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A Fortran Program for Computing the Power Response of a Hydrophone Array to a Spherical Wave and Plotting it as an Isometric Surface

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FOREWORD

The documentation of computer programs requires a careful explanation of the various aspects of each program. The Research Computation Center of NRL has a desirable and recommended format for reporting computer programs. This report follows that format.

The author thanks his coworkers in the Signal Processing Branch, Acoustics Division, and the members of the Research Computation Center for their encouragement, cooperation, suggestions, and advice.

ABSTRACT

PLOTBEAM is a Fortran program designed to simulate the power response of an arbitrary, focused hydrophone array to an incoming spherical wave whose source is at some predetermined distances. It is used with a three-dimensional plot routine to display output values as a response surface. The program is useful in the study of response dependence on such factors as focal direction and distance, delays due to hydrophone positioning, signal frequency, and hydrophone weighting.

PROBLEM STATUS

This is a final report on one phase of the NRL Problem.

AUTHORIZATION

NRL Problem S01-39
Project RF 05-552-403, Task 4069

Manuscript submitted January 21, 1972

A FORTRAN PROGRAM FOR COMPUTING THE POWER RESPONSE OF A HYDROPHONE ARRAY TO A SPHERICAL WAVE AND PLOTTING IT AS AN ISOMETRIC SURFACE

1. IDENTIFICATION

1.1 Title

Hydrophone Array Power Response to a Spherical Wave

1.2 Identification Name

T3-NRL-PLØTBEAM

1.3 Classification Code

T3 - Applications and Application-Oriented Programs, Other Physical Sciences

1.4 NRL-Research-Computation-Center Identification Number

T3002Ø00

1.5 Entry Points

PLØTBEAM

1.6 Programming Language

Language: 3600/3800 Fortran

Routine Type: Main program

Operating System: DRUM SCOPE 2.0

1.7 Computer and Configuration

CDC 3800

1.8 Contributor or Programmer

Leon P. LaLumiere, Jr., Code 8144, Signal Processing Branch, Acoustics Division (the program is based on the original of J.W. Jenkins, Code 8144, cited as Ref. 1 in Section 3.15)

1.9 Contributing Organization

Naval Research Laboratory (NRL), Washington, D.C. 20390

1.10 Program Availability

1.10.1 Submittal: Program write-up, Fortran source deck, and the source listing

1.10.2 On File: Program library of the NRL Research Computation Center

1.11 Verification

This program has been used and tested as discussed in Section 7.

1.12 Date

1 September 1970

2. PURPOSE

2.1 Description of the Routine

PLOTBEAM calculates the power response of an arbitrary, focused hydrophone array to an incoming spherical wave whose source is at some predetermined distances and angles. These calculations are then used to produce plotting commands for use by the subroutine cited as Ref. 2 in Section 3.15 in making an isometric response surface.

2.2 Problem Background

Many sonar systems use a beamformed array of receptors as their primary sensor. An array of receptors is the most convenient means of sampling a large-scale, long-wavelength, extended field. Since the individual receptors of a large array cannot be moved, control of the array directional sensitivity must be introduced through processing of their output signals. The beamformer performs this task by altering the relative delays and amplitudes of individual receptor outputs before summing them to form an array output.

The computer program described herein was developed to provide visual aid in acquiring insight into the response of a beamformed array of hydrophones to a special wave. In particular the effect of a parameter such as focal direction and distance, hydrophone position, frequency, or hydrophone weighting on array response can be easily seen.

The basic geometric variables involved in array response to an incoming spherical wave are shown in Fig. 1. A brief discussion of the mathematics of array processing is presented in Section 4.

References are listed in Section 3.15. Extended discussion of array processing are presented in Refs. 3 and 4. The analysis and conclusions based on the results of this program are given in Ref. 5. This report has a companion in Ref. 6.

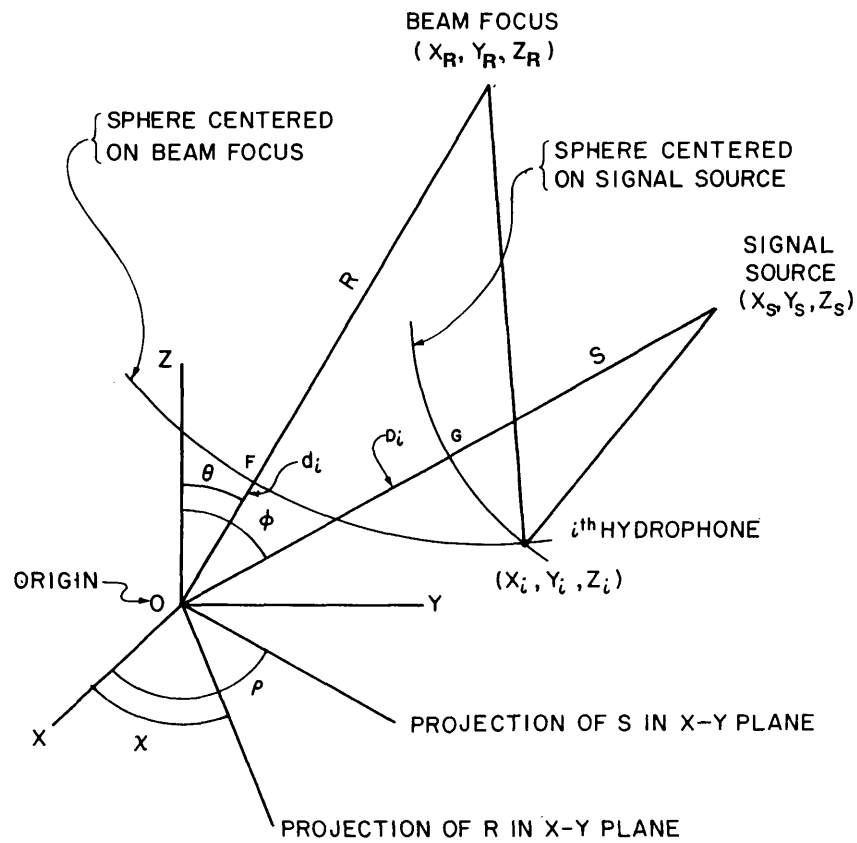

Fig. 1—Basic geometric variables

3. USAGE

3.1 Calling Sequence or Operational Procedure

Since PLOTBEAM is a complete program, the insertion of data cards along with the necessary control cards is the only requirement. The data cards control the program.

3.2 Arguments, Parameters, and Initial Conditions

The following parameters must be punched on data cards (Section 3.9 gives the formats:

LUN1 = storage unit for the response calculations. (This may be the drum or magnetic tape as desired.)

LUN2 = storage unit for the plotting commands. (LUN1 and LUN2 must be integer numbers in the range 1-49.)

C = speed of sound in water

NHYDRØ = number of hydrophones in the array

FREQMN = minimum frequency

FREQMX = maximum frequency (may be left blank)

DFREQ = increment in frequency (may be left blank)

R(1,1) = minimum theta

R(1,2) = maximum theta (may be left blank)

N(1) = number of increments in theta (leave blank if R(1,2) is blank)

R(2,1) = minimum chi

R(2,2) = maximum chi (may be left blank)

N(2) = number of increments in chi (leave blank if R(2,2) is blank)

R(3,1) = minimum phi

R(3,2) = maximum phi (may be left blank)

N(3) = number of increments in phi (leave blank if R(3,2) is blank)

R(4,1) = minimum rho

R(4,2) = maximum rho (may be left blank)

N(4) = number of increments in rho (leave blank if R(4,2) is blank)

R(5,1) = minimum beam focal distance

R(5,2) = maximum beam focal distance (may be left blank)

R(5,3) = increment size for beam focal distance (leave blank if R(5,2) is blank)

N(5) = if blank, beamfocal distance is assumed to be measured in feet. If nonzero, it is assumed to be measured in nautical miles

R(6,1) = minimum signal source distance

R(6,2) = maximum signal source distance (may be left blank)

R(6,3) = increment size for signal source distance (leave blank if R(6,2) is blank)

N(6) = statement as to whether the signed source distance is in feet or nautical miles (if blank, the distance is assumed to be measured in feet; if nonzero, the distance is assumed to be measured in nautical miles)

X, Y, Z = coordinates of each hydrophone

W = weighting of each hydrophone (if blank, the weighting is assumed to be 1)

XZERØ = horizontal distance in inches to the lower left-hand corner of the plot from the plot origin

YZERØ = vertical distance in inches to the lower left-hand corner of the plot from the plot origin

DELTAX = horizontal separation of data points in inches

DELTAY = vertical separation of horizontal cuts in inches

SLANT = horizontal offset in inches of adjacent horizontal cuts

HIDDEN = instruction concerning hidden points (if > 0, hidden points are to be plotted; if $\leqslant 0$, hidden points are not to be plotted)

SCALE = multiplying factor giving the desired height of the plots, since $0 \leqslant$ response $\leqslant 1$

3.3 Space Required (Decimal and Octal)

3.3.1 Unique Storage: 24502 octal or 10562 decimal locations

3.3.2 Common Blocks:

CØMMØN NHYDRØ, WAVE, NSCALE, W(401), X(400), Y(400), Z(400), SP(650), SP(650), CP(650), SR(650), XB(1), YB(1), ZB(1), XS(1), YS(1), ZS(1), RB(400), DELRB(400), RS(400), DELRS(400), NH, CR(650), BMIN(1), SMIN(1), LUN1, LUN2, DATATAB(650), NR, SCALE, NUMX

3.3.3 Temporary Storage: Results of the calculations are stored on the drum or magnetic tape as desired. Plotting commands are stored on the drum or magnetic tape as desired.

3.4 Messages and Instructions to the Operator

None

3.5 Error Returns, Messages, and Codes

A message is printed if neither phi nor rho is incremented.

3.6 Informative Messages to the User

The following are listed:

- All input data along with computed increments
- All distances for which calculations are made
- A statement that measurements are made in feet (or meters) or are made in nautical miles
- The largest computation multiplied by 1 million in decimal and octal
- The number of records for plotting purposes in decimal and octal
- The plotting parameters used in subroutine PLØTISØM
- The identifying number of each storage unit

3.7 Input

The input consists of data cards containing the parameters listed in Section 3.2 and illustrated in Section 3.9.

3.8 Output

The output is given in Section 3.6. All plotting commands can be placed on a magnetic tape for off-line plotting (and is recommended). All computations can be placed on a magnetic tape if desired.

3.9 Formats

Example of an Input Data Deck

CARD*	Data in Various Columns on the Cards								
	1-6	10	13-17	20	26-29	36-40	46-49	55-58	66-68
1		1		2					
2	4900.0								
3		8							
4	490.0								
5	90.0								
6	90.0								
7	90.0								
8	0.0		180.0			629			
9	50.0								
10	20.0		80.0		1.0				
NHYDRØ	17.5		0.0		0.0				
	12.5		0.0		0.0				
	7.5		0.0		0.0				
	2.5		0.0		0.0				
	−2.5		0.0		0.0				
	−7.5		0.0		0.0				
	−12.5		0.0		0.0				
	−17.5		0.0		0.0				
Last	1.0		1.0		0.02	0.05	0.05	−0.1	4.0

*See footnotes on following page.

*The cards contain data as follows (defined in Section 3.2):

CARD 1	= LUN1, LUN2 (in 2I10)
CARD 2	= C (in F10.3)
CARD 3	= NHYDRØ (in I10)
CARD 4	= FREQMN (in 3F10.3)
CARD 5	= R(1,1) (in 3F10.3,I10)
CARD 6	= R(2,1) (in 3F10.3, I10)
CARD 7	= R(3,1) (in 3F10.3, I10)
CARD 8	= R(4,1), R(4,2), N(4) (in 3F10.3,I10)
CARD 9	= R(5,1) (in 3F10.3,I10)
CARD 10	= R(6,1), R(6,2), R(6,3) (in 3F10.3,I10)
NHYDRØ CARDS	= X, Y, Z, W (in 4F10.3)
LAST CARD	= XZERØ, YZERØ, DELTAX, DELTAY, SLANT, HIDDEN, SCALE (in 7F10.3)

3.10 External Routines and Symbols

DATAGETR
WEIGHT
BEAMFOCI
PHASE
ØUTPUT
SIGRANGE
CALC
PLØTS
PLØTISØM
STØPPLØT
SINF
CØSF
SQRTF
PLØT

3.11 Timing

The compile time is 59 seconds; the running time is approximately 0.3 second per hydrophone per line of plot using 629 angular increments.

3.12 Accuracy

The accuracy is variable, depending on the input data; it is also limited by the accuracy of the plotter: 0.01 inch.

3.13 Cautions to Users

The control of this program depends on the optical use of incremental parameters at the discretion of the user. The maximum number of angular increments is 629. The maximum number of hydrophones is 400. At least one of the angles must be incremented (usually rho). For off-line plotting at the Research Computation Center, the plotting tape must be recorded at low density (200 bits/in.).

3.14 Program Deck Structure

7
9 JØB card

7/9 EQUIP card
7/9 EQUIP card } for magnetic tapes (optional)

7/9 FTN card

program PLØTBEAM
subroutine WEIGHT
subroutine BEAMFØCI
subroutine PHASE
subroutine SIGRANGE
subroutine CALC
subroutine ØUTPUT
subroutine DATAGETR
subroutine PLØTISØM (J5-NRL-PLØTISØM)
SCØPE card

7/9 LØAD card

7/9 RUN card

data cards

77/88 EØF card

3.15 References—Literature

(1) James Jenkins, "Program to Compute Array Response Surfaces," NRL Memorandum Report 2077, Sept. 1969

(2) Henry A. Brown, "A CDC 3800 Computer Subroutine for Producing Isometric Plots on the 565 CalComp Plotter," NRL Computer Note 31, 1 Aug. 1969

(3) Edward C. Jordan and K.G. Balmain, "Electromagnetic Waves and Radiating Systems," 2nd edition, Prentice-Hall, Englewood Cliffs, N.J., 1968

(4) John D. Kraus, "Antennas," McGraw-Hill, New York, 1950

(5) George W. Byram, G.V. Olds, and L.P. LaLumiere, "Array Beamforming Response Studies," NRL Report 7331, Oct. 1971.

(6) Leon P. LaLumiere, Jr., "A Fortran Program for Computing the Power Response of an Hydrophone Array to a Plane Wave and Plotting It as an Isometric Surface," NRL Report 7392, 17 April 1972

4. METHOD OF ALGORITHM

In Fig. 1 the geometry is as follows:

R = distance from the origin to the beam focus = R(5,J),

S = distance from the origin to the signal source = R(6,J),

d_i = distance from the origin to point F on R,

D_i = distance from the origin to point G on S.

For an array of n hydrophones the power response is $P = A^2$, where the amplitude is defined by

$$A = \left(\sqrt{(R_E)^2 + (I_M)^2}\right) \Big/ \sum_{i=1}^{n} W_i,$$

in which

$$R_E = \sum_{i=1}^{n} W_i \cos \left[2\pi \frac{f}{c} (D_i - d_i)\right]$$

and

$$I_M = \sum_{i=1}^{n} W_i \sin \left[2\pi \frac{f}{c} (D_i - d_i)\right].$$

Here W_i is the weighting of the ith hydrophone, f is the frequency, and c is the speed of sound in water. D_i determines the delay due to the signal source, and d_i determines the delay due to the beam focus; these are defined by

$$D_i = S - \sqrt{(x_i - x_S)^2 + (y_i - y_S)^2 + (Z_i - Z_S)^2}$$

and

$$d_i = R - \sqrt{(x_i - x_R)^2 + (y_i - y_R)^2 + (Z_i - Z_R)^2},$$

in which

y_i, y_i, Z_i = coordinates of the ith hydrophone,

y_S, y_S, Z_S = coordinates of the signal source,

x_R, y_R, Z_R = coordinates of the beam focus,

and

$$
\begin{aligned}
x_S &= S \sin \phi \cos \rho, \\
y_S &= S \sin \phi \cos \rho, \\
Z_S &= S \cos \phi, \\
x_R &= R \sin \theta \cos \chi, \\
y_R &= R \sin \theta \sin \chi, \\
Z_R &= R \cos \theta.
\end{aligned}
$$

The variables are calculated in subroutines as follows: P in DATAGETR, A in ØUTPUT, R_E and I_M in CALC, D_i in SIGRANGE, d_i in PHASE, x_S, y_S, and z_S in SIGRANGE, and x_R, y_R, and z_R in BEAMFØCI. Subroutine WEIGHT sums the hydrophone weightings, and this is used to normalize A in ØUTPUT.

5. SOURCE LANGUAGE LISTING

A listing of the program in the Fortran language is reproduced on the following 12 pages.

```
      PROGRAM PLOTBEAM                                                  A   1
C     IDENT NUMBER - T3002Ø00                                           A   2
C     TITLE - HYDROPHONE ARRAY POWER RESPONSE TO A SPHERICAL WAVE.      A   3
C     IDENT NAME - T3-NRL-PLOTBEAM                                      A   4
C     LANGUAGE - FORTRAN                                                A   5
C     COMPUTER - CDC-3800                                               A   6
C     CONTRIBUTER - LEON P. LA LUMIERE JR., CODE 8144                   A   7
C     (PROGRAM BASED ON THE ORIGINAL OF J. W. JENKINS, CODE 8144)       A   8
C                   SIGNAL PROCESSING BRANCH, ACOUSTICS DIVISION        A   9
C     ORGANIZATION - NRL - NAVAL RESEARCH LABORATORY                    A  10
C                          WASHINGTON, D.C. 20390                       A  11
C     DATE - 1 SEPT 1970                                                A  12
C     PURPOSE - TO CALCULATE THE POWER RESPONSE OF AN HYDROPHONE ARRAY  A  13
C               TO A SPHERICAL WAVE TO BE USED FOR PLOTTING AN ISOMETRIC A  14
C               SURFACE.                                                A  15
C                                                                       A  16
C     .....INPUT DATA DECK. DATA CARDS CAN BE LEFT BLANK AS DESIRED.    A  17
C     ..CARD 1 = LOGICAL UNIT NUMBERS (LUN1), (LUN2), IN (2I10).        A  18
C     LUN1 IS THE STORAGE UNIT FOR THE PLOTTING COMMANDS. PLOTTING      A  19
C     COMMANDS STORED ON MAGNETIC TAPE MUST BE IN LO DENSITY.           A  20
C     LUN2 IS THE STORAGE UNIT FOR THE ARRAY RESPONSE CALCULATIONS.     A  21
C     ..CARD 2 = SPEED OF SOUND, IN (F10.3).                            A  22
C     ..CARD 3 = NUMBER OF HYDROPHONES .LE. 400, IN (I10).              A  23
C     ..CARD 4 = MINIMUM FREQUENCY, MAXIMUM FREQUENCY, INCREMENT, IN    A  24
C     (3F10.3).                                                         A  25
C     ..4 CARDS GIVING ANGULAR PARAMETERS IN DEGREES, IN (3F10.4,I10).  A  26
C     IF INCREMENTS ARE NOT DESIRED N(I) SHOULD BE BLANK OR ZERO. AT    A  27
C     LEAST ONE OF THE SET (N(3), N(4)) SHOULD BE .GE. 2 AND NONE SHOULD A  28
C     EXCEED 629. THEN THE ANGULAR R(I,3) ARE COMPUTED INTERNALLY. IF   A  29
C     R(3,3) OR R(4,3) ARE INCLUDED AS DATA THE CORRESPONDING N(I)      A  30
C     MUST BE BLANK OR ZERO.                                            A  31
C     R(1,1) = MINIMUM THTA, R(1,2) = MAXIMUM THTA, R(1,3) = INCREMENT, A  32
C     N(1) = NUMBER OF INCREMENTS.                                      A  33
C     R(2,1) = MINIMUM CHI, R(2,2) = MAXIMUM CHI, R(2,3) = INCREMENT,   A  34
C     N(2) = NUMBER OF INCREMENTS.                                      A  35
C     R(3,1) = MINIMUM PHI, R(3,1) = MAXIMUM PHI, R(3,3) = INCREMENT,   A  36
C     N(3) = NUMBER OF INCREMENTS.                                      A  37
C     R(4,1) = MINIMUM RHO, R(4,1) = MAXIMUM RHO, R(4,3) = INCREMENT,   A  38
C     N(4) = NUMBER OF INCREMENTS.                                      A  39
C     THTA = ANGLE OF PREFERRED BEAM FOCUS DIRECTION FROM THE Z-AXIS.   A  40
C     CHI  = ANGLE OF PREFERRED BEAM FOCUS DIRECTION FROM THE X-AXIS.   A  41
C     PHI  = ANGLE OF INCIDENT BEAM FOCUS DIRECTION FROM THE Z-AXIS.    A  42
C     RHO  = ANGLE OF INCIDENT BEAM FOCUS DIRECTION FROM THE X-AXIS.    A  43
C     ..2 CARDS GIVING BEAM FOCUS AND SIGNAL SOURCE DISTANCE PARAMETERS A  44
C     IN (3F10.3,I10).                                                  A  45
C     R(5,1) = MINIMUM BEAM FOCUS, R(5,2) = MAXIMUM BEAM FORCUS, R(5,3) A  46
C     = INCREMENT, N(5).                                                A  47
C     R(6,1) = MINIMUM SIGNAL SOURCE DISTANCE, R(6,2) = MAXIMUM SIGNAL  A  48
C     SOURCE DISTANCE, R(6,3) = INCREMENT, N(6).                        A  49
C     IF N(5) .AND. N(6) ARE ZERO THEN THE BEAM FOCUS AND SIGNAL SOURCE A  50
```

```
C     DISTANCE ARE ASSUMED TO BE MEASURED IN FEET. OTHERWISE THEY ARE      A  51
C     MEASURED IN NAUTICAL MILES.                                          A  52
C     ..NHYDRO CARDS, EACH GIVING THE X,Y,Z COORDINATES OF THE             A  53
C     HYDROPHONES AND W, THE WEIGHTING OF EACH HYDROPHONE IF DESIRED,      A  54
C     IN (4F10.3). OTHERWISE W IS ASSUMED TO BE ONE.                       A  55
C     THE FOLLOWING DATA CARD IS REQUIRED FOR SUBROUTINE PLOTISOM.         A  56
C     ..LAST CARD = XZERO, YZERO, DELTAX, DELTAY, SLANT, HIDDEN, SCALE     A  57
C     IN (7F10.3).                                                         A  58
C     SCALE IS A MULTIPLIER GIVING THE DESIRED HEIGHT OF THE PLOTS.        A  59
C     NUMX, NUMY, AND INTERP ARE COMPUTED INTERNALLY BY THE MAIN PROGRAM   A  60
C     SUBROUTINE PLOTISOM IS THE RCC LIBRARY IDENT. NAME J5-NRL-PLOTISOM   A  61
C                                                                          A  62
      DIMENSION AMP(650), R(9,3), N(9), PLTARRAY(254), PEAK(6909)          A  63
      COMMON NHYDRO,WAVE,NSCALE,W(401),X(400),Y(400),Z(400),P(400),SP(65   A  64
     10),CP(650),SR(650),XB(1),YB(1),ZB(1),XS(1),YS(1),ZS(1),RB(400),DEL   A  65
     2RB(400),RS(400),DELRS(400),NH,CR(650),BMIN(1),SMIN(1),LUN1,LUN2,DA   A  66
     3TATAB(650),NR,SCALE,NUMX                                             A  67
      EXTERNAL DATAGETR                                                    A  68
    1 FORMAT (2X,45HHYDROPHONE ARRAY RESPONSE TO A SPHERICAL WAVE//)       A  69
    2 FORMAT (19H  SPEED OF SOUND = ,F10.3/)                               A  70
    3 FORMAT (2X,16HHYDROPHONE ARRAY/)                                     A  71
    4 FORMAT (2X,24HNUMBER OF HYDROPHONES = ,I3,//,7X,1HX,9X,1HY,9X,1HZ,   A  72
     17X,6HWEIGHT/)                                                        A  73
    5 FORMAT (14H  FREQUENCY = ,3F10.3,//,1X,18H ANGULAR VARIABLES/)       A  74
    6 FORMAT (/,2X,43HBEAM FOCAL DISTANCE AND SIGNAL SOURCE RANGE/)        A  75
    7 FORMAT (/,2X,47HTHESE DISTANCES ARE MEASURED IN FEET OR METERS./)    A  76
    8 FORMAT (/,2X,47HTHESE DISTANCES ARE MEASURED IN NAUTICAL MILES/)     A  77
    9 FORMAT (1H1,1X,6HRECORD,4X,4HBEAM,7X,6HSIGNAL/,2X,6HNUMBER,4X,5HFO   A  78
     1CUS,6X,5HRANGE/)                                                     A  79
   10 FORMAT (/,2X,17HLARGEST NUMBER = ,I7,10H OR OCTAL ,O7)               A  80
   11 FORMAT (/,2X,17HNO. OF RECORDS = ,I3,10H OR OCTAL ,O3,11H FOR LUN    A  81
     1= ,I2)                                                               A  82
   12 FORMAT (37H ERROR NEITHER PHI NOR RHO INCREMENT )                    A  83
   13 FORMAT (3I10)                                                        A  84
   14 FORMAT (3F10.3,I10)                                                  A  85
   15 FORMAT (2X,2HR(,I1,6H,J) = ,3F10.3,I10)                              A  86
   16 FORMAT (1H 10F10.3)                                                  A  87
   17 FORMAT (4F10.3)                                                      A  88
   18 FORMAT (3X,I3,3X,F9.1,3X,F9.1)                                       A  89
   19 FORMAT (7F10.3)                                                      A  90
   20 FORMAT (1H1,1X,19HPLOTTING PARAMETERS//2X,9HNUMX    = ,I3/,2X,9HNUM  A  91
     1Y    = ,I3/,2X,9HINTERP = ,I3)                                       A  92
   21 FORMAT (2X,9HXZERO  = ,F6.3/,2X,9HYZERO  = ,F6.3/,2X,9HDELTAX = ,F   A  93
     16.3/,2X,9HDELTAY = ,F6.3/,2X,9HSLANT  = ,F6.3/,2X,9HHIDDEN = ,F6.3   A  94
     2/,2X,9HSCALE  = ,F6.3)                                               A  95
   22 FORMAT (//,2X,7HLUN1 = ,I2,/,2X,7HLUN2 = ,I2)                        A  96
   23 FORMAT (1H1)                                                         A  97
      READ 13, LUN1,LUN2                                                   A  98
      READ 14, C                                                           A  99
      READ 13, NHYDRO                                                      A 100
```

```
      READ 14, FREQMN,FREQMX,DFREQ                                      A 101
      PRINT 1                                                           A 102
      PRINT 2, C                                                        A 103
      PRINT 5, FREQMN,FREQMX,DFREQ                                      A 104
      DO 31 I=1,4                                                       A 105
      READ 14, (R(I,J),J=1,3),N(I)                                      A 106
      IF (N(I)) 24,25,24                                                A 107
   24 T=N(I)-1                                                          A 108
      R(I,3)=(R(I,2)-R(I,1))/T                                          A 109
      GO TO 28                                                          A 110
   25 IF (R(I,3)) 27,26,27                                              A 111
   26 N(I)=1.0                                                          A 112
      GO TO 28                                                          A 113
   27 N(I)=ABS((R(I,2)-R(I,1))/R(I,3))+1.9                              A 114
   28 PRINT 15, I,(R(I,J),J=1,3),N(I)                                   A 115
      DO 29 J=1,3                                                       A 116
      R(I,J)=R(I,J)/57.295778                                           A 117
   29 CONTINUE                                                          A 118
      IF (N(I)) 30,31,31                                                A 119
   30 N(I)=-N(I)                                                        A 120
   31 CONTINUE                                                          A 121
      PRINT 6                                                           A 122
      DO 32 I=5,6                                                       A 123
      READ 14, (R(I,J),J=1,3)                                           A 124
      PRINT 15, I,(R(I,J),J=1,3),N(I)                                   A 125
   32 CONTINUE                                                          A 126
      IF (N(5).EQ.0.AND.N(6).EQ.0) GO TO 34                             A 127
      DO 33 I=5,6                                                       A 128
      DO 33 J=1,3                                                       A 129
   33 R(I,J)=R(I,J)*6076.1033                                           A 130
      PRINT 8                                                           A 131
      GO TO 35                                                          A 132
   34 PRINT 7                                                           A 133
   35 PRINT 23                                                          A 134
      PRINT 3                                                           A 135
      PRINT 4, NHYDRO                                                   A 136
      DO 36 J=1,NHYDRO                                                  A 137
   36 READ 17, X(J),Y(J),Z(J),W(J)                                      A 138
      CALL WEIGHT                                                       A 139
      DO 44 J=1,NHYDRO                                                  A 140
      IF (J-51) 44,43,37                                                A 141
   37 IF (J-101) 44,43,38                                               A 142
   38 IF (J-151) 44,43,39                                               A 143
   39 IF (J-201) 44,43,40                                               A 144
   40 IF (J-251) 44,43,41                                               A 145
   41 IF (J-301) 44,43,42                                               A 146
   42 IF (J-351) 44,43,44                                               A 147
   43 PRINT 23                                                          A 148
      PRINT 4, NHYDRO                                                   A 149
   44 PRINT 16, X(J),Y(J),Z(J),W(J)                                     A 150
```

```
      WAVE=FREQMN/C                                                     A 151
      THTA=R(1,1)                                                       A 152
      CHI=R(2,1)                                                        A 153
      I=0                                                               A 154
      INDEX=4                                                           A 155
      AA=R(3,1)                                                         A 156
      BB=R(4,1)                                                         A 157
      NX=N(3)                                                           A 158
      DO 45 K=1,NX                                                      A 159
      SP(K)=SIN(AA)                                                     A 160
      CP(K)=COS(AA)                                                     A 161
   45 AA=AA+R(3,3)                                                      A 162
      NX=N(4)                                                           A 163
      DO 46 K=1,NX                                                      A 164
      SR(K)=SIN(BB)                                                     A 165
      CR(K)=COS(BB)                                                     A 166
   46 BB=BB+R(4,3)                                                      A 167
      IF (DFREQ) 47,51,48                                               A 168
   47 DFREQ=-DFREQ                                                      A 169
   48 FREQ=FREQMN-DFREQ                                                 A 170
      INDEX=1                                                           A 171
   49 IF (FREQMX-FREQ) 50,86,50                                         A 172
   50 FREQ=FREQ+DFREQ                                                   A 173
      WAVE=FREQ/C                                                       A 174
      GO TO 59                                                          A 175
   51 IF (N(1)-1) 52,55,52                                              A 176
   52 INDEX=2                                                           A 177
      THTA=R(1,1)-R(1,3)                                                A 178
   53 IF (N(1)-I) 86,86,54                                              A 179
   54 THTA=THTA+R(1,3)                                                  A 180
      I=I+1                                                             A 181
      GO TO 59                                                          A 182
   55 IF (N(2)-1) 56,59,56                                              A 183
   56 INDEX=3                                                           A 184
      CHI=R(2,1)-R(2,3)                                                 A 185
   57 IF (N(2)-I) 86,86,58                                              A 186
   58 CHI=CHI+R(2,3)                                                    A 187
      I=I+1                                                             A 188
   59 BMIN=R(5,1)-R(5,3)                                                A 189
      IF (R(5,2)-R(5,1)) 60,86,60                                       A 190
   60 BMIN=BMIN+R(5,3)                                                  A 191
      CALL BEAMFOCI (THTA,CHI)                                          A 192
      CALL PHASE                                                        A 193
      PRINT 9                                                           A 194
      SMIN=R(6,1)-R(6,3)                                                A 195
   61 IF (R(6,2)-SMIN) 86,86,62                                         A 196
   62 SMIN=SMIN+R(6,3)                                                  A 197
      RHO=R(4,1)                                                        A 198
      PHI=R(3,1)                                                        A 199
      IF (N(3)-1) 65,63,76                                              A 200
```

```
63 IF (N(4)-1) 65,64,66                                          A 201
64 PRINT 12                                                      A 202
65 STOP 4                                                        A 203
66 RHO=R(4,1)-R(4,3)                                             A 204
   M=0                                                           A 205
   MN=1                                                          A 206
67 IF (N(4)-M) 68,68,75                                          A 207
68 CALL OUTPUT (N(4),AMP)                                        A 208
   IF (NH-51) 73,72,69                                           A 209
69 IF (NH-101) 73,72,70                                          A 210
70 IF (NH-151) 73,72,71                                          A 211
71 IF (NH-201) 73,72,74                                          A 212
72 PRINT 9                                                       A 213
73 PRINT 18, NH,BMIN,SMIN                                        A 214
74 GO TO (49,53,57,61), INDEX                                    A 215
75 RHO=RHO+R(4,3)                                                A 216
   M=M+1                                                         A 217
   CALL SIGRANGE (PHI,RHO)                                       A 218
   CALL CALC (MN,M,AMP(M))                                       A 219
   GO TO 67                                                      A 220
76 PHI=R(3,1)-R(3,3)                                             A 221
   MN=0                                                          A 222
   M=1                                                           A 223
77 IF (N(3)-MN) 78,78,80                                         A 224
78 IF (5-INDEX) 79,86,79                                         A 225
79 CALL OUTPUT (N(3),AMP)                                        A 226
   GO TO (49,53,57,61,86), INDEX                                 A 227
80 MN=MN+1                                                       A 228
   PHI=PHI+R(3,3)                                                A 229
   IF (N(4)-1) 82,81,82                                          A 230
81 CALL SIGRANGE (PHI,RHO)                                       A 231
   CALL CALC (MN,M,AMP(MN))                                      A 232
   GO TO 77                                                      A 233
82 RHO=R(4,1)-R(4,3)                                             A 234
   INDEX=5                                                       A 235
   M=0                                                           A 236
83 IF (N(4)-M) 84,84,85                                          A 237
84 CALL OUTPUT (N(4),AMP)                                        A 238
   GO TO 77                                                      A 239
85 M=M+1                                                         A 240
   RHO=RHO+R(4,3)                                                A 241
   CALL SIGRANGE (PHI,RHO)                                       A 242
   CALL CALC (MN,M,AMP(M))                                       A 243
   GO TO 83                                                      A 244
86 PRINT 10, NSCALE,NSCALE                                       A 245
   PRINT 11, NH,NH                                               A 246
   END FILE LUN2                                                 A 247
   REWIND LUN2                                                   A 248
   NUMY=NH                                                       A 249
   READ 19, XZERO,YZERO,DELTAX,DELTAY,SLANT,HIDDEN,SCALE         A 250
```

```
      INTERP=DELTAX/0.01-1.                                             A 251
      PRINT 20, NUMX,NUMY,INTERP                                        A 252
      IF (SCALE) 88,87,88                                               A 253
   87 SCALE=1.0                                                         A 254
   88 PRINT 21, XZERO,YZERO,DELTAX,DELTAY,SLANT,HIDDEN,SCALE            A 255
      CALL PLOTS (PLTARRAY,254,LUN1)                                    A 256
      CALL PLOTISOM (XZERO,YZERO,NUMX,NUMY,DELTAX,DELTAY,SLANT,INTERP,HI A 257
     1DDEN,DATAGETR,DATATAB,PEAK)                                       A 258
      XNEW=SLANT*(NUMY-1)+DELTAX*(NUMX-1)                               A 259
      CALL PLOT (XNEW,YZERO,-3)                                         A 260
      CALL PLOTS (0,0)                                                  A 261
      CALL STOPPLOT                                                     A 262
      END FILE LUN1                                                     A 263
      REWIND LUN1                                                       A 264
      REWIND LUN2                                                       A 265
      PRINT 22, LUN1,LUN2                                               A 266
      STOP                                                              A 267
      END                                                               A 268-

      SUBROUTINE WEIGHT                                                 B   1
C     COMPUTES THE SUMMATION OF HYDROPHONE WEIGHTINGS.                  B   2
      COMMON NHYDRO,WAVE,NSCALE,W(401),X(400),Y(400),Z(400),P(400),SP(65 B   3
     10),CP(650),SR(650),XB(1),YB(1),ZB(1),XS(1),YS(1),ZS(1),RB(400),DEL B   4
     2RB(400),RS(400),DELRS(400),NH,CR(650),BMIN(1),SMIN(1),LUN1,LUN2,DA B   5
     3TATAB(650),NR,SCALE,NUMX                                          B   6
      DO 2 I=1,NHYDRO                                                   B   7
      IF (W(I)) 2,1,2                                                   B   8
    1 W(I)=1.0                                                          B   9
    2 W(401)=W(401)+ABS(W(I))                                           B  10
      RETURN                                                            B  11
      END                                                               B  12-

      SUBROUTINE BEAMFOCI (THTA,CHI)                                    C   1
C     COMPUTES THE COORDINATES OF THE BEAM FOCUS.                       C   2
      COMMON NHYDRO,WAVE,NSCALE,W(401),X(400),Y(400),Z(400),P(400),SP(65 C   3
     10),CP(650),SR(650),XB(1),YB(1),ZB(1),XS(1),YS(1),ZS(1),RB(400),DEL C   4
     2RB(400),RS(400),DELRS(400),NH,CR(650),BMIN(1),SMIN(1),LUN1,LUN2,DA C   5
     3TATAB(650),NR,SCALE,NUMX                                          C   6
      XB=BMIN*SIN(THTA)*COS(CHI)                                        C   7
      YB=BMIN*SIN(THTA)*SIN(CHI)                                        C   8
      ZB=BMIN*COS(THTA)                                                 C   9
      RETURN                                                            C  10
      END                                                               C  11-

      SUBROUTINE PHASE                                                  D   1
C     COMPUTES THE HYDROPHONE DELAYS DUE TO THE BEAM FOCUS.             D   2
      COMMON NHYDRO,WAVE,NSCALE,W(401),X(400),Y(400),Z(400),P(400),SP(65 D   3
     10),CP(650),SR(650),XB(1),YB(1),ZB(1),XS(1),YS(1),ZS(1),RB(400),DEL D   4
     2RB(400),RS(400),DELRS(400),NH,CR(650),BMIN(1),SMIN(1),LUN1,LUN2,DA D   5
     3TATAB(650),NR,SCALE,NUMX                                          D   6
```

```
      DO 1 I=1,NHYDRO                                                   D   7
      RBSQ=(X(I)-XB)*(X(I)-XB)+(Y(I)-YB)*(Y(I)-YB)+(Z(I)-ZB)*(Z(I)-ZB)  D   8
    1 RB(I)=SQRT(RBSQ)                                                  D   9
      DO 2 J=1,NHYDRO                                                   D  10
      DELRB(J)=BMIN-RB(J)                                               D  11
    2 P(J)=6.28319*WAVE*DELRB(J)                                        D  12
      RETURN                                                            D  13
      END                                                               D  14-

      SUBROUTINE SIGRANGE (PHI,RHO)                                     E   1
C     COMPUTES THE COORDINATES OF THE SIGNAL SOURCE.                    E   2
      COMMON NHYDRO,WAVE,NSCALE,W(401),X(400),Y(400),Z(400),P(400),SP(65  E   3
     1O),CP(650),SR(650),XB(1),YB(1),ZB(1),XS(1),YS(1),ZS(1),RB(400),DEL  E   4
     2RB(400),RS(400),DELRS(400),NH,CR(650),BMIN(1),SMIN(1),LUN1,LUN2,DA  E   5
     3TATAB(650),NR,SCALE,NUMX                                          E   6
      XS=SMIN*SIN(PHI)*COS(RHO)                                         E   7
      YS=SMIN*SIN(PHI)*SIN(RHO)                                         E   8
      ZS=SMIN*COS(PHI)                                                  E   9
      DO 1 I=1,NHYDRO                                                   E  10
      RSSQ=(X(I)-XS)*(X(I)-XS)+(Y(I)-YS)*(Y(I)-YS)+(Z(I)-ZS)*(Z(I)-ZS)  E  11
    1 RS(I)=SQRT(RSSQ)                                                  E  12
      DO 2 J=1,NHYDRO                                                   E  13
    2 DELRS(J)=SMIN-RS(J)                                               E  14
      RETURN                                                            E  15
      END                                                               E  16-

      SUBROUTINE CALC (MN,M,AP)                                         F   1
C     COMPUTES THE AMPLITUDE DUE TO THE SUMMATION OF ALL DELAYS.        F   2
      COMMON NHYDRO,WAVE,NSCALE,W(401),X(400),Y(400),Z(400),P(400),SP(65  F   3
     1O),CP(650),SR(650),XB(1),YB(1),ZB(1),XS(1),YS(1),ZS(1),RB(400),DEL  F   4
     2RB(400),RS(400),DELRS(400),NH,CR(650),BMIN(1),SMIN(1),LUN1,LUN2,DA  F   5
     3TATAB(650),NR,SCALE,NUMX                                          F   6
      A=0.                                                              F   7
      B=0.                                                              F   8
      DO 1 I=1,NHYDRO                                                   F   9
      ARG=6.28319*WAVE*DELRS(I)-P(I)                                    F  10
      A=A+W(I)*SIN(ARG)                                                 F  11
    1 B=B+W(I)*COS(ARG)                                                 F  12
      AP=SQRT(A*A+B*B)                                                  F  13
      RETURN                                                            F  14
      END                                                               F  15-

      SUBROUTINE OUTPUT (K,A)                                           G   1
C     STORES THE RESPONSE CALCULATIONS IN LUN2.                         G   2
      COMMON NHYDRO,WAVE,NSCALE,W(401),X(400),Y(400),Z(400),P(400),SP(65  G   3
     1O),CP(650),SR(650),XB(1),YB(1),ZB(1),XS(1),YS(1),ZS(1),RB(400),DEL  G   4
     2RB(400),RS(400),DELRS(400),NH,CR(650),BMIN(1),SMIN(1),LUN1,LUN2,DA  G   5
     3TATAB(650),NR,SCALE,NUMX                                          G   6
      DATA (NA=629(0))                                                  G   7
      DIMENSION A(650), NA(650)                                         G   8
```

```
      NUMX=K                                                            G   9
      DO 2 J=1,K                                                        G  10
      A(J)=A(J)/W(401)                                                  G  11
      NA(J)=A(J)*1000000.                                               G  12
      IF (NA(J)-NSCALE) 2,2,1                                           G  13
    1 NSCALE=NA(J)                                                      G  14
    2 CONTINUE                                                          G  15
    3 IF (UNIT,LUN2) 3,4                                                G  16
    4 BUFFER OUT (LUN2,1) (A(1),A(NUMX))                                G  17
      NH=NH+1                                                           G  18
      RETURN                                                            G  19
      END                                                               G  20-

      SUBROUTINE DATAGETR                                               H   1
C     INPUTS THE RESPONSE CALCULATIONS FOR USE BY SUBROUTINE PLOTISOM.  H   2
      COMMON NHYDRO,WAVE,NSCALE,W(401),X(400),Y(400),Z(400),P(400),SP(65 H   3
     10),CP(650),SR(650),XB(1),YB(1),ZB(1),XS(1),YS(1),ZS(1),RB(400),DEL H   4
     2RB(400),RS(400),DELRS(400),NH,CR(650),BMIN(1),SMIN(1),LUN1,LUN2,DA H   5
     3TATAB(650),NR,SCALE,NUMX                                          H   6
      BUFFER IN (LUN2,1) (DATATAB(1),DATATAB(NUMX))                     H   7
    1 IF (UNIT,LUN2) 1,2                                                H   8
    2 DO 3 I=1,NUMX                                                     H   9
    3 DATA TAB(I)=DATATAB(I)*DATATAB(I)*SCALE                           H  10
      RETURN                                                            H  11
      END                                                               H  12-

      SUBROUTINE PLOTISOM( XZERO, YZERO, NUMX, NUMY, DELTA X, DELTA Y,  00000100
     1 SLANT, INTERP, HIDDEN, DATA GETR, DATA TAB, PEAK )               00000200
C     IDENT NUMBER - J5003R00                                           00000300
C     TITLE - ISOMETRIC PLOTTING                                        00000400
C     IDENT NAME - J5-NRL-PLOTISOM                                      00000500
C     LANGUAGE - FORTRAN                                                00000600
C     COMPUTER - CDC-3800                                               00000700
C     CONTRIBUTOR - HENRY A. BROWN, CODE 5344                           00000800
C                   TARGET CHARACTERISTICS BRANCH, RADAR DIVISION       00000900
C     ORGANIZATION - NRL - NAVAL RESEARCH LABORATORY                    00001000
C                          WASHINGTON, D.C.  20390                      00001100
C     DATE - 1 AUGUST 1969                                              00001200
C     PURPOSE - TO PLOT THE HORIZONTAL CUTS OF A FUNCTION               00001300
C               OF TWO VARIABLES ONE CUT AT A TIME.                     00001400
C *** THE FOLLOWING PARAMETERS MUST BE SET IN THE CALLING PROGRAM ---   00001500
C                                                                       00001600
C --- XZERO   = HORIZONTAL DISTANCE IN INCHES TO LOWER LEFT HAND CORNER 00001700
C               OF PLOT FROM PLOT ORIGIN                                00001800
C                                                                       00001900
C --- YZERO   = VERTICAL DISTANCE IN INCHES TO LOWER LEFT HAND CORNER   00002000
C               OF PLOT FROM PLOT ORIGIN                                00002100
C                                                                       00002200
C --- NUMX    = NUMBER OF DATA POINTS IN X DIRECTION                    00002300
C                                                                       00002400
```

```
C --- NUMY     = NUMBER OF HORIZONTAL CUTS TO BE PLOTTED
C
C --- DELTA X = HORIZONTAL SEPARATION OF DATA POINTS IN INCHES
C
C --- DELTA Y = VERTICAL SEPARATION OF HORIZONTAL CUTS IN INCHES
C
C --- SLANT    = HORIZONTAL OFFSET IN INCHES OF ADJACENT HORIZONTAL CUTS
C
C --- INTERP   = NUMBER OF LINEARLY INTERPOLATED POINTS TO BE INSERTED
C                BETWEEN DATA POINTS
C
C --- HIDDEN .GT. 0.IF HIDDEN POINTS ARE TO BE PLOTTED
C            .LT. 0.IF HIDDEN POINTS ARE NOT TO BE PLOTTED
C
C --- *DATA GETR* IS A SUBROUTINE WRITTEN BY THE USER AND DECLARED
C                 EXTERNAL IN THE CALLING PROGRAM WHICH TRANSFERS INTO
C                 DATA TAB THE DATA REPRESENTING ONE HORIZONTAL CUT FOR
C                 EACH CALL TO DATA GETR IN SEQUENCE FROM THE FRONT OF
C                 THE PLOT TO THE REAR OF THE PLOT.
C
C --- *DATA TAB* IS THE ARRAY INTO WHICH DATA GETR TRANSFERS ONE
C                HORIZONTAL CUT OF DATA. THIS ARRAY MUST BE DIMENSIONED
C                IN THE CALLING PROGRAM FOR NUMX LOCATIONS.
C
C --- *PEAK* IS A WORK ARRAY USED BY PLOTISOM AND MUST BE DIMENSIONED
C            IN THE CALLING PROGRAM FOR ( NUMX -1) *INTERP + NUMX
C            LOCATIONS
C
      DIMENSION DATA TAB(1), PEAK(1)
      EXTERNAL DATA GETR
      ASSIGN 220 TO IJP
      ASSIGN 32 TO IJK
      IF( HIDDEN .GT. 0. ) ASSIGN 210 TO IJP
      LMCK = 2 * INTERP
      DIX = DELTAX /( INTERP + 1.)
      NSLANT = INTF( SLANT / DIX )
      DZX = DIX * NSLANT
      NUBX = ( NUMX -1 )* INTERP + NUMX
      LM5 = NUBX - NSLANT
      LM6 = LM5 +1
      LM7 = NUMX / 2
      LM8 = NUBX / 2
      XZ = XZERO - DZX    $    YZ = YZERO - DELTAY
      DO 1 I = 1, NUBX
  1   PEAK(I) = -.52
      IFLAGD = -1
COMMENCE HORIZONTAL CUT LOOP
      DO 22 IY = 1, NUMY
      IFLAGD = -1 * IFLAGD
      YZ = YZ + DELTAY
```

```
      X2 = XZ = XZ + DZX                                                00007500
      CALL DATA GETR                                                    00007600
      GO TO IJK,( 30, 32 )                                              00007700
C *** PREPARE FOR NEG X DIRECTION PLOTTING                              00007800
   30 X2 = ( NUMX -1 )* DELTAX + XZ                                     00007900
      DELTAX = -1.* DELTAX                                              00008000
      DIX = -1.* DIX                                                    00008100
      LL = NUMX +1                                                      00008200
      DO 31 I = 1, LM7                                                  00008300
      LL = LL -1                                                        00008400
      TT = DATA TAB(I)                                                  00008500
      DATA TAB(I) = DATA TAB(LL)                                        00008600
      DATA TAB(LL) = TT                                                 00008700
   31 CONTINUE                                                          00008800
      ASSIGN 32 TO IJK                                                  00008900
      ASSIGN 19 TO JP1                                                  00009000
      ASSIGN 21 TO JP2                                                  00009100
      ASSIGN 16 TO JP3                                                  00009200
      GO TO 33                                                          00009300
   32 ASSIGN 30 TO IJK                                                  00009400
      ASSIGN 16 TO JP1                                                  00009500
      ASSIGN 19 TO JP2                                                  00009600
      ASSIGN 21 TO JP3                                                  00009700
   33 Y2 = DATA TAB(1) + YZ                                             00009800
      YPK = PEAK(1)                                                     00009900
      IF( Y2 .GT. PEAK(1) ) GO TO 2                                     00010000
      IFLAG2 = -1                                                       00010100
      GO TO 200                                                         00010200
    2 IFLAG2 = 1                                                        00010300
      PEAK(1) = Y2                                                      00010400
  200 IF( IFLAGD .LT. 0 ) GO TO 201                                     00010500
      IF( Y2 .LE. YZ ) GO TO 203                                        00010600
      IF( Y2 .LE. YPK ) GO TO 203                                       00010700
      Y3 = YZ                                                           00010800
      IF( YPK .GT. YZ ) Y3 = YPK                                        00010900
      GO TO 202                                                         00011000
  201 IF( Y2 .LE. YZ ) GO TO 203                                        00011100
      Y3 = YZ                                                           00011200
  202 CALL PLOT( X2, Y3, 3 )                                            00011300
      CALL PLOT( X2, Y2, 2 )                                            00011400
  203 CALL PLOT( X2, Y2, 3 )                                            00011500
COMMENCE PLOTTING OF SINGLE HORIZONTAL CUT                              00011600
      DO 15 IX = 2, NUMX                                                00011700
      YP = Y1 = Y2    $   XL = 0.                                       00011800
      XA = XP = X1 = X2                                                 00011900
      X2 = X2 + DELTAX                                                  00012000
      Y2 = DATA TAB(IX) + YZ                                            00012100
      GO TO IJP,( 210, 220)                                             00012200
C *** PLOT ALL POINTS ( HIDDEN .GT. 0 )                                 00012300
  210 CALL PLOT( X2, Y2, 2 )                                            00012400
```

```
      GO TO 15
C *** DO NOT PLOT HIDDEN POINTS ( HIDDEN .LT. 0 )
  220 LM1 = IX *( INTERP +1 ) - LMCK
      LM2 = LM1 + INTERP -1
      LM3 = LM2 +1
      SS = ( Y2 -Y1 )/ DELTAX
  3   DO 7 I = LM1, LM2
      IFLAG1 = IFLAG2
      XL = XL + DIX    $    XA = XA + DIX
      YL = SS * XL + Y1
      IFLAG2 = -1
      IF( YL .LT. PEAK(I) ) GO TO 34
      PEAK(I) = YL
      IFLAG2 = 1
  34  IFLAGM =IFLAG1 * IFLAG2
      IF( IFLAGM .GT. 0 ) GO TO 6
      IF( IFLAG2 .LT. 0 ) GO TO 5
      CALL PLOT( XA, YL, 3 )
      GO TO 6
  5   CALL PLOT( XP, YP, 2 )
  6   XP = XP + DIX
      YP = YL
  7   CONTINUE
      IFLAG1 = IFLAG2    $    IFLAG2 = -1
      YPK = PEAK(LM3)
      IF( Y2 .LT. YPK ) GO TO 70
      PEAK(LM3) = Y2
      IFLAG2 = 1
      IPEN = 2
      IF( IFLAG1 .LT. 0 ) IPEN = 3
      CALL PLOT( X2, Y2, IPEN )
      GO TO 15
  70  IF( IFLAG1 .LT. 0 ) GO TO 15
      CALL PLOT( XP, YP, 2 )
  15  CONTINUE
      Y3 = YZ
      IF( IFLAGD .LT. 0 ) GO TO 150
      IF( Y2 .GE. YZ ) 152, 153
  150 IF( Y2 .LE. YPK ) GO TO 153
      IF( Y2 .GE. YZ ) 151, 153
  151 IF( YPK .GT. YZ ) Y3 = YPK
  152 CALL PLOT( X2, Y2, 3 )
      CALL PLOT( X2, Y3, 2 )
  153 CONTINUE
      GO TO JP1, ( 16, 19 )
C *** SLIP PEAK TABLE
  16  DO 17 I = 1, LM5
      LM1 = I + NSLANT
  17  PEAK(I) = PEAK(LM1)
      DO 18 I = LM6, NUBX
```

```
      PEAK(I) = -.52                                                    00017500
   18 CONTINUE                                                          00017600
      GO TO JP2,( 19, 21 )                                              00017700
C ***FLIP PEAK TABLE                                                    00017800
   19 LL = NUBX +1                                                      00017900
      DO 20 I = 1, LM8                                                  00018000
      LL = LL -1                                                        00018100
      TT = PEAK(I)                                                      00018200
      PEAK(I) = PEAK(LL)                                                00018300
      PEAK(LL) = TT                                                     00018400
   20 CONTINUE                                                          00018500
      GO TO JP3,( 16, 21 )                                              00018600
   21 IF( DELTAX .LT. 0. ) DELTAX = -1.* DELTAX                         00018700
      IF( DIX .LT. 0. ) DIX = -1.* DIX                                  00018800
   22 CONTINUE                                                          00018900
      END                                                               00019000
```

6. COMPARISON

Except for the companion program of Ref. 6 (Section 3.15), no similar program is available.

7. TEST METHOD AND RESULTS

The input data deck illustrated in Section 3.9 was used in the program, producing the plot shown in Fig. 2 and the printout on the following three pages. In plots such as Fig. 2 the vertical axis defines the power response. The horizontal axes define the direction of the incoming wave; the generality of the program makes any specific labeling arbitrary.

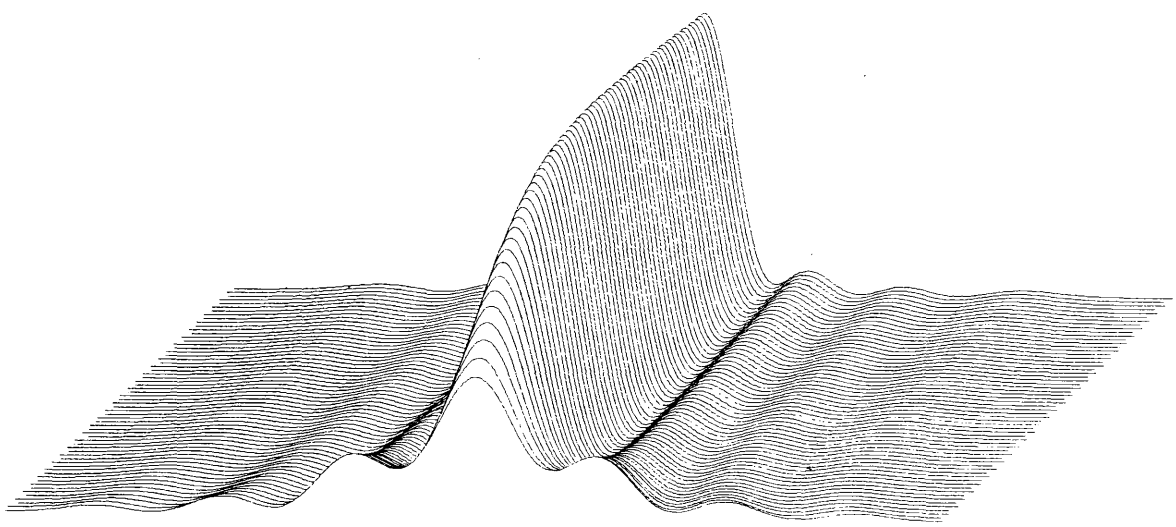

Fig. 2—Plot produced by the input data deck used as an example in Section 3.9

```
HYDROPHONE ARRAY RESPONSE TO A SPHERICAL WAVE

SPEED OF SOUND =    4900.000

FREQUENCY =     490.000     -0.000     -0.000

ANGULAR VARIABLES

R(1,J) =      90.000     -0.000     -0.000          1
R(2,J) =      90.000     -0.000     -0.000          1
R(3,J) =      90.000     -0.000     -0.000          1
R(4,J) =       0.000    180.000      0.287        629

BEAM FOCAL DISTANCE AND SIGNAL SOURCE RANGE

R(5,J) =      50.000     -0.000     -0.000          0
R(6,J) =      20.000     80.000      1.000          0

THESE DISTANCES ARE MEASURED IN FEET OR METERS,


HYDROPHONE ARRAY

NUMBER OF HYDROPHONES =    8

     X          Y          Z        WEIGHT

   17.500      0.000      0.000      1.000
   12.500      0.000      0.000      1.000
    7.500      0.000      0.000      1.000
    2.500      0.000      0.000      1.000
   -2.500      0.000      0.000      1.000
   -7.500      0.000      0.000      1.000
  -12.500      0.000      0.000      1.000
  -17.500      0.000      0.000      1.000
```

RECORD NUMBER	BEAM FOCUS	SIGNAL RANGE
1	50.0	20.0
2	50.0	21.0
3	50.0	22.0
4	50.0	23.0
5	50.0	24.0
6	50.0	25.0
7	50.0	26.0
8	50.0	27.0
9	50.0	28.0
10	50.0	29.0
11	50.0	30.0
12	50.0	31.0
13	50.0	32.0
14	50.0	33.0
15	50.0	34.0
16	50.0	35.0
17	50.0	36.0
18	50.0	37.0
19	50.0	38.0
20	50.0	39.0
21	50.0	40.0
22	50.0	41.0
23	50.0	42.0
24	50.0	43.0
25	50.0	44.0
26	50.0	45.0
27	50.0	46.0
28	50.0	47.0
29	50.0	48.0
30	50.0	49.0
31	50.0	50.0
32	50.0	51.0
33	50.0	52.0
34	50.0	53.0
35	50.0	54.0
36	50.0	55.0
37	50.0	56.0
38	50.0	57.0
39	50.0	58.0
40	50.0	59.0
41	50.0	60.0
42	50.0	61.0
43	50.0	62.0
44	50.0	63.0
45	50.0	64.0
46	50.0	65.0
47	50.0	66.0
48	50.0	67.0
49	50.0	68.0
50	50.0	69.0

RECORD NUMBER	BEAM FOCUS	SIGNAL RANGE
51	50,0	70,0
52	50,0	71,0
53	50,0	72,0
54	50,0	73,0
55	50,0	74,0
56	50,0	75,0
57	50,0	76,0
58	50,0	77,0
59	50,0	78,0
60	50,0	79,0
61	50,0	80,0

LARGEST NUMBER = 1000000 OR OCTAL 3641100

NO. OF RECORDS = 61 OR OCTAL 075 FOR LUN =1

PLOTTING PARAMETERS

```
NUMX   = 629
NUMY   =  61
INTERP =   1
XZERO  =  1,000
YZERO  =  1,000
DELTAX =  0,020
DELTAY =  0,050
SLANT  =  0,050
HIDDEN = -0,100
SCALE  =  4,000
```

```
LUN1 =  1
LUN2 =  2
```

8. REMARKS

This is a final report on one phase of the NRL Problem.

The author thanks his coworkers in the Signal Processing Branch, Acoustics Division, and the members of the Research Computation Center for their encouragement, cooperation, suggestions, and advice.

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13. ABSTRACT

PLOTBEAM is a Fortran program designed to simulate the power response of an arbitrary, focused hydrophone array to an incoming spherical wave whose source is at some predetermined distances. It is used with a three-dimensional plot routine to display output values as a response surface. The program is useful in the study of response dependence on such factors as focal direction and distance, delays due to hydrophone positioning, signal frequency, and hydrophone weighting.

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