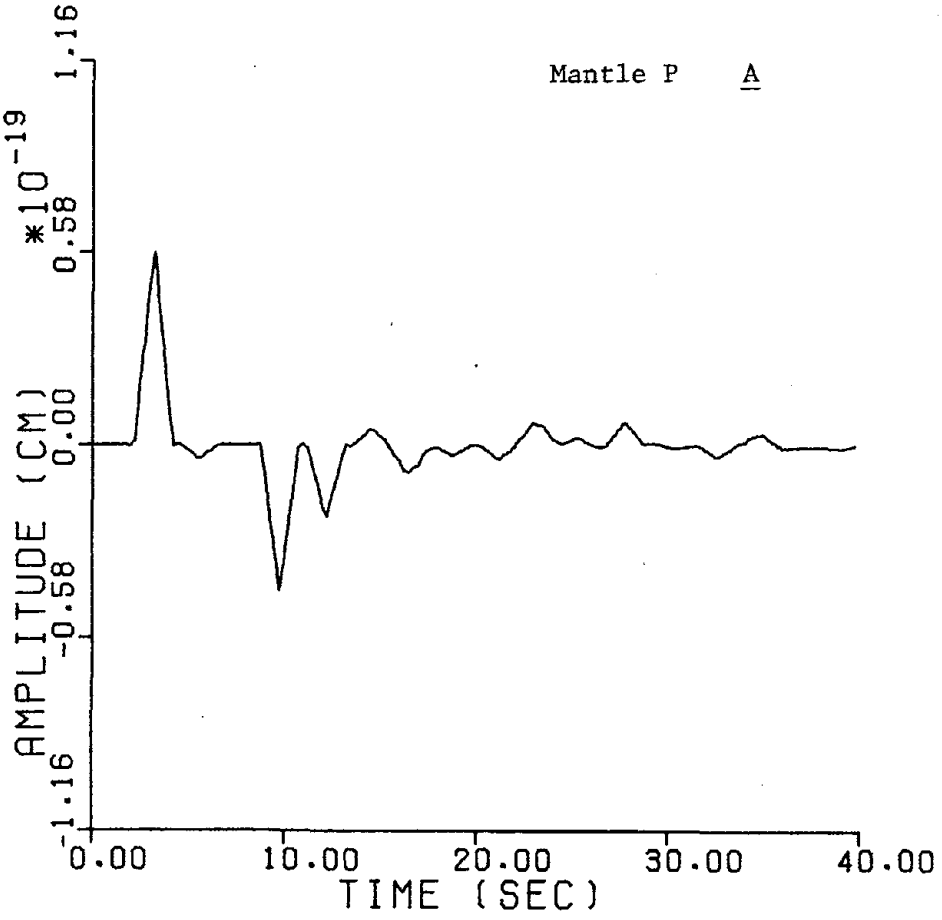
      SUBROUTINE EZPLOT2(X,Y,N,LS,XMIN,XMAX,SMIN,SMAX,XL,YL,TL,NI,MI)
      COMMON /PLTSEI/ X1,DELTAX,Y1,DELTAY
      CHARACTER XL(1),YL(1),TL(1)
      DIMENSION X(1),Y(1)
      CALL PLOT(7.0,0.0,-3)
      CALL PLOT(0.0,-11.0,-3)
      CALL PLOT(0.0,2.0,-3)
      X1 = XMIN
      DELTAX = (XMAX - XMIN) / 2.
      DELTAX = DELTAX / 2.
      X(N+1) = XMIN
      X(N+2) = DELTAX
      XAXLEN = 2.0
      Y1 = SMIN
      DELTAY = SMAX
      DELTAY = DELTAY / 2.
      Y(N+1) = SMIN
      Y(N+2) = DELTAY
      CALL AXIS(0.0,0.0,YL,18,4.0,90.0,Y1,DELTAY)
      CALL AXIS(0.0,0.0,XL,-18,4.0,0.0,X1,DELTAX)
      CALL LINE(X,Y,N,1,0,0)
      HT = 0.14
      XTL = (XAXLEN - 24.*HT)/2.
```

```
      YTL = - 0.75
      CALL SYMBOL(XTL,YTL,HT,TL,0,0,24)
      RETURN
      ENTRY NXCURV2(X,Y,N,LS)
      X(N+1) = X1
      X(N+2) = DELTAX
      Y(N+1) = Y1
      Y(N+2) = DELTAY
      CALL LINE(X,Y,N,1,0,0)
      RETURN
      END
```

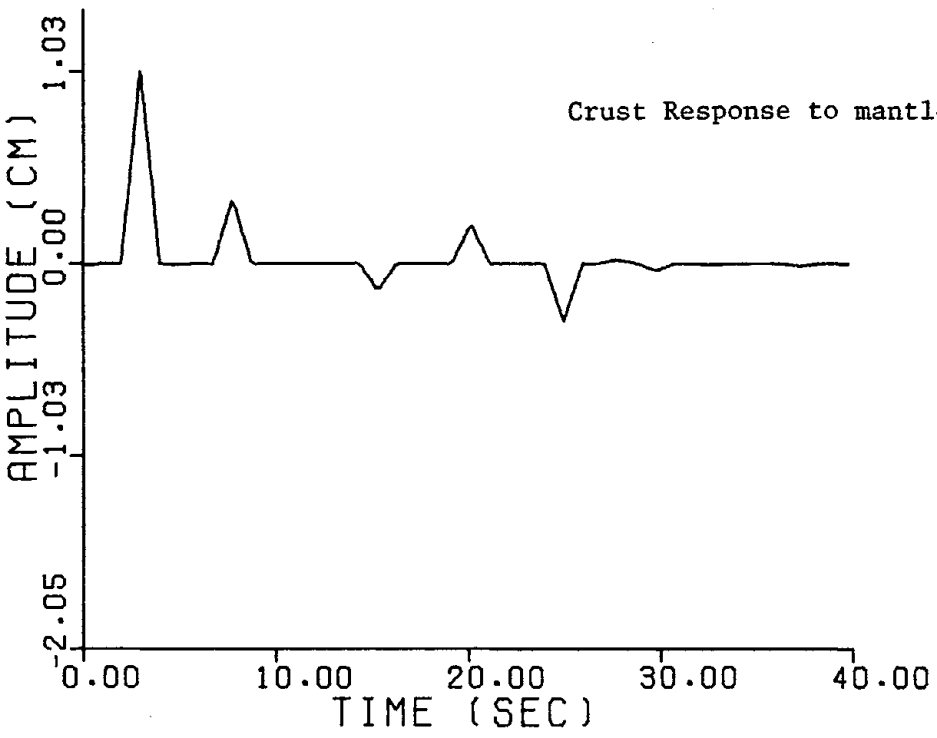
```
   2
     40.0          6.0          3.55          2.8
          8.0          4.67         3.3
   2
     40.0          6.0          3.55          2.8
          8.0          4.67         3.3
      0.0         40.0  1.000E-02  1.000E 02
 160              0.25
20.               45.          0.0          90.          1.0          0.0          1.0          1
    1     1      2     0      1     0      0     1      0     0
TEST              0.0          180.         16.          1.000E 00 1.000E 00
HALT
    1     2      2     0      1     0      0     1      0     0
TEST              0.0          180.         16.          1.000E 00 1.000E 00
HALT
    1     3      2     0      1     0      0     1      0     0
TEST              0.0          180.         16.          1.000E 00 1.000E 00
HALT
    2     1      2     0      1     0      0     1      1     1
SHSV              0.0          180.         20.44        1.000E-10 1.000E-10 10.
HALT
    2     1      2     0      1     0      0     1      1     0
TEST              45.          225.         16.          1.000E 00 1.000E 00 12.82
HALT
    2     2      2     0      1     0      0     1      1     0
TEST              45.          225.         16.          1.000E 00 1.000E 00 12.82
HALT
    2     3      2     0      1     0      0     1      1     0
TEST              45.          225.         16.          1.000E 00 1.000E 00 12.82
HALT
```

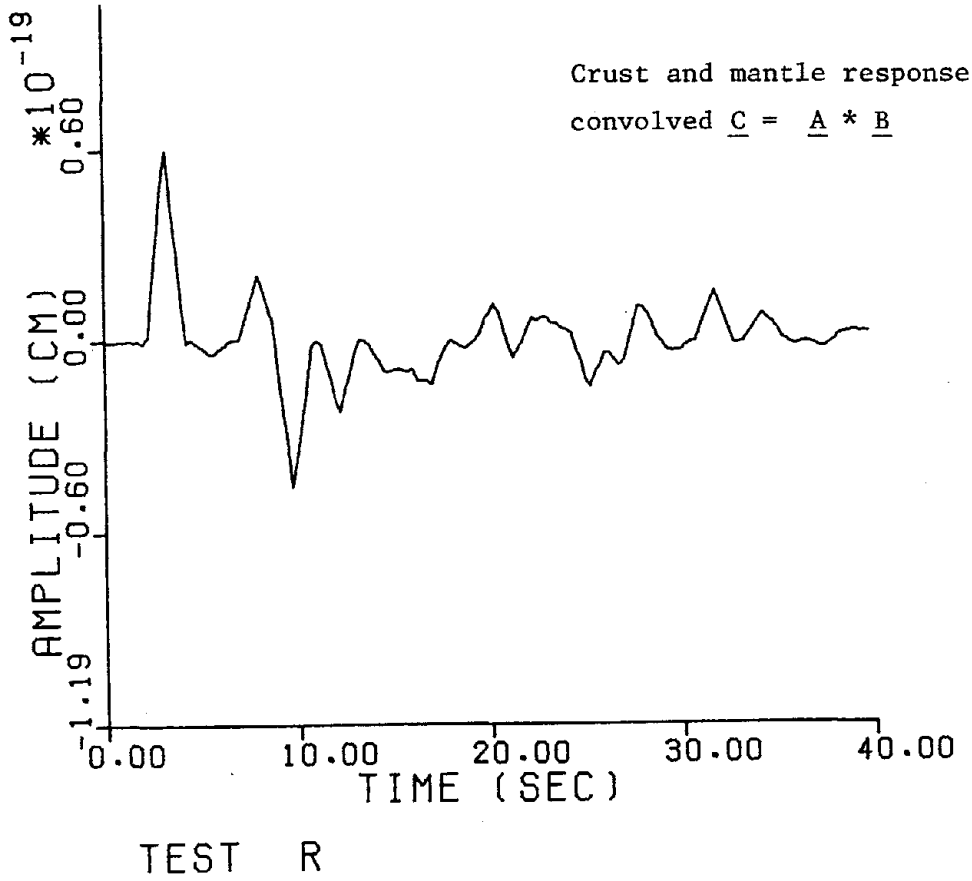


SOURCE PULSE



TEST P


Crust Response to mantle P B
AMPLITUDE (CM)
1.03
0.00
-1.03
-2.05
0.00
10.00
20.00
30.00
40.00
TIME (SEC)
TEST R


Crust and mantle responses
convolved C = A * B
*10-19
0.60
0.00
-0.60
-1.19
AMPLITUDE (CM)
0.00
10.00
20.00
30.00
40.00
TIME (SEC)
TEST R

SOURCE CRUSTAL MODEL

THICK	P VEL	S VEL	DENSITY
40,0000	6,0000	3,5500	2,8000
	8,0000	4,6700	3,3000

RECEIVER CRUSTAL MODEL

THICK	P VEL	S VEL	DENSITY
40,0000	6,0000	3,5500	2,8000
	8,0000	4,6700	3,3000

```
NN =  160     DT =   0.25     EARTHQUAKE

H =  20.00    DIP =  45.00    STK =   0.      SLIP =  90.00    DT1 =   1.00    DT2 =   0.      DT3 =   1.00    MOM = 0.100E 01

X = ( 0.0000867,-0.7071374,-0.7070761)     Y = ( 0.       , 0.7070761,-0.7071374)     Z = ( 1.0000000, 0.0000613, 0.0000613)
T = (-0.0000613, 0.0000434, 1.0000000)     P = ( 0.0000613,-1.0000000, 0.0000434)
    1     1     2     0     1     0     0     1     0     0
XMAX = 0.100E 01      XMIN = 0.
TEST          0.       180.000    16.000 0.100E 01 0.100E 01   0.          C
XMAX = 0.124E-18      XMIN =-0.936E-19
XMAX = 0.597E-19      XMIN =-0.454E-19
    1     2     2     0     1     0     0     1     0     0
XMAX = 0.100E 01      XMIN = 0.
TEST          0.       180.000    16.000 0.100E 01 0.100E 01   0.          A
XMAX = 0.579E-19      XMIN =-0.439E-19
XMAX = 0.579E-19      XMIN =-0.439E-19
    1     3     2     0     1     0     0     1     0     0
XMAX = 0.100E 01      XMIN = 0.
TEST          0.       180.000    16.000 0.100E 01 0.100E 01   0.
XMAX = 0.214E 01      XMIN =-0.276E 00                                          B
XMAX = 0.103E 01      XMIN =-0.308E 00
    2     1     2     0     1     0     0     1     1     1
XMAX = 0.100E 01      XMIN = 0.
SWSV          0.       180.000    80.440 0.100E 01 0.100E 01  10.00000
XMAX = 0.202E-18      XMIN =-0.153E-18
XMAX = 0.823E-22      XMIN =-0.685E-22
SPOL = 180.0     SH = 0.499E-03     SV =-0.889E 00
XMAX = 0.412E-14      XMIN =-0.295E-14
XMAX = 0.150E-13      XMIN =-0.197E-13
XMAX = 0.823E-22      XMIN =-0.685E-22
    2     1     2     0     1     0     0     1     1     0
XMAX = 0.100E 01      XMIN = 0.
TEST         45.000    225.000    16.000 0.100E 01 0.100E 01  12.82000
XMAX = 0.544E-19      XMIN =-0.749E-19
XMAX = 0.284E-18      XMIN =-0.201E-18
XMAX = 0.328E-20      XMIN =-0.968E-19
    2     2     2     0     1     0     0     1     1     0
XMAX = 0.100E 01      XMIN = 0.
TEST         45.000    225.000    16.000 0.100E 01 0.100E 01  12.82000
XMAX = 0.876E-19      XMIN =-0.124E-18
XMAX = 0.876E-19      XMIN =-0.124E-18
XMAX = 0.825E-20      XMIN =-0.402E-19
    2     3     2     0     1     0     0     1     1     0
XMAX = 0.100E 01      XMIN = 0.
TEST         45.000    225.000    16.000 0.100E 01 0.100E 01  12.82000
XMAX = 0.621E 00      XMIN =-0.208E 00
XMAX = 0.261E 00      XMIN =-0.230E 01
XMAX = 0.241E 01      XMIN =-0.494E 00
```

XI. SEISDIS

PROGRAMMER : R. B. HERRMANN / June 1978

PURPOSE

This program has been designed to assist in interpreting old seismograms. A digitized seismogram trace is corrected for curvilinear pen movement, slant of the trace, and non-uniform translation along the time axis. Output consists of plotted traces and also punched cards of the corrected trace, which can be directly input to EXSPEC, SPSPEC or PLTSEIS. The plots are scaled to be the same size as the original record so that an overlay can be performed to check for digitizing accuracy.

INPUT/OUTPUT

Input is through FILE 60 and is usually on punched card. Printer output is on FILE 61. FILE 10 is used for the CALCOMP plot tape.

PROGRAM DESCRIPTION

PROGRAM SEISDIS: This is the main control link.

SUBROUTINE CARDIN : This reads in digitized trace coordinates and converts coordinates to inches from counts.

SUBROUTINE SEIPLT: This routine plots the title and the trace.

SUBROUTINE TIC: This draws the time tics at the base of the plot.

SUBROUTINE UNCURV: This corrects for the curvature of the trace due to the recording device.

SUBROUTINE UNSLNT: This corrects for the skewness of the trace.

SUBROUTINE SPACE: This corrects for non-uniform translation of the time axis.

INPUT DATA

Card Sequence	Column	Name	Format	Explanation
A.	1-48	ITTL	8A6	Title for plot. If the first six columns are ******, end program.
B.	1-10	RAD	F10.2	GT.0 Radius in inches to use for curvilinear correction. EQ.0 Do not correct for curvature.
	11-20	ANGI	F10.2	NE.0 correct for skewness. ANGI is the observed skew measured clockwise from true positive Y axis EQ.0 no skew correction
	21-30	PNCH	F10.2	GT.1.0 correct for non-uniform translation. LE.0 no correction.
C.	1-10	SCALEX	F10.2	Counts per inch along x-axis.
	11-20	SCALEY	F10.2	Counts per inch along y-axis.
D. Digitized trace.				
		X(I), Y(I)	16F5.0	X,Y pairs. The first pair must be +0000+0000 and the last -9999-9999.

At this point the program will perform all operations and will return to Point A to read in a new data set.

```
C     PROGRAM TO PLOT SEISMOGRAMS
      COMMON / TWO / X(2002),Y(2002),SCALEX,SCALEY
      CHARACTER ITTL(8)
      DIMENSION XXX(100),YYY(100)
      DIMENSION IBUF(1000)
      CALL PLOTS(IBUF,1000,10)
 1000 CONTINUE
      CALL PLOT(0.0,-11.0,-3)
      CALL PLOT(0.0,0.5,-3)
      READ(60,1) (ITTL(I),I=1,8)
    1 FORMAT(8A6)
      WRITE(61,1) ITTL
      IF(ITTL(1).EQ.6H******) GO TO 9999
      READ(60,111) RAD,ANGI,PNCH
      WRITE(61,112) RAD,ANGI,PNCH
  112 FORMAT(1H ,5HRAD =,F10.2,5X,6HANGI =,F10.5,5X,6HPNCH =,F10.2)
      CALL CARDIN(NUM)
      IMX = X(NUM)+6.5
      XMX = IMX
      CALL SEIPLT(X,Y,NUM,ITTL,XMX)
      DO 110 I = 1,40,4
      J = I + 3
      READ(60,111) ((XXX(K),YYY(K)),K=I,J)
      WRITE(61,111)((XXX(K),YYY(K)),K=I,J)
  111 FORMAT(8F10.2)
      DO 110 K = I,J
      IF(XXX(K).LT.0.0) GO TO 115
  110 CONTINUE
  115 N = K - 1
      DO 116 K = 1,N
  116 YYY(K) = YYY(K)/SCALEX
      WRITE(61,111)((XXX(K),YYY(K)),K=1,N)
      CALL TIC(XXX,YYY,N,XMX)
      IPNCH=PNCH
      TESTR = ABS(RAD) - 0.001
      TEST = ABS(ANGI) - 0.001
      IF(TEST.LT.0.0. AND.TESTR.LT.0.0)  GO TO 1000
      IF(TESTR.GT.0.0) CALL UNCURV(X,Y,NUM,RAD)
      IF(TESTR.GT.0.0) CALL SEIPLT(X,Y,NUM,ITTL,XMX)
      IF(TESTR.GT.0.0) CALL TIC(XXX,YYY,N,XMX)
      IF(TEST.GT.0.0) CALL UNSLNT(X,Y,NUM,ANGI)
      IF(TEST .GT.0.0) CALL SEIPLT(X,Y,NUM,ITTL,XMX)
      IF(TEST .GT.0.0) CALL TIC(XXX,YYY,N,XMX)
      IF(IPNCH.GT.0)CALL SPACE(X,Y,NUM,XXX,YYY,N)
      WRITE(61,113) (X(K),Y(K),K=1,NUM)
  113 FORMAT(1H ,16F8.3)
      IF(IPNCH.LE.0.0) GO TO 1000
      IM = X(NUM) + 1
      X0 = XXX(1)
      DO 201 I=1,IM
```

```
      YYY(I) = I - 1
  201 XXX(I) = I - 1 * X0
      IMX = X(NUM)+6.5
      XMX = IMX
      CALL SEIPLT(X,Y,NUM,ITTL,XMX)
      CALL TIC(XXX,YYY,N,XMX)
      GO TO 1000
 9999 CALL PLOT(XMX,0.0,999)
      STOP
      END

      SUBROUTINE CARDIN(NUM)
      COMMON / TWO / X(2002),Y(2002),SCALEX,SCALEY
      DIMENSION XJUMP(10)
      READ(60,1) SCALEX,SCALEY
      WRITE(61,1) SCALEX,SCALEY
    1 FORMAT(2F10.2)
      DO 2 I = 1,10
    2 XJUMP(I) = (I-1) * 10000.
      DO 110 I = 1,2000,8
      J = I + 7
      READ(60,111) ((X(K),Y(K)),K=I,J)
  111 FORMAT(16F5.0)
      WRITE(61,112) ((X(K),Y(K)),K=I,J)
  112 FORMAT(1H ,16F6.0)
      DO 110 K = I , J
      IF(X(K)+9999.) 115,115,110
  110 CONTINUE
  115 NUM = K - 1
      JUMP = 1
      DO 200 I = 2,NUM
      QQ = X(I) + XJUMP(JUMP)
      IF(ABS(QQ-X(I-1)).GT.9000.) JUMP = JUMP + 1
      X(I) = X(I) + XJUMP(JUMP)
  200 CONTINUE
      DO 300 I = 1,NUM
      X(I) = X(I) / SCALEX
  300 Y(I) = Y(I) / SCALEY
      WRITE(61,3) ((X(K),Y(K)),K=1,NUM)
    3 FORMAT(1H ,16F7.3)
      RETURN
      END

      SUBROUTINE SEIPLT(X,Y,NUM,ITTL)
      CHARACTER ITTL(1)
      DIMENSION X(1),Y(1)
      CALL SYMBOL(0.0,10.0,0.21,ITTL,0.0,48)
      CALL PLOT(0.0,4.5,-3)
      X(NUM+1) = 0.0
      X(NUM+2) = 1.0
```

```
      Y(NUM+1) = 0.0
      Y(NUM+2) = 1.0
      CALL LINE(X,Y,NUM,1,0,0)
      WRITE(61,3) NUM
    3 FORMAT(6H NUM =,I5)
      RETURN
      END

      SUBROUTINE TIC(X,Y,N,XMX)
      DIMENSION X(1),Y(1)
      CALL PLOT(0.0,-4.0,3)
      DO 120 I = 1,N
      YY = Y(I)
      XX = X(I)
      YY2 = YY - 0.1
      CALL PLOT(YY,-4.0,2)
      CALL PLOT(YY,-3.8,2)
      CALL NUMBER(YY2,-3.7,0.14,XX,0.0,-1)
      CALL PLOT(YY,-4.0,3)
  120 CONTINUE
      CALL PLOT(0.0,-11.0,-3)
      CALL PLOT(XMX,0.5,-3)
      RETURN
      END

      SUBROUTINE UNCURV(X,Y,N,RAD)
      DIMENSION X(1),Y(1), XX(181),YY(181)
      DO 100 I=1,181
      ANGI=(I-1)*0.01745329/2.
      XX(I)=RAD*(1.-COS(ANGI))
      YY(I)=RAD*SIN(ANGI)
  100 CONTINUE
      DO 200 I=1,N
      DO 300 J=1,180
      JJ=J
      IF(ABS(Y(I)).GE.YY(J).AND.ABS(Y(I)).LT.YY(J+1)) GO TO 301
  300 CONTINUE
  301 CONTINUE
      DANGI=(ABS(Y(I))-YY(JJ))/(YY(JJ+1)-YY(JJ))
      DX=XX(JJ)+DANGI*(XX(JJ+1)-XX(JJ))
      X(I)=X(I)-DX
      SIGN = 1.0
      IF(Y(I).LT.0.0) SIGN = -1.0
      Y(I)=(FLOAT(JJ-1)+DANGI)*0.01745329*RAD/2.
      Y(I)=Y(I)*SIGN
  200 CONTINUE
      RETURN
      END

      SUBROUTINE UNSLNT(X,Y,N,ANGI)
```

```
      DIMENSION X(1),Y(1)
C     THIS PROGRAM UNSLANTS A SKEWED SEISMOGRAM, ANGI IS THE ANGLE OF
C     SKEW, POSITIVE CLOCKWISE WITH RESRECT TO POSITIVE X-AXIS
      DEGRAD=0.017453293
      COSI=COS(DEGRAD*ANGI)
      SINI=SIN(DEGRAD*ANGI)
      TANI=SINI/COSI
      DO 100 I=1,N
      XX=X(I)
      YY=Y(I)
      X(I)=XX-YY*TANI
      Y(I)=Y(I)/COSI
  100 CONTINUE
      RETURN
      END

      SUBROUTINE SPACE(X,Y,NUM,XX,YY,N)
      DIMENSION X(1),Y(1),XX(1),YY(1)
      DIMENSION IX(2000),IY(2000)
C     THIS SUBROUTINE CORRECTS FOR NON-UNIFORM TRANSLATION RATE
      JJ=1
      YJ=(YY(JJ+1)-YY(JJ))/(XX(JJ+1)-XX(JJ))
      DO 1000 J=1,NUM
      IF(X(J).GT.YY(N)) GO TO 600
      IF(X(J).LE.YY(JJ+1)) GO TO 600
      IF(X(J).LE.YY(J+1)) GO TO 600
      IJ = JJ + 1
      IF(IJ.GE.N) GO TO 600
      JJ = JJ + 1
      YJ=(YY(JJ+1)-YY(JJ))/(XX(JJ+1)-XX(JJ))
  600 CONTINUE
      FRAC= (X(J)-YY(JJ))/YJ
      FRAC= FRAC+XX(JJ)
      X(J)=FRAC
 1000 CONTINUE
      XO=X(1)
      XMAX=0.0
      YMAX=0.0
      DO 1001 J=1,NUM
      X(J)=X(J)-XO
      IF(ABS(X(J)).GT.XMAX)XMAX=ABS(X(J))
      IF(ABS(Y(J)).GT.YMAX)YMAX=ABS(Y(J))
 1001 CONTINUE
C     SCALE FOR CARD OUTPUT
C     X IS NOW IN MINUTES, Y IS IN INCHES
      DO 1005 J=1,NUM
      IX(J)=8000*X(J)/XMAX
      IY(J)= 5000*Y(J)/YMAX
 1005 CONTINUE
      NUM1=NUM+1
```

```
      IX(NUM1)=-9999
      IY(NUM1)=-9999
      CPMM=5000./(YMAX*25.4)
      CPM=8000./XMAX
      TMAX=XMAX*60.
      WRITE(42,3)CPMM
      WRITE(43,3)CPMM
      WRITE(43,4)TMAX,CPM
      WRITE(42,4)TMAX,CPM
    4 FORMAT(25X,F10.2,F10.3)
    3 FORMAT(60X,1PE10.3)
    2 FORMAT(16I5)
      WRITE(43,2)((IX(I),IY(I)),I=1,NUM1)
      WRITE(42,2)((IX(I),IY(I)),I=1,NUM1)
      RETURN
      END
```

DATA PAGE 1

```
DEN WIECHERT TOP 16 AUG 31 TEXAS
6.392    -3.91     1.0
781.33   772.125
0000 0000 0036 0001 0100 0001 0117 0002 0132 0003 0155 0001 0173 0007 0180 00
0186 0001 0195 0003 0206 0001 0213 0002 0217 0004 0226-0001 0239 0003 0249 00
0260 0004 0266 0002 0273-0001 0279 0008 0293 0003 0305 0003 0309 0001 0333 00
0346 0001 0350 0004 0356 0009 0361 0009 0367 0001 0371 0005 0375 0003 0381 00
0387-0007 0392 0010 0396 0001 0402-0005 0405 0015 0410 0001 0415 0012 0421 00
0427 0014 0435-0027 0442 0021 0449-0022 0454 0023 0463-0015 0466 0019 0472-00
0477-0009 0480 0015 0485-0012 0490 0003 0493 0014 0500-0008 0506 0005 0509 00
0514-0018 0517-0004 0521 0005 0528-0011 0531 0011 0540-0016 0545 0019 0548-00
0552-0003 0556-0011 0559-0001 0561-0003 0562 0011 0568 0005 0571 0004 0574-00
0579 0015 0585 0001 0588 0002 0592-0007 0597-0000 0601-0007 0604 0023 0612-00
0615 0002 0619-0001 0623 0018 0631-0023 0636 0016 0641-0009 0645-0002 0648-00
0653-0012 0658 0014 0661 0001 0666-0011 0671 0005 0680 0015 0687-0029 0692 00
0698-0000 0703-0011 0709 0012 0711 0005 0715 0006 0720-0006 0722 0008 0730-00
0734 0016 0739-0001 0745-0018 0749 0008 0752 0017 0760-0012 0764 0008 0767 00
0774-0015 0778 0012 0786-0001 0790 0005 0796-0007 0798 0024 0808-0028 0813 00
0818-0005 0824-0007 0831 0018 0836-0015 0842 0009 0845 0025 0855-0028 0859 00
0864-0001 0868 0002 0872-0021 0874 0024 0881-0007 0884 0016 0890-0009 0893 00
0904-0039 0905 0034 0917-0015 0921 0021 0929-0009 0931 0005 0935-0012 0944 00
0950 0018 0957 0015 0964-0003 0968 0031 0976 0001 0987-0037 0992 0007 0998-00
1000 0011 1007-0002 1011 0022 1017 0017 1019 0040 1025 0021 1036-0010 1038 00
1043 0002 1053-0013 1055 0011 1061 0015 1066 0000 1068 0025 1072 0037 1079-00
1087-0051 1091-0016 1099-0049 1100 0012 1105 0002 1105 0062 1110 0060 1111 00
1123 0004 1127 0038 1135-0005 1142-0029 1148-0055 1151 0005 1159-0045 1163-00
1166 0015 1173-0029 1186-0095 1181 0005 1177 0121 1174 0202 1177 0275 1181 01
1193-0024 1208-0161 1225-0266 1247-0405 1227-0268 1214-0157 1205-0061 1196 00
1190 0186 1186 0328 1189 0475 1193 0569 1192 0394 1195 0252 1201 0107 1211-00
1224-0143 1240-0267 1255-0357 1270-0451 1289-0548 1317-0670 1279-0479 1263-03
1248-0287 1235-0181 1224-0075 1213 0052 1207 0175 1204 0288 1204 0372 1208 05
1208 0357 1212 0216 1221 0090 1230-0020 1241-0143 1259-0266 1277-0384 1290-04
1272-0326 1258-0205 1247-0085 1239 0025 1234 0135 1228 0269 1230 0419 1238 01
1247 0047 1265-0176 1284-0285 1310-0434 1284-0268 1266-0098 1253 0070 1244 02
1245 0410 1250 0275 1256 0134 1270-0046 1287-0187 1308-0325 1290-0166 1279-00
1270 0077 1266 0205 1283 0015 1277 0187 1273 0291 1277 0541 1286 0702 1300 08
1326 1033 1306 0893 1292 0707 1283 0417 1286 0235 1294 0067 1313-0122 1329-02
1318-0124 1303 0037 1296 0187 1295 0271 1304 0127 1322-0091 1332-0173 1350-02
1334-0167 1321-0035 1313 0109 1311 0155 1321 0065 1329-0031 1334-0074 1350-01
1352-0140 1361-0207 1399-0444 1442-0639 1407-0474 1403-0434 1375-0249 1362-01
1351-0010 1346 0081 1361-0078 1372-0175 1410-0418 1460-0654 1434-0517 1413-03
1393-0265 1379-0148 1366-0020 1357 0138 1354 0234 1355 0319 1378-0035 1365 03
1370 0566 1384 0764 1411 0977 1396 0797 1391 0555 1393 0267 1403 0075 1418-00
1448-0310 1486-0530 1525-0711 1579-0901 1653-1147 1688-1245 1719-1325 1762-14
1705-1282 1657-1139 1627-1050 1586-0915 1561-0818 1537-0716 1505-0561 1463-03
1448-0165 1433 0050 1423 0257 1423 0417 1430 0612 1439 0745 1450 0833 1440 06
1436 0501 1438 0395 1447 0515 1450 0385 1453 0252 1461 0122 1468 0027 1477-00
1494-0210 1509-0312 1532-0448 1552-0549 1580-0674 1612-0794 1574-0625 1621-08
1659-0935 1695-1044 1647-0880 1603-0713 1576-0589 1557-0490 1533-0338 1515-02
1500-0077 1488 0083 1481 0249 1479 0401 1486 0612 1495 0759 1508 0886 1522 09
```

1542 1121 1520 0960 1503 0805 1493 0653 1489 0513 1493 0339 1497 0202 1508 00
1519-0052 1522-0029 1529-0113 1540-0208 1555-0289 1570-0386 1590-0492 1608-05
1617-0598 1602-0500 1585-0308 1567-0265 1553-0165 1544-0053 1535 0088 1529 02
1531 0379 1537 0203 1549 0078 1543 0308 1546 0463 1551 0304 1556 0177 1565 00
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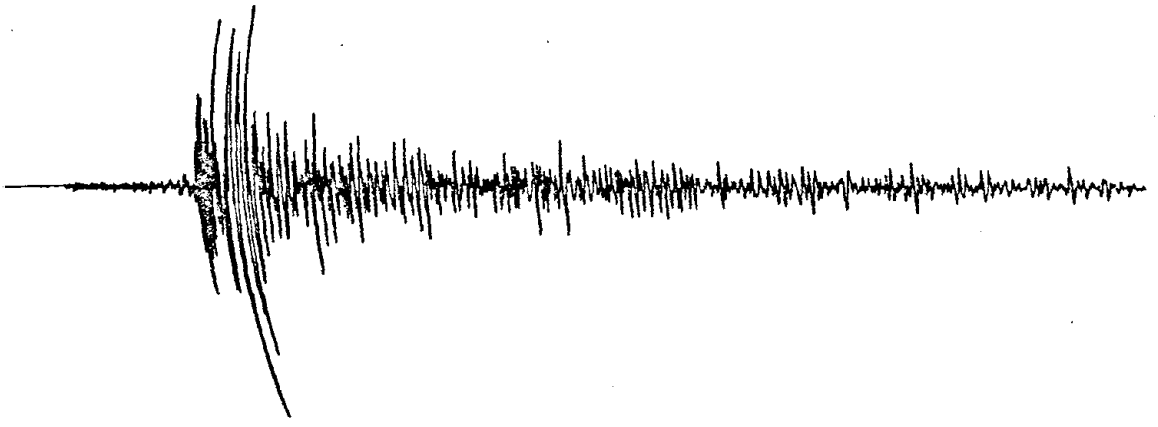

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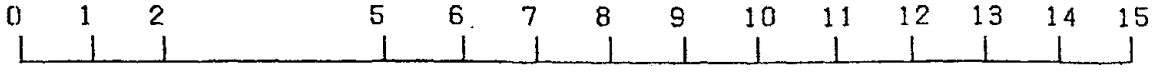

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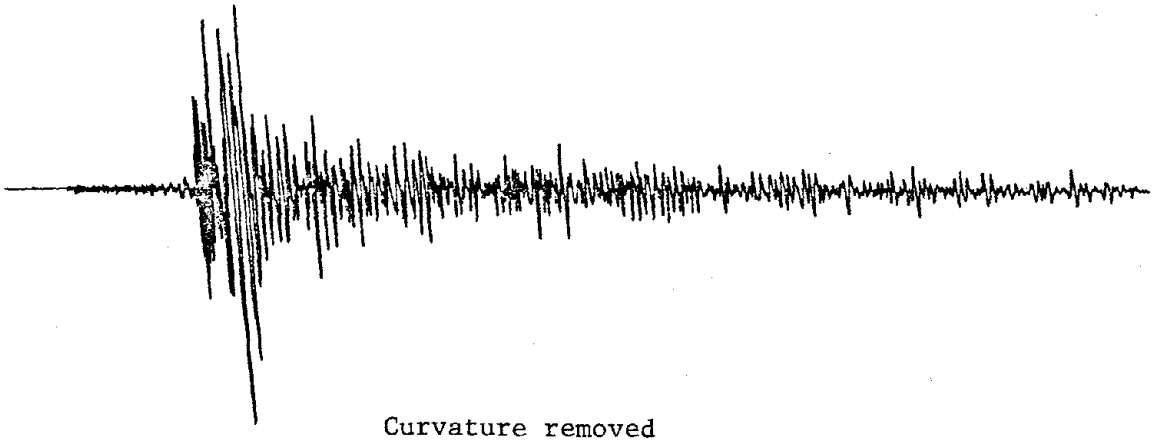

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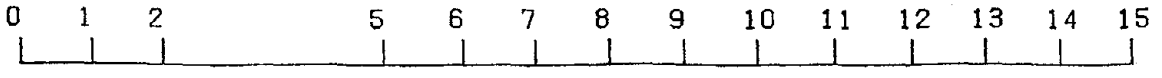

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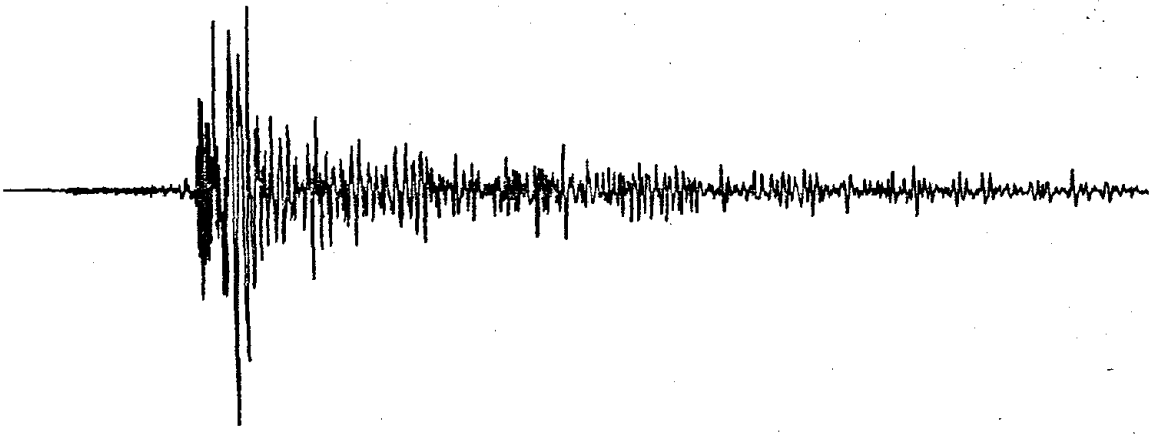

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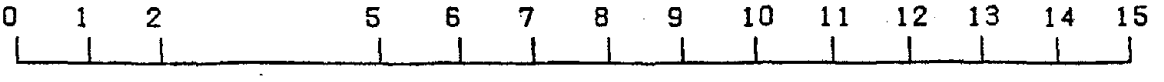

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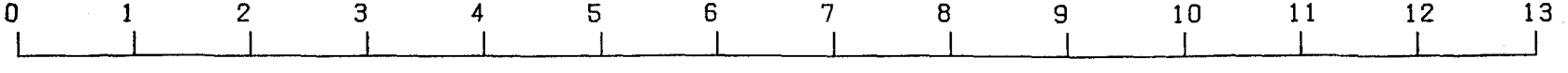

XI-15

Translation rate corrected

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1741.	220.	1748.	121.	1755.	24.	1764.	-68.	1771.	-96.	1779.	-155.	1784.	-187.	1778.	-85.
1789.	-142.	1778.	9.	1773.	103.	1772.	157.	1807.	-187.	1785.	212.	1807.	-4.	1810.	25.
1820.	-47.	1820.	20.	1824.	-1.	1826.	50.	1833.	31.	1836.	70.	1846.	-30.	1858.	-130.
1873.	-245.	1864.	-128.	1852.	19.	1870.	-117.	1860.	28.	1856.	189.	1854.	292.	1865.	134.
1876.	19.	1875.	167.	1884.	53.	1894.	-58.	1910.	-167.	1928.	-283.	1950.	-414.	1975.	-543.
1944.	-353.	1926.	-209.	1912.	-87.	1901.	54.	1897.	155.	1915.	-14.	1906.	220.	1904.	372.
1907.	452.	1915.	202.	1922.	85.	1932.	-24.	1946.	-88.	1941.	13.	1942.	110.	1957.	-59.
1980.	-237.	2001.	-365.	1980.	-215.	1966.	-92.	1962.	-1.	1960.	59.	1973.	-30.	1971.	127.
1973.	241.	1980.	155.	1988.	47.	2000.	-69.	2010.	-147.	2000.	41.	2016.	-103.	2027.	-201.
2051.	-344.	2029.	-141.	2017.	-8.	2042.	139.	2023.	45.	2025.	154.	2042.	29.	2051.	-66.
2061.	-128.	2070.	-175.	2060.	-1.	2068.	-48.	2067.	195.	2079.	58.	2085.	-24.	2098.	-122.
2087.	45.	2085.	125.	2122.	-193.	2106.	-5.	2107.	65.	2120.	-23.	2133.	-127.	2150.	-226.
2137.	-58.	2127.	83.	2126.	143.	2138.	49.	2133.	273.	2140.	188.	2145.	173.	2153.	71.
2162.	-25.	2175.	-133.	2169.	-25.	2187.	-162.	2216.	-341.	2195.	-145.	2185.	15.	2179.	182.
2179.	314.	2168.	158.	2195.	104.	2199.	68.	2202.	88.	2207.	56.	2214.	-36.	2231.	-163.
2223.	26.	2243.	-119.	2254.	-159.	2245.	31.	2242.	169.	2254.	75.	2260.	57.	2264.	78.
2272.	-8.	2283.	-95.	2297.	-170.	2291.	-42.	2286.	47.	2291.	36.	2291.	150.	2301.	79.
2314.	-25.	2325.	-91.	2322.	-11.	2337.	-106.	2329.	100.	2359.	-150.	2349.	32.	2351.	158.
2376.	-8.	2394.	-77.	2402.	-121.	2404.	-76.	2416.	-145.	2408.	1.	2404.	116.	2404.	273.
2416.	125.	2425.	56.	2433.	7.	2442.	-69.	2457.	-170.	2446.	1.	2479.	-226.	2466.	-77.
2464.	66.	2471.	59.	2467.	293.	2476.	168.	2486.	50.	2501.	-87.	2502.	-47.	2528.	-175.
2519.	-41.	2510.	159.	2517.	142.	2520.	188.	2535.	42.	2550.	-78.	2564.	-177.	2579.	-271.
2561.	-52.	2557.	241.	2571.	169.	2591.	-31.	2636.	-323.	2603.	25.	2596.	206.	2610.	81.
2616.	93.	2625.	15.	2641.	-78.	2630.	138.	2648.	-14.	2651.	46.	2674.	-102.	2667.	27.
2698.	-171.	2681.	-8.	2679.	98.	2695.	2.	2697.	64.	2703.	79.	2714.	-13.	2725.	-70.
2731.	-93.	2727.	29.	2728.	71.	2736.	37.	2743.	17.	2747.	44.	2753.	51.	2762.	-10.
2785.	-162.	2777.	-32.	2774.	161.	2776.	221.	2788.	69.	2799.	-49.	2813.	-146.	2810.	-57.
2818.	-81.	2816.	17.	2827.	-43.	2826.	124.	2833.	102.	2843.	20.	2849.	14.	2859.	-39.
2871.	-128.	2864.	67.	2875.	-2.	2874.	165.	2893.	-27.	2913.	-189.	2902.	72.	2915.	-1.
2915.	122.	2930.	1.	2939.	-48.	2943.	-6.	2953.	-52.	2957.	44.	2962.	-4.	2967.	-27.
2972.	39.	2983.	-30.	2983.	46.	2986.	16.	2992.	27.	3003.	-29.	3008.	45.	3037.	-161.
3023.	48.	3027.	72.	3041.	11.	3043.	89.	3060.	-49.	3073.	-135.	3070.	6.	3084.	-68.
3080.	56.	3085.	47.	3085.	211.	3091.	92.	3118.	-157.	3104.	84.	3118.	-15.	3132.	-64.
3130.	129.	3157.	-127.	3148.	123.	3177.	-130.	3166.	104.	3183.	-4.	3187.	49.	3200.	-45.
3211.	114.	3229.	-40.	3243.	-91.	3248.	-54.	3253.	-65.	3255.	150.	3264.	77.	3284.	-105.
3312.	-293.	3295.	-167.	3282.	55.	3282.	134.	3302.	7.	3303.	130.	3316.	-19.	3330.	-135.
3329.	95.	3358.	-124.	3348.	64.	3363.	-39.	3365.	111.	3377.	32.	3389.	15.	3393.	-32.
3400.	-83.	3397.	69.	3427.	-134.	3424.	-7.	3428.	-28.	3425.	284.	3442.	11.	3477.	-209.
3487.	-296.	3469.	-65.	3466.	2.	3473.	83.	3483.	25.	3488.	105.	3504.	-33.	3517.	-81.
3524.	-74.	3527.	43.	3535.	28.	3538.	63.	3559.	-78.	3554.	46.	3571.	-67.	3575.	-57.
3583.	-105.	3576.	70.	3574.	191.	3587.	83.	3593.	46.	3596.	73.	3604.	15.	3613.	-49.
3619.	-76.	3624.	-65.	3628.	-63.	3631.	-25.	3634.	104.	3641.	87.	3652.	15.	3660.	-40.
3665.	-29.	3670.	-43.	3673.	1.	3673.	113.	3684.	27.	3696.	-63.	3697.	-14.	3702.	-27.
3705.	-20.	3717.	-77.	3708.	157.	3725.	-93.	3735.	2.	3740.	-17.	3741.	118.	3751.	33.
3760.	-29.	3766.	-35.	3781.	-96.	3774.	9.	3770.	92.	3788.	-23.	3783.	109.	3798.	-30.
3809.	-115.	3817.	-161.	3808.	-21.	3802.	95.	3819.	-13.	3821.	-28.	3823.	-13.	3827.	-18.
3831.	62.	3841.	7.	3844.	51.	3858.	-50.	3877.	-186.	3867.	-42.	3860.	108.	3874.	47.
3878.	66.	3897.	-46.	3919.	-102.	3906.	-26.	3896.	172.	3920.	-19.	3918.	82.	3935.	-33.
3953.	-144.	3945.	100.	3956.	71.	3962.	94.	3980.	-27.	4001.	-179.	3996.	20.	4004.	4.
4003.	162.	4022.	-2.	4032.	-47.	4034.	14.	4046.	-73.	4058.	-151.	4052.	37.	4058.	114.
4070.	31.	4098.	-190.	4085.	-9.	4089.	88.	4100.	47.	4110.	-34.	4125.	-127.	4124.	-13.
4130.	-25.	4126.	150.	4137.	104.	4146.	17.	4156.	-70.	4164.	-125.	4161.	-2.	4170.	-55.
4184.	-152.	4174.	1.	4170.	120.	4177.	111.	4186.	44.	4191.	13.	4196.	-4.	4206.	-79.
4204.	32.	4211.	7.	4212.	72.	4223.	7.	4241.	-133.	4234.	57.	4245.	3.	4248.	81.
4259.	-6.	4278.	-135.	4272.	58.	4278.	45.	4285.	54.	4294.	13.	4303.	-32.	4310.	-24.
4316.	-29.	4320.	12.	4330.	-19.	4337.	49.	4347.	23.	4357.	-11.	4360.	35.	4376.	-54.
4384.	17.	4389.	5.	4395.	9.	4402.	-22.	4409.	-29.	4407.	161.	4417.	78.	4426.	-11.
4438.	494.	4446.	-131.	4440.	49.	4457.	-73.	4455.	82.	4468.	23.	4480.	-32.	4484.	-7.
4492.	1.	4492.	34.	4501.	-9.	4507.	38.	4514.	23.	4522.	-3.	4531.	-31.	4535.	-23.
4540.	-30.	4541.	35.	4549.	50.	4560.	11.	4576.	-63.	4582.	21.	4590.	28.	4597.	6.
4606.	-37.	4610.	118.	4631.	-52.	4687.	-41.	4644.	-52.	4650.	-57.	4654.	-40.	4655.	103.
4668.	39.	4683.	-27.	4688.	-8.	4697.	-32.	4704.	-39.	4710.	-62.	4711.	92.	4717.	99.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

4784.	116.	4792.	75.	4803.	14.	4811.	-7.	4[illegible]											
4853.	-38.	4856.	-14.	4858.	87.	4872.	30.	4883.	[illegible]	4[illegible]	-12.	4[illegible]	-78.	4[illegible]	-1[illegible]				
4918.	127.	4925.	91.	4932.	29.	4941.	-41.	4[illegible]	-7[illegible]	4[illegible]	101.	4[illegible]	5[illegible]	4[illegible]	-[illegible]				
4993.	-159.	4986.	45.	4993.	42.	4997.	105.	5[illegible]	47.	5[illegible]	-76.	5[illegible]	30.	5[illegible]	-[illegible]				
5049.	38.	5057.	8.	5063.	33.	5072.	-7.	5[illegible]	-47.	5[illegible]	7.	5[illegible]	-15.	5[illegible]	[illegible]				
5109.	8.	5117.	-14.	5125.	25.	5141.	-34.	5[illegible]	29.	5[illegible]	44.	5[illegible]	3[illegible]	5[illegible]	[illegible]				
5172.	30.	5183.	-49.	5201.	-138.	5193.	27.	5202.	99.	5233.	-23.	5239.	15.	5245.	[illegible]				
5251.	10.	5263.	-41.	5272.	1.	5283.	-24.	5291.	65.	5317.	-31.	5315.	1.	5325.	-12.				
5326.	53.	5335.	10.	5343.	-1.	5350.	-31.	5354.	12.	5365.	-29.	5373.	55.	5385.	-14.				
5394.	-47.	5398.	50.	5411.	-12.	5417.	12.	5431.	-41.	5433.	71.	5458.	-73.	5458.	118.				
5490.	-82.	5495.	-2.	5505.	-31.	5509.	28.	5523.	-24.	5529.	9.	5531.	76.	5539.	48.				
5560.	-81.	5565.	16.	5584.	-60.	5588.	152.	5596.	85.	5614.	-63.	5631.	-159.	5624.	64.				
5651.	-39.	5657.	77.	5664.	43.	5675.	15.	5687.	-44.	5690.	51.	5703.	5.	5717.	-73.				
5726.	15.	5734.	39.	5744.	23.	5753.	-7.	5757.	9.	5764.	2.	5768.	22.	5784.	-43.				
5790.	26.	5797.	14.	5809.	-19.	5814.	26.	5830.	-33.	5839.	75.	5857.	-14.	5874.	-96.				
5877.	121.	5892.	11.	5900.	-44.	5914.	-58.	5919.	80.	5942.	-17.	5953.	12.	5960.	-7.				
5970.	-45.	5983.	17.	5997.	-26.	6002.	19.	6014.	-3.	6016.	110.	6036.	-9.	6049.	-86.				
6053.	-53.	6061.	-39.	6064.	109.	6073.	63.	6096.	-61.	6102.	25.	6112.	-7.	6127.	31.				
6143.	-34.	6156.	14.	6164.	23.	6174.	42.	6185.	-9.	6199.	-44.	6206.	-19.	6213.	-7.				
6215.	50.	6227.	19.	6237.	-22.	6245.	1.	6251.	9.	6256.	26.	6271.	-18.	6274.	-7.				
6297.	-3.	6302.	-10.	6311.	53.	6324.	45.	6333.	-9.	6348.	-60.	6354.	4.	6358.	61.				
6370.	10.	6382.	-52.	6388.	44.	6402.	-39.	6414.	53.	6419.	44.	6424.	54.	6444.	-69.				
6455.	-9.	6465.	-1.	6472.	30.	6484.	-1.	6496.	-13.	6503.	1.	6509.	24.	6518.	12.				
6520.	19.	6533.	-10.	6537.	-2.	6551.	-41.	6560.	-20.	6566.	130.	6588.	-20.	6601.	-95.				
6607.	1.	6615.	8.	6620.	44.	6639.	-20.	6649.	33.	6653.	53.	6680.	-60.	6664.	1.				
6693.	-2.	6692.	13.	6703.	11.	6706.	35.	6717.	21.	6719.	9.	6725.	1.	6742.	-1.				
6745.	8.	6764.	-49.	6772.	54.	6785.	50.	6793.	21.	6810.	-75.	6819.	32.	6830.	3.				
6843.	26.	6860.	-12.	6870.	-30.	6881.	38.	6899.	-3.	6916.	3.	6927.	18.	6938.	-40.				
6948.	19.	6959.	13.	6964.	27.	6972.	4.	6987.	-5.	6992.	-2.	7001.	0.	7010.	-7.				
7023.	10.	7029.	-2.	7040.	-4.	-9999.	-9999.	0.	0.	0.	0.	0.	0.	0.	0.				
0.	0.	0.046	0.001	0.128	0.801	0.150	0.003	0.169	0.004	0.198	0.001	0.221	0.009	0.230	0.003				
0.238	0.001	0.250	0.004	0.264	0.801	0.273	0.003	0.278	0.005	0.289	-0.001	0.306	0.004	0.319	0.001				
0.333	0.005	0.340	0.003	0.349	-0.001	0.357	0.004	0.375	0.004	0.390	0.006	0.395	0.001	0.426	0.003				
0.443	0.001	0.448	0.005	0.456	0.001	0.462	0.006	0.470	0.001	0.475	0.006	0.480	0.004	0.488	0.006				
0.495	-0.009	0.502	0.013	0.507	0.001	0.515	-0.006	0.518	0.019	0.525	0.001	0.531	0.016	0.539	0.001				
0.547	0.018	0.557	-0.035	0.566	0.027	0.575	-0.028	0.581	0.030	0.593	-0.019	0.596	0.025	0.604	-0.019				
0.610	-0.012	0.614	0.019	0.621	-0.016	0.627	0.004	0.631	0.018	0.640	-0.010	0.648	0.005	0.651	0.017				
0.658	-0.023	0.662	-0.005	0.667	0.006	0.676	-0.014	0.680	0.014	0.691	-0.021	0.698	0.025	0.701	-0.001				
0.706	-0.004	0.712	-0.014	0.715	-0.001	0.718	-0.006	0.719	0.014	0.727	0.006	0.731	0.005	0.735	-0.025				
0.741	0.019	0.749	0.001	0.753	0.009	0.758	-0.009	0.764	0.	0.769	-0.009	0.773	0.030	0.783	-0.025				
0.787	0.003	0.792	-0.001	0.797	0.023	0.808	-0.030	0.814	0.021	0.820	-0.012	0.826	-0.003	0.829	0.				
0.836	-0.016	0.842	0.018	0.846	0.001	0.852	-0.014	0.859	0.006	0.870	0.019	0.879	-0.038	0.886	0.018				
0.893	0.	0.900	-0.014	0.907	0.016	0.910	0.006	0.915	0.008	0.922	-0.008	0.924	0.010	0.934	-0.008				
0.939	0.021	0.946	-0.001	0.954	-0.018	0.959	0.008	0.962	0.022	0.973	-0.016	0.978	0.010	0.982	0.017				
0.991	-0.019	0.996	0.016	1.006	-0.001	1.011	0.006	1.019	-0.009	1.021	0.031	1.034	-0.036	1.041	0.014				
1.047	-0.006	1.055	-0.009	1.064	0.018	1.070	-0.017	1.078	0.012	1.081	0.032	1.094	-0.036	1.099	0.018				
1.106	-0.001	1.111	0.003	1.116	-0.027	1.119	0.031	1.128	-0.009	1.131	0.021	1.139	-0.012	1.143	0.025				
1.157	-0.051	1.158	0.044	1.174	-0.019	1.179	0.027	1.189	-0.012	1.192	0.006	1.197	-0.016	1.208	0.001				
1.216	0.023	1.225	0.019	1.234	-0.004	1.239	0.040	1.249	0.001	1.263	-0.048	1.270	0.009	1.277	-0.006				
1.280	0.014	1.289	-0.003	1.294	0.028	1.302	0.022	1.304	0.052	1.312	0.027	1.326	-0.013	1.329	0.023				
1.335	0.003	1.348	-0.017	1.350	0.014	1.358	0.017	1.364	0.	1.367	0.032	1.372	0.048	1.381	-0.004				
1.391	-0.066	1.396	-0.021	1.407	-0.863	1.408	0.016	1.414	0.003	1.414	0.080	1.421	0.078	1.422	0.095				
1.437	0.005	1.442	0.049	1.453	-0.006	1.462	-0.038	1.469	-0.071	1.473	0.006	1.483	-0.058	1.488	-0.018				
1.492	0.019	1.501	-0.038	1.518	-0.123	1.512	0.006	1.506	0.157	1.503	0.262	1.506	0.356	1.512	0.155				
1.527	-0.031	1.546	-0.209	1.568	-0.345	1.596	-0.525	1.570	-0.347	1.554	-0.203	1.542	-0.079	1.531	0.071				
1.523	0.241	1.518	0.425	1.522	0.615	1.527	0.737	1.526	0.510	1.529	0.326	1.537	0.139	1.550	-0.014				
1.567	-0.185	1.587	-0.346	1.606	-0.462	1.625	-0.584	1.650	-0.710	1.686	-0.868	1.637	-0.620	1.616	-0.500				
1.597	-0.372	1.581	-0.234	1.567	-0.897	1.552	0.047	1.545	0.227	1.541	0.373	1.541	0.482	1.546	0.708				
1.546	0.462	1.551	0.280	1.563	0.124	1.574	-0.026	1.588	-0.185	1.611	-0.345	1.634	-0.497	1.651	-0.585				
1.628	-0.422	1.610	-0.266	1.596	-0.110	1.586	0.032	1.579	0.175	1.572	0.348	1.574	0.543	1.584	0.245				
1.596	0.061	1.619	-0.228	1.643	-0.369	1.677	-0.562	1.643	-0.347	1.620	-0.127	1.604	0.091	1.592	0.297				
1.593	0.531	1.600	0.356	1.608	0.170	1.625	-0.060	1.647	-0.242	1.674	-0.421	1.651	-0.215	1.637	-0.074				
1.625	0.100	1.620	0.266	1.642	0.619	1.634	0.242	1.629	0.377	1.634	0.701	1.646	0.909	1.664	1.109				
1.697	1.338	1.672	1.157	1.654	0.916	1.642	0.540	1.646	0.304	1.656	0.087	1.680	-0.158	1.701	-0.308				
1.687	-0.161	1.668	0.048	1.659	0.242	1.657	0.351	1.669	0.164	1.692	-0.118	1.705	-0.224	1.728	-0.387				
1.727	-0.[illegible]	1.691	-0.045	1.680	0.135	1.678	0.198	1.691	0.084	1.701	-0.040	1.727	-0.096	1.728	-0.249				

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1.836	0.649	1.840	0.512	1.852	0.667	1.856	0.499	1.863	0.326	1.870	0.150	1.879	0.035	1.890	-0.098
1.912	-0.272	1.931	-0.404	1.961	-0.580	1.986	-0.711	2.022	-0.873	2.063	-1.028	2.015	-0.809	2.075	-1.039
2.123	-1.211	2.169	-1.352	2.108	-1.140	2.052	-0.923	2.017	-0.763	1.993	-0.635	1.962	-0.438	1.939	-0.281
1.920	-0.100	1.904	0.107	1.895	0.322	1.893	0.519	1.902	0.793	1.913	0.983	1.930	1.147	1.948	1.293
1.974	1.452	1.945	1.243	1.924	1.043	1.911	0.846	1.906	0.664	1.911	0.439	1.916	0.262	1.930	0.057
1.944	-0.067	1.948	-0.036	1.957	-0.146	1.971	-0.259	1.990	-0.374	2.009	-0.500	2.035	-0.637	2.058	-0.745
2.070	-0.774	2.050	-0.648	2.029	-0.503	2.006	-0.343	1.988	-0.214	1.976	-0.069	1.965	0.114	1.957	0.280
1.959	0.491	1.967	0.263	1.983	0.091	1.975	0.391	1.979	0.600	1.985	0.394	1.991	0.229	2.003	0.067
2.020	-0.084	2.039	-0.253	2.058	-0.383	2.090	-0.556	2.068	-0.399	2.049	-0.256	2.034	-0.096	2.022	0.067
2.021	0.198	2.034	0.069	2.047	-0.653	2.040	0.130	2.038	0.317	2.047	0.180	2.058	0.026	2.070	-0.095
2.080	-0.163	2.084	-0.146	2.091	-0.214	2.100	-0.271	2.112	-0.348	2.128	-0.442	2.112	-0.310	2.095	-0.152
2.084	-0.006	2.077	0.139	2.087	0.818	2.099	-0.095	2.091	0.085	2.085	0.264	2.081	0.434	2.084	0.593
2.087	0.442	2.096	0.284	2.108	0.107	2.123	-0.053	2.141	-0.185	2.137	-0.080	2.150	-0.172	2.164	-0.277
2.189	-0.411	2.172	-0.221	2.159	-0.052	2.149	0.105	2.151	0.205	2.151	0.424	2.162	0.337	2.174	0.170
2.186	0.045	2.200	-0.097	2.213	-0.212	2.227	-0.322	2.245	-0.421	2.246	-0.378	2.251	-0.403	2.240	-0.302
2.226	-0.152	2.221	-0.057	2.238	-0.167	2.226	-0.019	2.215	0.163	2.210	0.348	2.215	0.519	2.223	0.413
2.228	0.285	2.237	0.157	2.246	0.031	2.258	-0.088	2.267	-0.124	2.277	-0.201	2.283	-0.242	2.276	-0.110
2.290	-0.184	2.276	0.012	2.269	0.133	2.268	0.203	2.313	-0.242	2.285	0.275	2.313	-0.005	2.317	0.032
2.329	-0.061	2.329	0.026	2.334	-0.001	2.337	0.065	2.346	0.040	2.350	0.091	2.363	-0.039	2.378	-0.168
2.397	-0.317	2.386	-0.166	2.370	0.025	2.393	-0.152	2.381	0.036	2.375	0.245	2.373	0.378	2.387	0.174
2.401	0.025	2.400	0.216	2.411	0.869	2.424	-0.075	2.445	-0.216	2.468	-0.367	2.496	-0.536	2.528	-0.703
2.488	-0.457	2.465	-0.271	2.447	-0.113	2.433	0.070	2.428	0.201	2.451	-0.018	2.439	0.285	2.437	0.482
2.441	0.585	2.451	0.262	2.460	0.110	2.473	-0.031	2.491	-0.114	2.484	0.017	2.486	0.142	2.505	-0.076
2.534	-0.307	2.561	-0.473	2.534	-0.278	2.516	-0.119	2.511	-0.001	2.509	0.076	2.525	-0.039	2.523	0.164
2.525	0.312	2.534	0.201	2.544	0.861	2.560	-0.089	2.573	-0.190	2.560	0.053	2.580	-0.133	2.594	-0.260
2.625	-0.446	2.597	-0.183	2.581	-0.010	2.575	0.180	2.589	0.058	2.592	0.199	2.613	0.038	2.625	-0.085
2.638	-0.166	2.649	-0.227	2.637	-0.001	2.647	-0.062	2.645	0.253	2.661	0.075	2.669	-0.031	2.685	-0.158
2.671	0.058	2.669	0.162	2.716	-0.250	2.695	-0.006	2.697	0.084	2.713	-0.030	2.730	-0.164	2.752	-0.293
2.735	-0.075	2.722	0.107	2.721	0.185	2.736	0.063	2.730	0.354	2.739	0.243	2.745	0.224	2.756	0.092
2.767	-0.032	2.784	-0.172	2.776	-0.032	2.799	-0.210	2.836	-0.442	2.809	-0.188	2.797	0.019	2.789	0.236
2.789	0.407	2.800	0.243	2.809	0.135	2.814	0.088	2.818	0.114	2.825	0.073	2.834	-0.047	2.855	-0.211
2.845	0.034	2.871	-0.154	2.885	-0.206	2.873	0.040	2.869	0.219	2.885	0.097	2.893	0.074	2.898	0.101
2.908	-0.010	2.922	-0.123	2.940	-0.246	2.932	-0.054	2.926	0.061	2.932	0.047	2.932	0.194	2.945	0.102
2.962	-0.032	2.976	-0.116	2.972	-0.814	2.991	-0.137	2.981	0.130	3.019	-0.194	3.006	0.041	3.009	0.205
3.041	-0.010	3.064	-0.100	3.074	-0.157	3.077	-0.098	3.092	-0.188	3.082	0.001	3.077	0.150	3.077	0.354
3.092	0.162	3.104	0.073	3.114	0.009	3.125	-0.089	3.145	-0.220	3.131	0.001	3.173	-0.293	3.156	-0.100
3.154	0.085	3.163	0.076	3.157	0.379	3.169	0.218	3.182	0.065	3.201	-0.113	3.202	-0.061	3.236	-0.227
3.224	-0.053	3.212	0.206	3.221	0.184	3.225	0.243	3.244	0.054	3.264	-0.101	3.282	-0.229	3.301	-0.351
3.278	-0.067	3.273	0.312	3.291	0.219	3.316	-0.040	3.374	-0.418	3.331	0.032	3.323	0.267	3.340	0.105
3.348	0.120	3.360	0.019	3.380	-0.101	3.366	0.179	3.389	-0.018	3.393	0.060	3.422	-0.132	3.413	0.035
3.453	-0.221	3.431	-0.010	3.429	0.127	3.449	0.003	3.452	0.083	3.459	0.102	3.474	-0.017	3.488	-0.091
3.495	-0.120	3.490	0.038	3.491	0.092	3.502	0.048	3.511	0.022	3.516	0.057	3.523	0.066	3.535	-0.013
3.564	-0.210	3.554	-0.041	3.550	0.209	3.553	0.286	3.568	0.089	3.582	-0.063	3.600	-0.189	3.596	-0.074
3.607	-0.105	3.604	0.022	3.618	-0.856	3.617	0.161	3.626	0.132	3.639	0.026	3.646	0.018	3.659	-0.051
3.675	-0.166	3.666	0.087	3.680	-0.003	3.678	0.214	3.703	-0.035	3.728	-0.245	3.714	0.093	3.731	-0.001
3.731	0.158	3.750	0.001	3.762	-0.062	3.767	-0.008	3.779	-0.067	3.785	0.057	3.791	-0.005	3.797	-0.035
3.804	0.051	3.818	-0.039	3.818	0.860	3.822	0.021	3.829	0.035	3.843	-0.038	3.850	0.058	3.887	-0.209
3.869	0.062	3.874	0.093	3.892	0.814	3.895	0.115	3.916	-0.063	3.933	-0.175	3.929	0.008	3.947	-0.088
3.942	0.073	3.948	0.061	3.948	0.273	3.956	0.119	3.991	-0.203	3.973	0.109	3.991	-0.019	4.009	-0.083
4.006	0.167	4.041	-0.164	4.029	0.159	4.066	-0.168	4.052	0.135	4.074	-0.005	4.079	0.063	4.096	-0.058
4.110	0.148	4.133	-0.052	4.151	-0.118	4.157	-0.070	4.163	-0.084	4.166	0.194	4.177	0.100	4.203	-0.136
4.239	-0.379	4.217	-0.164	4.201	0.071	4.201	0.174	4.226	0.009	4.227	0.168	4.244	-0.025	4.262	-0.175
4.261	0.123	4.298	-0.199	4.285	0.883	4.304	-0.051	4.307	0.144	4.322	0.041	4.337	0.019	4.343	-0.041
4.352	-0.107	4.348	0.089	4.386	-0.174	4.382	-0.009	4.387	-0.036	4.384	0.368	4.405	0.014	4.450	-0.271
4.463	-0.383	4.440	-0.084	4.436	0.803	4.445	0.107	4.458	0.032	4.464	0.136	4.485	-0.043	4.501	-0.105
4.510	-0.096	4.514	0.056	4.524	0.836	4.528	0.082	4.555	-0.101	4.549	0.060	4.570	-0.087	4.576	-0.074
4.586	-0.136	4.577	0.091	4.574	0.247	4.591	0.107	4.599	0.060	4.602	0.095	4.613	0.019	4.624	-0.063
4.632	-0.098	4.638	-0.114	4.643	-0.882	4.647	-0.032	4.651	0.135	4.660	0.113	4.674	0.019	4.684	-0.052
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4.742	-0.026	4.757	-0.190	4.746	0.177	4.780	-0.120	4.780	0.003	4.787	-0.022	4.788	0.153	4.801	0.043
4.812	-0.038	4.820	-0.045	4.839	-0.124	4.830	0.012	4.825	0.119	4.848	-0.030	4.842	0.141	4.861	-0.039
4.875	-0.149	4.885	-0.209	4.874	-0.027	4.866	0.123	4.888	-0.017	4.890	-0.036	4.893	-0.017	4.898	-0.023
4.903	0.080	4.916	0.009	4.920	0.066	4.938	-0.065	4.962	-0.241	4.949	-0.054	4.940	0.140	4.958	0.061
4.963	0.085	4.988	-0.060	5.016	-0.236	4.999	-0.034	4.986	0.223	5.017	-0.025	5.015	0.106	5.036	-0.043
5.059	-0.186	5.049	0.130	5.063	0.092	5.071	0.122	5.094	-0.035	5.121	-0.232	5.114	0.026	5.125	0.005
5.123	0.210	5.148	-0.003	5.160	-0.061	5.163	0.018	5.178	-0.095	5.194	-0.196	5.186	0.048	5.194	0.148
5.209	0.040	5.245	-0.246	5.228	-0.812	5.233	0.114	5.247	0.061	5.260	-0.044	5.279	-0.164	5.278	-0.017
5.286	-0.032	5.281	0.194	5.295	0.135	5.306	0.022	5.319	-0.091	5.329	-0.162	5.326	-0.003	5.337	-0.071
5.355	-0.197	5.342	0.001	5.337	0.155	5.346	0.144	5.358	0.057	5.364	0.017	5.370	-0.005	5.383	-0.102
5.381	0.041	5.390	0.009	5.391	0.093	5.405	0.009	5.428	-0.172	5.419	0.074	5.433	0.004	5.437	0.105
5.451	-0.008	5.475	-0.175	5.468	0.075	5.475	0.058	5.484	0.070	5.496	0.017	5.507	-0.041	5.516	-0.031
5.524	-0.038	5.529	0.016	5.542	-0.025	5.551	0.063	5.564	0.030	5.576	-0.014	5.580	0.045	5.601	-0.070
5.611	0.022	5.617	0.006	5.625	0.012	5.634	-0.028	5.643	-0.038	5.640	0.209	5.653	0.101	5.665	-0.014
5.680	-0.122	5.690	-0.170	5.683	0.063	5.704	-0.095	5.702	0.106	5.718	0.030	5.734	-0.041	5.739	-0.009
5.749	0.001	5.749	0.044	5.761	-0.012	5.768	0.049	5.777	0.030	5.788	-0.004	5.799	-0.040	5.804	-0.030
5.811	-0.039	5.812	0.045	5.822	0.065	5.836	0.014	5.857	-0.082	5.864	0.027	5.875	0.036	5.884	0.008
5.895	-0.048	5.900	0.153	5.927	-0.067	5.935	-0.053	5.944	-0.067	5.951	-0.074	5.957	-0.052	5.958	0.133
5.974	0.051	5.994	-0.035	6.000	-0.010	6.012	-0.041	6.021	-0.051	6.028	-0.080	6.029	0.119	6.037	0.128
6.046	0.084	6.060	-0.008	6.078	-0.060	6.079	0.088	6.093	0.001	6.108	-0.075	6.122	-0.124	6.116	0.100
6.123	0.150	6.133	0.097	6.147	0.018	6.163	-0.097	6.174	-0.148	6.170	0.126	6.188	0.012	6.207	-0.092
6.211	-0.049	6.215	-0.018	6.218	0.113	6.236	0.047	6.248	0.019	6.257	-0.016	6.276	-0.093	6.291	-0.137
6.294	0.164	6.303	0.118	6.312	0.038	6.326	-0.056	6.335	-0.095	6.339	0.131	6.351	0.073	6.367	-0.074
6.390	-0.206	6.381	0.058	6.390	0.054	6.393	0.136	6.407	0.061	6.429	-0.098	6.431	0.047	6.454	-0.084
6.462	0.049	6.472	0.010	6.480	0.043	6.491	-0.009	6.502	-0.061	6.511	0.009	6.520	-0.017	6.527	0.049
6.539	0.010	6.549	-0.018	6.559	0.032	6.579	-0.044	6.582	0.038	6.587	0.057	6.599	0.039	6.608	0.076
6.619	0.039	6.634	-0.063	6.657	-0.179	6.653	0.035	6.658	0.128	6.698	-0.030	6.700	0.019	6.713	0.032
6.721	0.013	6.736	-0.053	6.747	0.001	6.762	-0.031	6.771	0.084	6.792	-0.040	6.803	0.001	6.813	-0.016
6.817	0.069	6.828	0.013	6.838	-0.001	6.847	-0.040	6.852	0.016	6.866	-0.038	6.877	0.073	6.892	-0.018
6.904	-0.061	6.909	0.065	6.925	-0.016	6.933	0.016	6.951	-0.053	6.954	0.092	6.986	-0.095	6.986	0.153
7.026	-0.106	7.033	-0.003	7.046	-0.040	7.051	0.036	7.069	-0.031	7.076	0.012	7.079	0.098	7.089	0.062
7.116	-0.105	7.122	0.021	7.147	-0.078	7.152	0.197	7.162	0.110	7.185	-0.082	7.207	-0.206	7.198	0.083
7.233	-0.051	7.240	0.100	7.249	0.056	7.263	0.019	7.279	-0.057	7.282	0.066	7.299	0.006	7.317	-0.095
7.329	0.019	7.339	0.051	7.352	0.030	7.363	-0.009	7.368	0.012	7.377	0.003	7.382	0.028	7.403	-0.056
7.410	0.034	7.419	0.018	7.435	-0.025	7.441	0.034	7.462	-0.043	7.473	0.097	7.496	-0.018	7.518	-0.124
7.522	0.157	7.541	0.014	7.551	-0.057	7.569	-0.075	7.576	0.104	7.605	-0.022	7.619	0.016	7.628	-0.009
7.641	-0.058	7.657	0.022	7.675	-0.034	7.682	0.025	7.697	-0.004	7.700	0.142	7.725	-0.012	7.742	-0.111
7.747	-0.069	7.757	-0.051	7.761	0.141	7.773	0.082	7.802	-0.079	7.810	0.032	7.823	-0.009	7.842	0.040
7.862	-0.044	7.879	0.018	7.869	0.030	7.902	0.054	7.916	-0.012	7.934	-0.057	7.943	-0.025	7.952	-0.009
7.954	0.065	7.970	0.025	7.983	-0.028	7.993	0.001	8.000	0.012	8.007	0.034	8.026	-0.023	8.030	-0.009
8.059	-0.004	8.066	-0.013	8.077	0.069	8.094	0.058	8.105	-0.012	8.125	-0.078	8.132	0.005	8.137	0.079
8.153	0.013	8.168	-0.067	8.176	0.057	8.194	-0.051	8.209	0.069	8.215	0.057	8.222	0.070	8.247	-0.089
8.262	-0.012	8.274	-0.001	8.283	0.039	8.299	-0.001	8.314	-0.017	8.323	0.001	8.331	0.031	8.342	0.016
8.345	0.025	8.361	-0.013	8.367	-0.003	8.384	-0.053	8.396	-0.026	8.404	0.168	8.432	-0.026	8.448	-0.123
8.456	0.001	8.466	0.010	8.473	0.057	8.497	-0.026	8.510	0.043	8.515	0.069	8.550	-0.078	8.555	0.001
8.566	-0.003	8.565	0.017	8.579	0.014	8.583	0.045	8.597	0.027	8.599	0.012	8.607	0.001	8.629	-0.001
8.633	0.010	8.657	-0.063	8.667	0.070	8.684	0.065	8.694	0.027	8.716	-0.097	8.727	0.041	8.742	0.004
8.758	0.034	8.780	-0.016	8.793	-0.039	8.807	0.049	8.830	-0.004	8.852	0.004	8.866	0.023	8.880	-0.052
8.893	0.025	8.907	0.017	8.913	0.035	8.923	0.005	8.942	-0.006	8.949	-0.003	8.960	0.	8.972	-0.009
8.989	0.013	8.996	-0.003	9.010	-0.005										

NUM = 1211

0.	0.	1.00	444.00	2.00	883.00	5.00	2241.00
6.00	2731.00	7.00	3178.00	8.00	3636.00	9.00	4092.00
10.00	4545.00	11.00	5018.00	12.00	5489.00	13.00	5939.00
14.00	6402.00	15.00	6844.00	-1.00	-1.00	0.	0.
0.	0.	1.00	0.57	2.00	1.13	5.00	2.87
6.00	3.50	7.00	4.07	8.00	4.65	9.00	5.24
10.00	5.82	11.00	6.42	12.00	7.03	13.00	7.60
14.00	8.19	15.00	8.76				

NUM = 1211

NUM = 1211

0.	0.	0.081	0.001	0.225	0.001	0.264	0.003	0.298	0.004	0.349	0.001	0.391	0.009	0.406	0.003
0.419	0.001	0.440	0.004	0.464	0.001	0.480	0.003	0.489	0.005	0.509	-0.001	0.539	0.004	0.561	0.001
0.586	0.005	0.599	0.003	0.619	-0.001	0.629	0.004	0.660	0.004	0.687	0.004	0.696	0.001	0.750	0.003
0.779	0.001	0.789	0.005	0.802	0.001	0.814	0.006	0.827	0.001	0.836	0.006	0.845	0.004	0.859	0.006
[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	

0.964	0.018	0.975	-0.035	0.994	0.027	1.008	-0.029	1.026	0.030	1.044	-0.019	1.053	0.025	1.061	-0.019
1.074	-0.012	1.084	0.019	1.091	-0.016	1.105	0.004	1.114	0.018	1.126	-0.010	1.142	0.006	1.150	0.017
1.156	-0.023	1.166	-0.005	1.176	0.006	1.190	-0.014	1.200	0.014	1.216	-0.021	1.233	0.025	1.237	-0.001
1.246	-0.004	1.253	-0.014	1.262	-0.001	1.266	-0.004	1.270	0.014	1.283	0.006	1.290	0.005	1.293	-0.025
1.310	0.019	1.321	0.001	1.329	0.009	1.336	-0.009	1.349	0.	1.356	-0.009	1.368	0.030	1.380	-0.025
1.390	0.003	1.398	-0.001	1.410	0.023	1.422	-0.030	1.440	0.021	1.447	-0.012	1.458	-0.003	1.465	0.
1.474	-0.016	1.490	0.018	1.494	0.001	1.504	-0.014	1.518	0.006	1.540	0.019	1.549	-0.038	1.567	0.018
1.579	0.	1.588	-0.014	1.605	0.016	1.609	0.006	1.618	0.008	1.628	-0.008	1.634	0.010	1.650	-0.008
1.663	0.021	1.672	-0.001	1.683	-0.018	1.696	0.008	1.704	0.022	1.718	-0.016	1.730	0.010	1.738	0.017
1.749	-0.019	1.763	0.016	1.779	-0.001	1.789	0.006	1.801	-0.009	1.810	0.031	1.824	-0.036	1.842	0.014
1.851	-0.006	1.864	-0.009	1.884	0.018	1.891	-0.017	1.908	0.012	1.917	0.032	1.932	-0.036	1.947	0.018
1.957	-0.001	1.966	0.003	1.971	-0.027	1.983	0.031	1.994	-0.009	2.004	0.021	2.014	-0.012	2.025	0.025
2.040	-0.051	2.053	0.044	2.073	-0.019	2.087	0.027	2.100	-0.012	2.107	0.006	2.113	-0.016	2.135	0.001
2.151	0.023	2.166	0.019	2.178	-0.004	2.192	0.040	2.206	0.001	2.224	-0.048	2.242	0.009	2.253	-0.006
2.260	0.014	2.274	-0.003	2.286	0.029	2.298	0.022	2.306	0.052	2.317	0.027	2.336	-0.013	2.345	0.023
2.354	0.003	2.373	-0.017	2.382	0.014	2.395	0.017	2.404	0.	2.412	0.032	2.423	0.048	2.433	-0.004
2.442	-0.066	2.457	-0.021	2.469	-0.064	2.481	0.016	2.491	0.003	2.499	0.080	2.510	0.078	2.514	0.095
2.531	0.005	2.544	0.049	2.556	-0.006	2.567	-0.038	2.576	-0.071	2.593	0.006	2.602	-0.058	2.616	-0.018
2.627	0.019	2.636	-0.038	2.653	-0.123	2.659	0.006	2.665	0.157	2.664	0.262	2.674	0.357	2.673	0.156
2.681	-0.031	2.687	-0.209	2.699	-0.345	2.705	-0.526	2.703	-0.348	2.702	-0.204	2.701	-0.079	2.699	0.071
2.699	0.242	2.695	0.426	2.697	0.618	2.698	0.740	2.708	0.512	2.713	0.327	2.716	0.139	2.723	-0.014
2.727	-0.186	2.732	-0.347	2.738	-0.464	2.740	-0.586	2.745	-0.713	2.754	-0.872	2.749	-0.623	2.747	-0.502
2.744	-0.373	2.742	-0.235	2.740	-0.097	2.736	0.068	2.736	0.227	2.734	0.374	2.735	0.483	2.734	0.712
2.744	0.464	2.749	0.280	2.759	0.125	2.763	-0.026	2.764	-0.186	2.774	-0.345	2.778	-0.499	2.783	-0.588
2.785	-0.424	2.787	-0.266	2.789	-0.110	2.790	0.032	2.792	0.175	2.787	0.349	2.791	0.545	2.805	0.245
2.811	0.061	2.810	-0.229	2.824	-0.370	2.834	-0.564	2.829	-0.348	2.829	-0.127	2.827	0.091	2.821	0.297
2.824	0.533	2.836	0.357	2.840	0.170	2.847	-0.060	2.856	-0.243	2.865	-0.422	2.867	-0.216	2.865	-0.074
2.865	0.100	2.868	0.266	2.886	0.019	2.891	0.243	2.887	0.378	2.887	0.704	2.886	0.914	2.885	1.117
2.893	1.351	2.890	1.166	2.898	0.921	2.908	0.542	2.914	0.305	2.917	0.087	2.928	-0.158	2.936	-0.309
2.938	-0.161	2.933	0.048	2.933	0.243	2.935	0.352	2.946	0.165	2.954	-0.118	2.959	-0.225	2.966	-0.388
2.964	-0.217	2.962	-0.045	2.962	0.135	2.963	0.199	2.976	0.084	2.980	-0.040	2.984	-0.096	2.994	-0.249
3.010	-0.182	3.015	-0.269	3.027	-0.577	3.045	-0.829	3.034	-0.616	3.040	-0.564	3.035	-0.323	3.034	-0.170
3.032	-0.013	3.034	0.105	3.042	-0.101	3.047	-0.227	3.061	-0.543	3.077	-0.851	3.077	-0.672	3.074	-0.516
3.070	-0.344	3.068	-0.192	3.064	-0.026	3.064	0.179	3.064	0.304	3.068	0.414	3.088	-0.045	3.090	0.407
3.090	0.736	3.091	0.996	3.098	1.277	3.111	1.039	3.137	0.722	3.151	0.347	3.159	0.097	3.164	-0.129
3.179	-0.403	3.187	-0.689	3.194	-0.926	3.214	-1.176	3.222	-1.503	3.229	-1.634	3.237	-1.741	3.250	-1.878
3.239	-1.684	3.236	-1.492	3.229	-1.374	3.221	-1.195	3.220	-1.067	3.218	-0.933	3.217	-0.730	3.211	-0.409
3.217	-0.214	3.222	0.065	3.217	0.334	3.217	0.542	3.217	0.797	3.216	0.971	3.222	1.087	3.232	0.867
3.241	0.652	3.251	0.513	3.265	0.670	3.278	0.500	3.283	0.327	3.292	0.158	3.296	0.035	3.299	-0.099
3.308	-0.273	3.313	-0.405	3.328	-0.582	3.325	-0.714	3.333	-0.878	3.345	-1.035	3.342	-0.814	3.361	-1.046
3.371	-1.221	3.383	-1.366	3.376	-1.149	3.365	-0.929	3.362	-0.766	3.359	-0.637	3.358	-0.439	3.352	-0.282
3.350	-0.100	3.348	0.106	3.348	0.328	3.341	0.521	3.341	0.797	3.337	0.989	3.337	1.156	3.337	1.305
3.340	1.468	3.344	1.254	3.345	1.050	3.351	0.850	3.357	0.667	3.373	0.440	3.378	0.262	3.387	0.057
3.396	-0.068	3.407	-0.038	3.407	-0.147	3.412	-0.260	3.421	-0.375	3.425	-0.502	3.431	-0.640	3.438	-0.748
3.449	-0.778	3.455	-0.650	3.457	-0.504	3.455	-0.344	3.449	-0.214	3.451	-0.069	3.452	0.114	3.450	0.280
3.457	0.492	3.466	0.264	3.481	0.091	3.484	0.392	3.487	0.602	3.501	0.395	3.507	0.230	3.514	0.068
3.524	-0.084	3.530	-0.253	3.536	-0.384	3.549	-0.558	3.551	-0.400	3.547	-0.257	3.547	-0.096	3.547	0.068
3.556	0.199	3.567	0.065	3.575	-0.053	3.584	0.130	3.590	0.318	3.599	0.180	3.604	0.026	3.609	-0.095
3.616	-0.164	3.626	-0.147	3.628	-0.214	3.633	-0.271	3.637	-0.349	3.645	-0.443	3.645	-0.310	3.645	-0.152
3.645	-0.006	3.648	0.139	3.654	0.018	3.660	-0.095	3.668	0.086	3.670	0.265	3.667	0.435	3.666	0.595
3.678	0.443	3.690	0.284	3.699	0.108	3.708	-0.053	3.719	-0.186	3.728	-0.080	3.736	-0.173	3.742	-0.278
3.756	-0.412	3.765	-0.222	3.778	-0.052	3.769	0.105	3.781	0.205	3.789	0.425	3.805	0.338	3.819	0.170
3.828	0.045	3.834	-0.097	3.838	-0.213	3.841	-0.323	3.850	-0.422	3.862	-0.379	3.866	-0.404	3.867	-0.303
3.870	-0.152	3.875	-0.057	3.888	-0.167	3.889	-0.019	3.889	0.164	3.889	0.349	3.898	0.521	3.912	0.414
3.918	0.286	3.926	0.157	3.930	0.031	3.935	-0.088	3.945	-0.125	3.950	-0.201	3.954	-0.243	3.963	-0.110
3.975	-0.184	3.978	0.012	3.979	0.134	3.982	0.204	4.005	-0.243	4.015	0.275	4.041	-0.005	4.051	0.032
4.062	-0.061	4.073	0.026	4.079	-0.001	4.090	0.065	4.103	0.040	4.115	0.091	4.123	-0.039	4.130	-0.169
4.136	-0.318	4.144	-0.166	4.143	0.025	4.159	-0.152	4.162	0.036	4.170	0.245	4.170	0.379	4.186	0.174
4.196	0.025	4.211	0.217	4.219	0.069	4.224	-0.075	4.237	-0.217	4.247	-0.368	4.255	-0.538	4.262	-0.706
4.262	-0.459	4.262	-0.271	4.258	-0.113	4.256	0.070	4.258	0.201	4.278	0.018	4.283	0.286	4.281	0.483
4.285	0.586	4.301	0.262	4.307	0.110	4.313	-0.031	4.333	-0.114	4.339	0.017	4.353	0.143	4.363	-0.077
4.374	-0.308	4.384	-0.474	4.388	-0.279	4.376	-0.119	4.383	-0.001	4.387	0.077	4.403	-0.039	4.419	0.165
4.432	0.313	4.442	0.201	4.448	0.061	4.456	-0.090	4.462	-0.191	4.473	0.053	4.485	-0.134	4.487	-0.261
4.501	-0.447	4.506	-0.183	4.504	-0.010	4.511	0.180	4.525	0.058	4.541	0.200	4.565	0.038	4.569	-0.086
4.579	-0.166	4.589	-0.227	4.600	-0.001	4.610	-0.062	4.637	0.253	4.650	0.075	4.651	-0.031	4.662	-0.158

										4.708	0.244	4.800	0.225	4.615	0.092
										4.871	-0.188	4.870	0.019	4.883	0.236
										4.933	0.073	4.939	-0.047	4.947	-0.212
										5.039	0.097	5.080	0.074	5.061	0.101
										5.116	0.047	5.120	0.195	5.143	0.103
										5.253	-0.195	5.240	0.042	5.261	0.205
										5.369	0.001	5.379	0.151	5.385	0.355
5.402	0.262	5.424	0.073	5.429	0.009	5.432	-0.090	5.445	-0.224	5.453	0.001	5.480	-0.293	5.484	-0.100
5.502	0.086	5.516	0.077	5.525	0.381	5.538	0.218	5.548	0.065	5.559	-0.113	5.569	-0.061	5.600	-0.227
5.607	-0.053	5.613	0.206	5.627	0.184	5.637	0.244	5.655	0.055	5.669	-0.101	5.679	-0.230	5.689	-0.352
5.698	-0.068	5.722	0.313	5.748	0.219	5.768	-0.040	5.799	-0.420	5.803	0.032	5.806	0.267	5.826	0.105
5.841	0.121	5.856	0.019	5.878	-0.101	5.876	0.179	5.897	-0.018	5.912	0.060	5.939	-0.132	5.945	0.039
5.977	-0.222	5.971	-0.010	5.980	0.127	6.003	0.003	6.016	0.083	6.031	0.103	6.043	-0.017	6.057	-0.091
6.066	-0.121	6.076	0.038	6.089	0.092	6.099	0.048	6.111	0.022	6.124	0.057	6.138	-0.066	6.149	-0.013
6.171	-0.210	6.179	-0.042	6.196	0.209	6.205	0.287	6.218	0.090	6.225	-0.064	6.236	-0.190	6.247	-0.074
6.261	-0.105	6.273	0.022	6.288	-0.056	6.308	0.161	6.321	0.132	6.333	0.026	6.345	0.018	6.359	-0.051
6.368	-0.166	6.385	0.087	6.400	-0.003	6.417	0.214	6.436	-0.035	6.447	-0.245	6.470	0.093	6.489	-0.001
6.504	0.155	6.522	0.001	6.534	-0.062	6.550	-0.008	6.564	-0.068	6.588	0.057	6.592	-0.005	6.599	-0.035
6.620	0.051	6.634	-0.039	6.646	0.060	6.648	0.021	6.663	0.035	6.679	-0.038	6.701	0.058	6.728	-0.209
6.734	0.062	6.746	0.093	6.634	0.014	6.710	0.116	6.728	-0.064	6.740	-0.175	6.759	0.008	6.778	-0.088
6.789	0.073	6.799	0.061	6.814	0.274	6.818	0.119	6.836	-0.204	6.846	0.109	6.863	-0.019	6.885	-0.083
6.909	0.167	6.930	-0.165	6.948	0.160	6.974	-0.169	6.987	0.135	7.010	-0.005	7.026	0.064	7.041	-0.058
7.086	0.148	7.105	-0.052	7.126	-0.118	7.144	-0.070	7.153	-0.084	7.186	0.195	7.198	0.100	7.213	-0.136
7.229	-0.381	7.233	-0.165	7.235	0.071	7.243	0.174	7.272	0.009	7.289	0.169	7.298	-0.025	7.307	-0.175
7.342	0.123	7.364	-0.201	7.388	0.083	7.398	-0.051	7.422	0.144	7.439	0.042	7.463	0.019	7.464	-0.042
7.471	-0.103	7.487	0.090	7.519	-0.174	7.536	-0.009	7.541	-0.036	7.564	0.369	7.578	0.014	7.611	-0.271
7.610	-0.384	7.625	-0.084	7.629	0.003	7.655	0.108	7.669	0.032	7.690	0.136	7.706	-0.043	7.726	-0.105
7.743	-0.096	7.768	0.056	7.782	0.036	7.795	0.082	7.819	-0.101	7.827	0.060	7.847	-0.087	7.857	-0.074
7.866	-0.136	7.878	0.091	7.885	0.248	7.904	0.108	7.913	0.060	7.922	0.095	7.932	0.019	7.942	-0.064
7.950	-0.099	7.959	-0.110	7.972	-0.082	7.985	-0.032	8.009	0.135	8.022	0.113	8.037	0.019	8.046	-0.052
8.059	-0.038	8.068	-0.056	8.081	0.001	8.095	0.147	8.109	0.035	8.121	-0.082	8.132	-0.018	8.140	-0.035
8.148	-0.026	8.165	-0.100	8.174	0.178	8.201	-0.121	8.217	0.003	8.225	-0.022	8.245	0.153	8.257	0.043
8.267	-0.038	8.279	-0.045	8.301	-0.125	8.304	0.012	8.306	0.119	8.330	-0.030	8.336	0.142	8.350	-0.039
8.359	-0.149	8.367	-0.209	8.374	-0.027	8.376	0.123	8.399	-0.017	8.401	-0.036	8.408	-0.017	8.416	-0.023
8.436	0.080	8.451	0.009	8.463	0.066	8.479	-0.065	8.492	-0.242	8.500	-0.055	8.505	0.140	8.529	0.061
8.540	0.086	8.565	-0.060	8.585	-0.236	8.588	-0.034	8.590	0.223	8.620	-0.025	8.629	0.106	8.650	-0.043
8.669	-0.187	8.690	0.130	8.711	0.092	8.727	0.122	8.750	-0.035	8.766	-0.232	8.792	0.026	8.808	0.005
8.823	0.210	8.846	-0.003	8.861	-0.061	8.875	0.018	8.887	-0.095	8.897	-0.196	8.918	0.048	8.940	0.148
8.956	0.040	8.976	-0.247	8.988	-0.012	9.005	0.114	9.024	0.061	9.034	-0.044	9.049	-0.165	9.068	-0.017
9.079	-0.032	9.092	0.195	9.112	0.135	9.121	0.022	9.129	-0.091	9.135	-0.162	9.151	-0.003	9.162	-0.071
9.173	-0.197	9.180	0.001	9.186	0.156	9.200	0.144	9.212	0.057	9.219	0.017	9.227	-0.005	9.237	-0.103
9.250	0.042	9.262	0.009	9.273	0.093	9.288	0.009	9.303	-0.173	9.319	0.074	9.336	0.004	9.353	0.105
9.365	-0.008	9.383	-0.175	9.408	0.075	9.414	0.058	9.431	0.070	9.445	0.017	9.458	-0.042	9.474	-0.031
9.487	-0.038	9.502	0.016	9.519	-0.025	9.544	0.064	9.562	0.030	9.579	-0.014	9.593	0.045	9.614	-0.070
9.643	0.022	9.652	0.006	9.666	0.012	9.676	-0.029	9.690	-0.038	9.709	0.209	9.723	0.101	9.731	-0.014
9.742	-0.122	9.753	-0.170	9.770	0.064	9.788	-0.095	9.807	0.106	9.828	0.030	9.846	-0.042	9.859	-0.009
9.877	0.001	9.882	0.044	9.895	-0.012	9.915	0.049	9.929	0.030	9.942	-0.004	9.958	-0.040	9.968	-0.030
9.978	-0.039	9.990	0.045	10.009	0.065	10.028	0.014	10.051	-0.082	10.078	0.027	10.096	0.036	10.108	0.008
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2. "A Time Domain Study of the Attenuation of 10-Hz Waves in the New Madrid Seismic Zone," by Otto W. Nuttli, Bulletin, Seismological Society of America, Vol. 68, April 1978, pp. 343-356.

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4. "On the Relation Between MM Intensity and Body-Wave Magnitude," by Otto W. Nuttli, G.A. Bollinger, and Donald W. Griffiths (submitted to Bulletin, Seismological Society of America), 1978.

5. "Computer Programs in Earthquake Seismology, Volume 1: General Programs," edited by Robert B. Herrmann, Department of Earth and Atmospheric Sciences, Saint Louis University, September 1978.

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