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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Interest has arisen in the last few years to develop analytical models of the undersea acoustic environment which are suitable for use on digital computers. To realistically represent the sound-field structure which exists in the ocean, one must consider the variation of sound speed in two dimensions: depth and range. A computer program, TRIMAIN, was written in Fortran IV in which the sound-speed field for a given region is divided into triangular segments of the range-and-depth plane. In each segment the sound-speed field, in terms of $(1/c)^2$, is defined by a linear function of range and depth. The ray paths for this field become parabolic

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19. (Cont'd)

Caustics
Spreading loss
Inhomogeneous media
Multiple profiles
Linear segmented bottom
Calcomp plotting
Computer applications

20. (Cont'd)

trajectories in each triangular segment. All the rays are advanced to a given range at one time, and an interpolation in depth is performed to arrive at the intensity values. Four types of intensity calculations are available: a completely random phase summation, a completely coherent phase summation, a statistical influence over depth, and an average over a convergence zone. Additional output options are ray depth distributions, ray printplots, and Calcomp ray plots, including plots of input sound speeds and of bathymetric profiles.

CONTENTS

HORIZONTAL-GRADIENT ACOUSTICAL RAY-TRACE PROGRAM TRIMAIN

INTRODUCTION

The growth in computer capability over the last 15 years coupled with interest in underwater acoustics has prompted the creation of several computer programs for acoustical ray tracing. For short-range calculation, for which the sound-speed profile can be considered to be the same throughout the given domain and the bottom topography can be considered flat, computation time is conserved by using a single profile program which takes advantage of the periodic form of the ray trajectories, such as the program RTRACE [1]. For long-range acoustical ray tracing, for which the bottom profile as well as the horizontal velocity structure is quite varied, a more general program [2-4] is required. One example of this is the program TRIMAIN, the principal features of which are as follows:

- Acoustic velocity gradients in the sound speed field are accounted for by reading in sound-speed profiles as a function of range and depth. Sound-speed profiles may be introduced at any point in range, and there is no limit to the number which may be used, although each new profile slows the program. A maximum of 50 input and internally generated points are allowed per profile. The sound-speed profiles are assumed to be piecewise linear functions of depth and range. An excellent source of sound-speed-profile data is the NODC tapes [5].
- A variable bottom may be read in as a piecewise linear function of depth, with a maximum of 250 points as the end points of the linear pieces.
- The range-and-depth plane is divided into triangular regions whose vertexes are all initially at ranges equal to the ranges of the endpoints of the linear bottom segments.
- The rays are assumed to be parabolic in each triangle, and it is their intersections with the triangle boundaries that are calculated.
- All the rays are advanced at one time to a given range, rather than tracing one ray at a time all the way to the end of the track.
- Four types of intensity calculation are available: type I random phase summation, type I coherent phase summation, type II (average over depth), and type III (average over convergence zone). Unmodified ray theory is used throughout. (Caustics will be discussed later.)
- The volume attenuation in the medium is assumed to follow a modified Marsh-Schulkin formula.
- Bottom-loss values (in dB), may be entered as a function of grazing angle, one value per degree, or the Marine Geophysical Survey (MGS) bottom-loss values may be used by specifying the class and the range to which that value is to be used.
- A bottom-phase-shift table may be entered for coherent phase calculation if known; it is read in as a value in radians, one value per degree.

Note: Manuscript submitted September 17, 1974.

- The sea surface is represented as a flat, specularly reflecting boundary with a constant user-specified reflection coefficient and a constant phase shift of 180°.
- A source beam pattern may be read in at 1-degree intervals.

Several output options are available:

- A printplot of intensity vs range,
- A printout of intensity vs range values,
- A printplot of the ray trajectories vs range,
- A Calcomp plot of ray trajectories vs range,
- Ray depth distribution at specified ranges,
- A Calcomp plot of the input sound-speed profiles,
- A printplot of the input, or of the input and interpolated, sound-speed profiles,
- An eigenray printout if intensity calculations are performed,
- Punched cards for intensity values or eigenrays.

Up to ten output control cards may be specified.

The calculated results from TRIMAIN have been compared with experimental results, (Appendix B), and good agreement exists between the two.

The time required to run the program depends on a number of factors, such as the number of rays, the number of range increments, and the output requested. A sample case using 81 rays, 200 range increments, one receiver, and two profiles took 7 minutes and 48 seconds.

The core requirement for the program and system routines is 43,503 decimal locations. Also, some sort of deferred printout equipment is required, such as a drum, or the data may be written on tapes and the tapes printed.

The original development [6] of this computer code was due to Mr. Edward L. Wright, who is now at Harvard Observatory, Cambridge, Massachusetts. The author has added a number of features which were not in the original program and has revised certain sections. The funciton of each subroutine will be outlined in this report for the convenience of those individuals who might be interested in modifying the program.

BASIC EQUATIONS

The basic differential equations which are solved in TRIMAIN for ray position and time are:

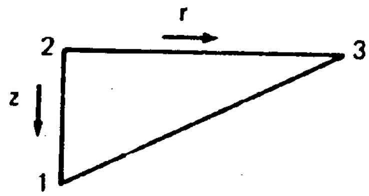
$$n(\vec{r}) = \frac{1}{c(\vec{r})}, \tag{1}$$

$$(d/ds)T = n(\vec{r}), \tag{2}$$

$$(d/ds)\,[n(\vec{r})(d/ds)\vec{r}] = \vec{\nabla} n(\vec{r}). \tag{3}$$

Eq. (1) states that the index of refraction as a function of range is equal to the reciprocal of the sound speed as a function of range. Eq. (2) is the equation for the ray time, where T is time and ds is arc length. Eq. (3) is the Lagrangian equation, where $\vec{\nabla}$ is the Lagrangian; it gives the ray path and accounts for the refraction.

We will now develop an equation for velocity fit. If we have the triangle



where depth is in the 2 → 1 or z direction and range is in the 2 → 3 or r direction, then the following equations hold:

$$\frac{1}{c_3^2} - \frac{1}{c_1^2} = G_r(r_3 - r_1) + G_z(z_3 - z_1), \quad (4)$$

$$\frac{1}{c_2^2} - \frac{1}{c_1^2} = G_r(r_2 - r_1) + G_z(z_2 - z_1), \quad (5)$$

$$\frac{1}{c^2} = \frac{1}{c_1^2} + G_r(r - r_1) + G_z(z - z_1), \quad (6)$$

where G_r is the gradient in the r direction and G_z is the gradient in the z direction. Eq. (6) gives the reciprocal of the sound speed squared at a range r and depth z in the triangle. We will specialize to the case $r_2 = r_1$, because we will always be getting vertical profiles.

TRIMAIN INPUT

Following will be a list describing the data deck of the program TRIMAIN, and for illustration the sample data deck shown in Fig. 1 will be referred to. The Roman numbers itemizing the list are the card group numbers at the right in Fig. 1.

I. *Title (columns 1-80).* In the restarting case, the word RESTART is placed in columns 1-7. If a dump is desired if program runs out of time again, DUMP is placed in columns 9-12.

II. *Source Parameters*

Variable	Columns	Remarks or Meaning
Source depth	1-8	In meters. (In Fig. 1 the source depth is 500 meters.)
Frequency	9-13	In kilohertz (0.05 kHz in Fig. 1)

```
THIS IS THE TITLE FOR THE PROBLEM
500.0  0.050  0.0  0.0  0.0  0.0  0011120  24.0
-15.0  75.0  1.0  1
15.0  15.0  0.25  1
75.0  -15.0  1.0  0
457.0  6
0.0  1.0  2.0  3.0  4.0  5.0  6.0  7.0  8.0  9.0  10.
0.0  7
4.0  5.0  6.0  7.0  8.0  9.0  10.0  11.0  12.0  13.0  14.0
100.0  100.0  1000.0  10001000100  50.0  150.0  250.0  350.0  450.0
5.0  5.0  1000.0  10001003000  50.0  150.0  250.0  350.0  450.0
1.0  1.0  100.0  10100000000  50.0  15u.0  250.0  350.0  450.0
0.0  1.0  1000.0  00000000011  25.0
0.0  501.0  10.0  1000.0  23.5
243.0  4500.0  457.0  4300.0  483.0  2500.0  57.0  4000.0  100.0  5000.0
511.0  4200.0  1000.0  2100.0  -1.0  3800.0  465.0  4800.0  489.0  3100.0
0.0.0  FIRST PROFILE AT RANGE 0.0 KM
0.0  1531.0  20.0  1532.0  50.0
200.0  1516.0  300.0  1513.0  400.0  1529.0  100.0  1520.0  150.0  1517.0
1000.0  1497.0  1250.0  1501.0  1500  1511.0  800.0  1507.0  800.0  1503.0
3000.0  1535.0  4000.0  1553.0  -1.0  1509.0  1750.0  1515.0  2000.0  1518.0
0107.6  SECOND PROFILE AT RANGE 107.6 KM
0.0  1527.0  20.  1527.0  50.0
200.0  1516.0  300.0  1513.0  400.0  1627.0  100.0  1520.0  150.0  1517.
1000.0  1497.0  1250.0  1501.0  1500.0  1611.0  800.0  1507.0  800.0  1503.0
3000.0  1535.0  4000.0  1553.0  -1.0  1609.0  1750.0  1515.0  2000.0  1518.0
01135.4  THIRD PROFILE AT RANGE 1135.4 KM
0.0  1485.0  20.0  1484.0  50.0
200.0  1487.5  300.0  1490.0  400.0  1484.0  100.0  1485.7  150.0  1486.3
1000.0  1501.0  1250.0  1505.0  1500.0  1491.0  600.0  1494.5  800.0  1498.0
3000.0  1536.0  4000.0  1554.0  -1.0  1509.0  1750.0  1514.0  2000.0  1519.0
END OF FILE CARD
END OF FILE CARD
```

Fig. 1 — Sample data deck of the program TRIMAIN

Variable	Columns	Remarks or Meaning
Attenuation switch	14	0 (as in Fig. 1) means no volume attenuation; nonzero means $\alpha = 0.0003025f^2 + 44f^2/(4100 + f^2)$ dB/km, where f is the frequency in kilohertz.
Source level	15-19	Level in decibels (0.0 in Fig. 1)
Beam pattern switch (to be referred to later as ITBP)	20	0 (as in Fig. 1) means no beam pattern; nonzero means the beam pattern will be read in later.
Down tilt	21-25	Tilt of the beam-pattern axis in degrees (0.0 in Fig. 1).
Surface loss	26-30	Surface loss in decibels (0.0 in Fig. 1).
Bottom-loss switch	31	1 means an infinite bottom loss, so that no table will be read in; 0 (as in Fig. 1) means a loss table will be read in later.
Bottom-phase switch (ISCP)	32	1 means a bottom-phase-shift table will be read in; 0 (as in Fig. 1) means no table will be read in.
Curved earth (receiver)	33	1 (as in Fig. 1) means a curved earth correction for the receiver; 0 means no curve.
Curved bottom points	34	1 (as in Fig. 1) means a curved earth correction for the bottom; 0 means no curve.
Plot (Calcomp) profiles	35	2 means input and interpolated profiles are plotted; 1 (as in Fig. 1) means only input profiles are plotted; 0 means no plot.
Printplot profiles	36	1 means printplot-input profiles; 0 means no plot; 2 (as in Fig. 1) means printplot-input and interpolated profiles.
Calcomp plot profiles in kilometers or nautical miles	37	1 means plot nm; 0 (as in Fig. 1) means km.
Plot length	38-45	Calcomp plot length in inches (24.0 inches in Fig. 1).

Variable	Columns	Remarks or Meaning
Bottom-reflection termination (NBRS)	46-50	Maximum number of bottom hits allowed before a ray is terminated; if blank (as in Fig. 1) or 0, 2500 will be used.
Surface-reflection termination (NSRS)	51-55	Maximum number of surface hits allowed before a ray is terminated; if blank (as in Fig. 1) or 0, 2500 will be used.
Loss termination (ALIM)	56-65	Maximum loss allowed before a ray is terminated; the input value is a positive number in dB, such as 200.0; if blank (as in Fig. 1) or 0, a value of 300.0 will be used.
Multiple replacement option IA	66	If IA is blank (as in Fig. 1) or 0 and ITBP = 0, angle cards are read from the card reader; if IA is blank or 0 and ITBP = 1, angle fan cards and beam-pattern cards are read from the card reader. If IA = 1 and ITBP = 0, the last set of fan cards for which multiple replacement option LA (in column 71) is 1 will be used, and if ITBP = 1 a new beam pattern will then be read in. If IA = 2, which requires that ITBP = 1, the old beam pattern will be used and a new set of angles will be read. If IA = 3, the old angle set and beam-pattern set is used.
Multiple replacement option IB	67	If IB is blank or 0, bottom-loss cards are read from the card reader, and if ISCP = 1, phase-shift cards are read. Bottom classes 0 through 5 are assumed to have a zero phase shift, so phase-shift cards are not read for these classes. If IB = 1, the old bottom-loss set is used, and a new bottom-phase-shift set is read in if ISCP = 1. If IB = 2, a new bottom-loss set will be read in, and if ISCP = 1, the old bottom-phase-shift set will be used. If IB = 3 and ISCP = 1, the old bottom-phase-shift and bottom loss will be used.

Variable	Columns	Remarks or Meaning
Multiple replacement option IP	68	If IP is blank or 0, a new set of output control cards will be read in; if IP = 1, the old set will be used.
Multiple replacement option ID	69	If ID is blank or 0, a new bottom track will be read, if ID = 1, the old bottom track will be used.
Multiple replacement option IS	70	If IS is blank or 0, a new set of sound-speed profiles will be read; if IS = 1, the old set will be read.
Multiple replacement option LA	71	If LA = 1, the current deck will be used later; if LA is blank or 0, no portion of this deck will be used later. Thus in the following pages the discussion of the various input sections are subject to the provisions of this section.
Restart Option	73-76	If restart capability is desired, the word DUMP is placed in columns 73-76.

III. *Ray Initialization Cards*

A. Fan Cards

Variable	Columns	Remarks
Up-angle limit	1-10	In degrees; the sign convention is + for up and – for down. (In Fig. 1 there are three fan cards, each on a separate line; the three up-angle limits are 15° down, 15° up, and 75° up.)
Down-angle limit (DAL)	11-20	DAL = –DAL for input. (In Fig. 1 the three down-angle limits that pair with the up-angle limits are 75° down, 15° down, and 15° up.)
Angular step	21-30	The step input is always positive. (In Fig. 1 the step is 1° from 75° down to 15° down, ¼° from 15° down to 15° up, and 1° from 15° up to 75° up.)

Variable	Columns	Remarks
Continuation Switch	31-35	0 means this is the last fan card; 1 means more cards follow.
Source Level	36-40	Decibels added for this fan to the source level in columns 15-19 on card II. This is left blank (as in Fig. 1) if no additional beam pattern on the transmitter is desired.
Phase	41-45	Phase in radians for this fan.

B. Beam Pattern Cards

If the beam pattern switch on card II (column 20) was nonzero, the beam pattern is read in, 20 values to a card, which is four columns per value, in decibels below the axial value. The first value is on axis, the next 1° off, etc. A blank or zero after the axial value ends the readin; the last nonzero value is extended to all higher angles.

IV. *Bottom-Loss Cards*

Cards are read with a variable (referred to as RUNTIL) in columns 1-8 in kilometers (in an F8.4 format)
and IClass in columns 9-10 (I2 format). RUNTIL is the last range for IClass. (In the Fig. 1 example 457.0   6 means class 6 until 457 km (assuming another RUNTIL after this which is 0.0). *The last* RUNTIL *must be negative or zero.* The associated class will be used for the rest of the run. The possible values for IClass are 0-9:

0	zero bottom loss
1-5	MGS bottom class loss curves
6-9	user supplied tables.

The first time an IClass of 6 (as in Fig. 1), 7, 8, or 9 is read, a bottom-loss table is read, one value per degree, in decibels, 20 per card (in a 20F4.2 format) until a blank appears. (In Fig. 1 the table with an IClass of 6 is

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. blank
(zero grazing angle) … (9 degrees)

When an IClass of 6, 7, 8, or 9 is read in after the first time, the table does not need to be read in again. In reading in a table the last nonzero value is extended to all higher angles. If ISCP ≠ 0 on card II, a phase-shift table will be read after each loss table (classes 6-9; classes 0-5 have zero phase shift). The phase-shift table is read in, 20 values per card, 1° per value. The phase shifts are in radians. A zero value terminates read in; the last two nonzero values are used to extrapolate the phase shift to zero. (In Fig. 1 no phase-shift table was read in. The bottom-loss tables in Fig. 1 establish the following:

Grazing Angle (degrees)	Loss Until 457 km (dB)	Loss After 457 km (dB)
0	0	4
1	1	5
2	2	6
3	3	7
4	4	8
5	5	9
6	6	10
7	7	11
8	8	12
9	9	13
10	10	14
11	10	14
12	10	14
↓	↓	↓
90		

V. *Output Control Cards*

Output control cards specify the range and depths at which intensities are to be calculated, whether a ray plot or ray tape will be made, whether ray depth distributions will be printed, etc.

Variable	Columns	Remarks
R1	1-6	First range in kilometers.
DR	7-12	Range step in kilometers. If DR is negative, the range spacing will be logarithmic, with constant factor $f = 1 + abs(DR)/R1$.
R2	13-18	Last range in kilometers. (In Fig. 1 the ranges specified are 100, 200, ..., 1000 kilometers on the first group V card, 5, 10, 15, ..., 1000 kilometers on the second card, 1, 2, ..., 100

Variable	Columns	Remarks
		kilometers on the third card, and 0, 1, 2, ..., 1000 kilometers on the fourth card.)
IC	19-20	Continuation switch. 0 means this is the last output control card; (as on the last OCC in Fig. 1) otherwise more will be read in.
ISCP	21	Switch for type I coherent phase; 1 means on, and 0 means off.
IT1	22	Switch for type I random phase; 1 means on, and 0 means off. MUST = 1 when ISCP = 1.
IT2	23	Switch for type II; 1 means on, and 0 means off.
IT3	24	Switch for type III; 1 means on, and 0 means off.
IPER	25	Switch for type I eigenrays; 1 means on, and 0 means off.
LLMR	26	1 means Lloyd's mirror effect is included.
JVSR	27	0 means no intensity-vs-range plot for this output control card; 1 means a plot of type I vs range; 2 means a plot of type II vs range; 3 means a plot of type III vs range; 4 means coherent phase vs range. Only one intensity-vs-range plot can be made.
IRD	28	Switch for ray depth distribution (1 means on, as on the first group V card in Fig. 1), and 0 means off.
IRP	29	Switch for ray plot.
IRT	30	Switch for ray tape for Calcomp plot.

If any of the switches in columns 21-25 are on, receiver depths are needed. The first six, in meters, are on the output control card itself, as follows:

Variable	Columns
RCD(1)	33-40
RCD(2)	41-48
RCD(3)	49-56
RCD(4)	57-64
RCD(5)	65-72
RCD(6)	73-80

If there are more than six, the next ten depths follow the output control card on one card, and then, if needed, the 17th through 26th on another card. Twenty-six is the maximum available. Receiver depths are read until a zero or blank is found. (In Fig. 1 five receiver depths are specified on each of the first three cards: 50, 150, 250, 350, and 450 meters.) If none of the switches 21-25 are on, then no intensities will be calculated, so no receiver depths are necessary. These and some earlier spaces are then used for the ray plot, as follows:

Variable	Columns	Remarks
DR	7-12	Becomes the spacing in kilometers between lines in the ray plot.
R2	13-18	Becomes the end of the ray plot.
RCD(1)	33-40	Becomes the number of rays to be plotted, $1 \leqslant N \leqslant 25$. This must be punched with a decimal point. (On the fourth group V card in Fig. 1, 25 rays are specified to be plotted.)
RCD(2)	41-48	Becomes the maximum depth for the ray plot, in meters.

All these variables will be set to default values if not specified because of intensities. The defaults are: 1 kilometer spacing, 15 rays plotted, and the maximum bottom depth. Even if DR and R2 are set, the defaults for number of rays and (as in Fig. 1) maximum depth may be used if the columns are left blank.

VI. *Bottom Track*

A. Ranges and Depths

There are 10 values to a card, with range and depths in pairs with respective units in kilometers and meters. The first range must be zero. A later blank or zero or negative value terminates the input. As many cards as necessary, up to 50 cards for 250 ranges, will be read. Thus R_1 is in columns 1-8 of card 1, D_1 is in columns 9-16 of card 1, R_2 is in columns 17-24, D_2 is in columns 25-32, etc. The format for range and depth is 10F8.4.

VII. *Sound-Speed Profiles*

A. Range and Title

On the first card for each velocity profile, 0 is placed in column 1 if the curved-earth correction is desired. The range to the profile in kilometers is in columns 2-8. The title is in columns 9-80.

B. Depth and Velocity

There are 10 values per card after the range-and-title card. The first value on the card is the depth in meters for this profile. The second value is the sound speed in meters/per second, at the first depth. As many sound speeds as depths are read in. A blank or negative value terminates input. The format for all cards is 10F8.4. (The number of input and internally generated points in a sound-speed profile cannot exceed 50; the number of internally generated points can be reduced by reading in profiles with common depths.)

VIII. *Program Termination*

An end-of-file card terminates each data set or case. If multiple cases are desired, the program will go back to the first card, after the end-of-file card. To terminate the run two end-of-file cards should be placed after the last case.

CONTROL CARDS FOR TRIMAIN

There are several equip cards, which have different functions (Fig. 2). Some of the cards are used for delayed printout, and some are used to punch cards. When using the program, one should change his job card to the form 7_9 JOB (30), charge, ID, time, rather than the usual form 7_9 JOB, charge, ID, time. The change from JOB to JOB (30) allows 30 additional logical units; without this change the program will abort.

If the output is not desired from a certain unit, it may be omitted by using the BY statement. Thus if one wanted to omit the output from logical unit 35, then one should have 7_9 EQUIP, 35=BY, where BY means bypass. The PR designation on an equip card means that unit will be printed. A PU designation means that logical unit will punch cards. The function for each card is as follows:

7_9 DEMAND, 50000B - This card is required for the restart option.

7_9 EQUIP, 3=PL - This card forces plotting of profiles if the program aborts, if the plot is requested.

```
SEQUENCE C6660 STARTED  PRINTING 06/06/73 AT 132946 ON LP00
DRUM SCOPE 2.1  COMPUTER ONE,  MAX, DEMAND IS 54000R    VERSION 006     11/24/72
SEQUENCE NUMBER 606660 STARTED AT TIME  132726  DATED  06/06/73
JOB(30),8150162,014BGR,10
DEMAND,50C006
COMMENT,THIS JOB PRODUCES DELAYED PRINTOUTS
EQUIP,1=MT,HI,N9,(TEST CASE,1,1,999),DA
EQUIP,3=PL
EQUIP,15=MT,LO,(TEST,1,1,999),DA
EQUIP,16=MT,LO,**,DA
EQUIP,20=MT,HI,R9,(TRIMAIN,01,01,999)
EQUIP,35=BY
EQUIP,36=BY
EQUIP,37=PR
EQUIP,38=PR
EQUIP,39=PR
EQUIP,41=PR
EQUIP,42=PR
EQUIP,45=BY
EQUIP,46=BY
EQUIP,47=BY
EQUIP,48=BY
EQUIP,49=BY
***BINARY DECK***
BANK,(0), LUMP
LOAD,20
RUN,10,10000
```

Fig. 2 — Example of control cards; this is the front page from the sample run

7_9 EQUIP, 35=BY(PU)	- This will punch the bottom track and receiver depths if set equal to PU. Format 10F8.3.
7_9 EQUIP, 36=BY(PU)	- This will punch intensity values in 16F5.1 format, for each range point. Each type of intensity will be punched for each receiver.
7_9 EQUIP, 37=PR	- This produces a ray depth distribution if requested.
7_9 EQUIP, 38=PR	- This produces a printplot of intensity vs range if requested on an output control card.
7_9 EQUIP, 39=PR	- This prints the intensity values for the types specified.
7_9 EQUIP, 41=PR	- This prints the Type I eigenrays when they are requested.
7_9 EQUIP, 42=PR	- This produces the printplot of the ray trajectories when requested.
7_9 EQUIP, 45=BY(PU)	- If this is set equal to PU, it will punch type I coherent intensity values for the contouring program. If should be set up for 19 receivers.

7_9 EQUIP, 46=BY(PU) - If this is set equal to PU, it will punch type I random intensity values for the contouring program. It should be set up for 19 receivers.

7_9 EQUIP, 47=BY(PU) - If this is set equal to PU, it will punch type II intensity values for the contouring program. It should be set up for 19 receivers.

7_9 EQUIP, 48=BY(PU) - If this is set equal to PU, it will punch type III intensity values for the contouring program. It should be set up for 19 receivers.

7_9 EQUIP, 49=BY(PU) - This punches type I eigenrays; it punches everything that is printed in the eigenray printout.

7_9 EQUIP. 1=MT,HI,WØ,**,DA--OUTPUT TAPE FOR CALCOMP PLOT OF RAY PATHS

The equip cards may be left in the deck if a certain option is not desired; there will be no output from that unit unless a write operation is performed in the program.

SUBROUTINES

The main, or executive, program TRIMAIN is used chiefly for selecting options and calling the proper subroutine to compute the desired quantities. The subroutines are shown in Fig. 3, and these will be discussed on the succeeding pages. All of the output control cards (group V), title cards (group I), and source depths, frequency, etc. (group II) are read in by the main program. A listing of TRIMAIN and the subroutines is found in Appendix A. A comparison of calculated and experimental values is found in Appendix B.

Subroutine INITRAYS

The subroutine INITRAYS (whose cards are identified in the right margin in Appendix A by INIT 1, INIT 2, ..., INIT 81) reads in the angle cards and the beam-pattern cards and sets up the initial values of each ray's tangent of the angle, depth, phase, and signal level. (card group numbers will be listed in the section). Information from card group II from the main program is passed in the common block /PATTERN/ (INIT 3, Appendix A), which contains the source depth, beam-pattern switch, degrees of down tilt, and source level (in decibels). INITRAYS then reads in card group III, comprising the fan cards and the beam pattern cards. Rays are started from the lowest angle of each fan to the top. If the low angle of a fan equals the highest angle of the previous fan, a continuous ray group results. Otherwise a buffer ray with zero signal strength separates the fans, and type I intensity calculations will not interpolate over the gap.

Subroutine BRLTRD

The subroutine BRLTRD reads in the bottom-loss cards (group IV) and sets up the first loss table. On entry, dummy parameter RB is equated to ISCP (card group II), is

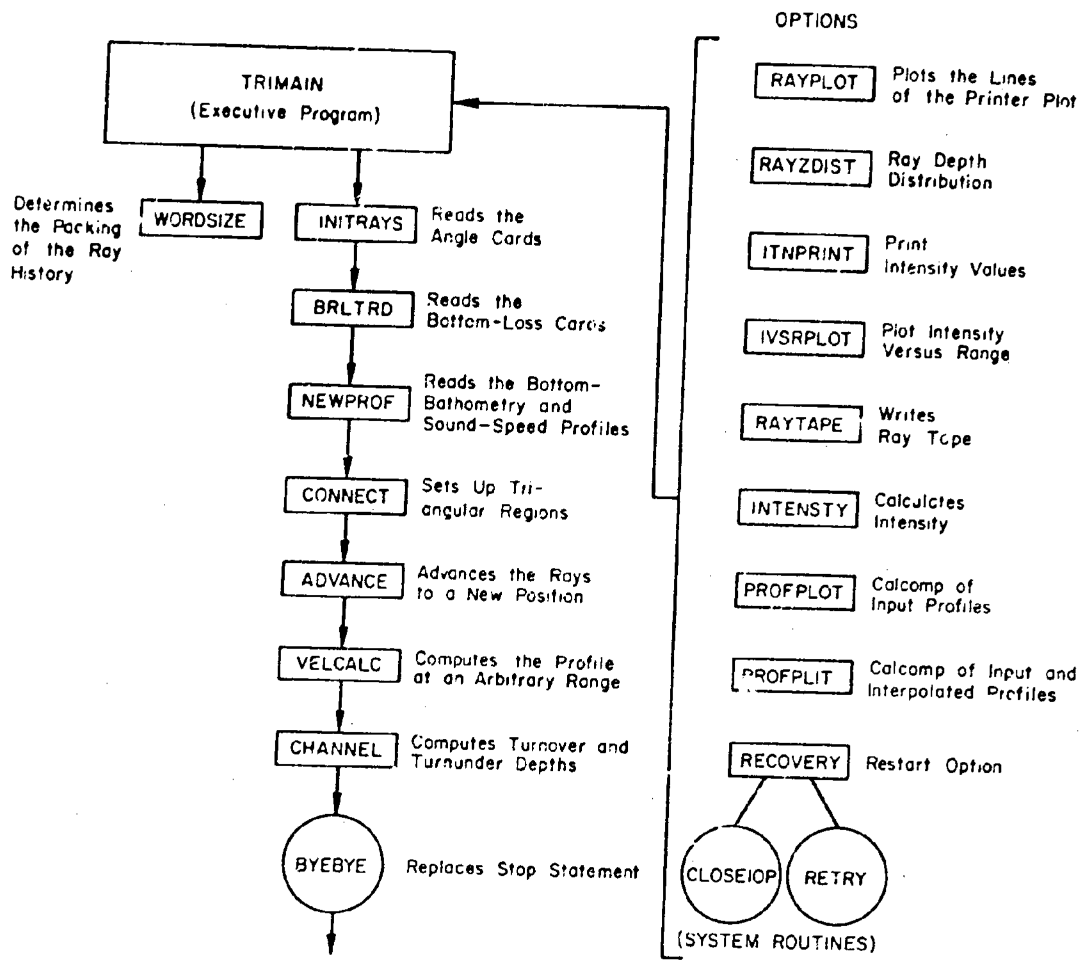


Fig. 3 — Function of each subroutine of the program TRIMAIN

either 1.0 or 0., and determines whether phase-shift tables will be read. On exit, RB is set to the range in kilometers until which the first loss table is to be used. The term ENTRY NWBRLT (as in BLRD 146) resets the loss table and RB. TRIMAIN will call NWBRLT whenever the rays pass RB. For example, if there are two loss tables, one for 0 to 100 km and the second for 100 km to the end of the run, BRLTRD will read in both tables, set BRLT and BPST in the common block /MIRRORS/ (BLRD 3, Appendix A) and set RB to 100. Later a call to NWBRLT sets BRLT and BPST to the second table of values, and RB to 1.E30 (i.e., 10^{30} km $\gg$ end of run). Subroutine BRLTRD includes the Marine Geophysical Survey (MGS) classes 0 through 5, plus user classes 6 through 9 stored in array BR, or user loss and phase classes 6 and 7, stored in arrays BR and BP. If a class 0 through 5 is specified, bottom phase classes do not have to be read in. A maximum of four user classes are available without phase shifts, and two classes are available with phase shifts. If classes 0 through 5 are used, a maximum of 50 cards is allowed.

Subroutine NEWPROF

Subroutine NEWPROF reads the bottom ranges, bottom depths (group VI), and the first two sound-speed profiles (group VII) on the first call. It then interpolates a profile for the first bottom point. Succeeding calls generate a new interpolated profile for each bottom point, unless this would pass the last read-in profile. In that case, a bottom point is interpolated to the profile range, and the profile is returned. A new profile is then read in. Thus the basic action of NEWPROF is to move *R*2 (range to the current profile), *N*2 (number of points in the current profile), *Z*2 (depth array), and *V*2 (sound-speed array) to *R*1 (range to the previous profile), *N*1 (number of points in the previous profile), *Z*1 (depth array for the previous profile), and *V*1 (sound-speed array for the previous profile) and set new values for *R*2, *N*2, *Z*2, and *V*2. It returns the maximum bottom depth in ZMAX. The printed output of NEWPROF is illustrated in Figs. 4a and 4b.

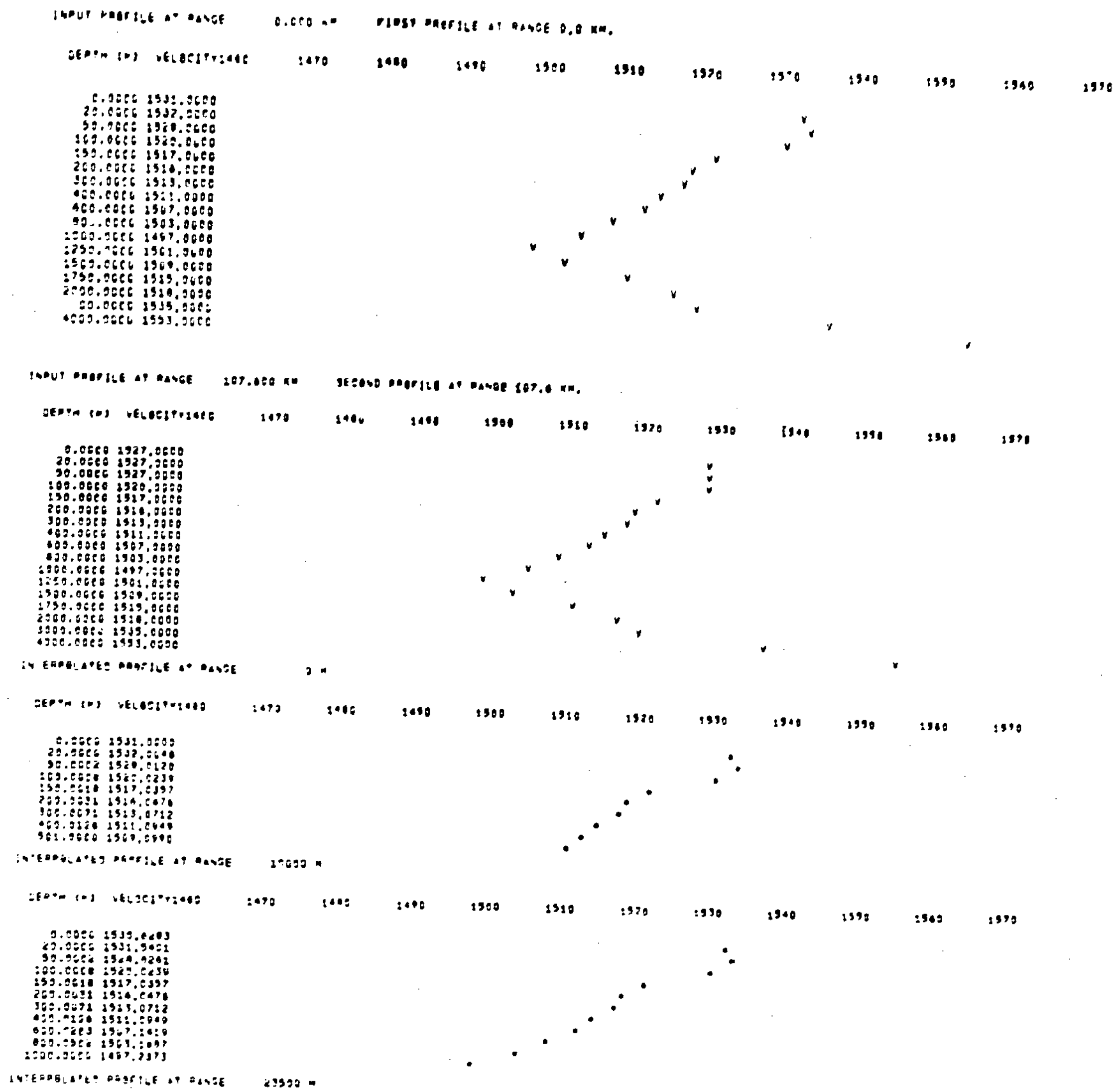


Fig. 4a — Output of NEWPROF. The first two input profiles are those of the sample case given in Fig. 1.

DEPTH (M) VELOCITY 1460 1470 1480 1490 1500 1510 1520 1530 1540 1550 1560 1570

DEPTH (M)	VELOCITY
0.0000	1530.1200
20.0000	1530.4128
50.0002	1530.5792
100.0000	1528.0430
150.0010	1527.8397
200.0021	1518.2476
300.0071	1513.0712
400.0120	1511.0040
600.0283	1507.1410
800.0502	1503.1887
1000.0785	1497.2350
1250.1228	1501.2045
1500.1760	1509.3553
1750.2403	1519.4101
2000.3129	1518.4765
2500.0000	1547.5909

INTERPOLATED PROFILE AT RANGE 57300 M

DEPTH (M) VELOCITY 1460 1470 1480 1490 1500 1510 1520 1530 1540 1550 1560 1570

DEPTH (M)	VELOCITY
0.0000	1528.0010
20.0000	1528.3581
50.0004	1527.4529
100.0000	1528.0230
150.0010	1527.0397
200.0021	1518.6476
300.0071	1513.0712
400.0126	1511.0049
600.0283	1507.1419
800.0502	1503.1887
1000.0785	1497.2350
1250.1228	1501.2045
.500.1760	1509.3553
.750.2403	1519.4101
2000.3129	1518.4765
3000.7583	1535.7228
4000.0000	1553.4521

INTERPOLATED PROFILE AT RANGE 511030 M

DEPTH (M) VELOCITY 1460 1470 1480 1490 1500 1510 1520 1530 1540 1550 1560

DEPTH (M)	VELOCITY
0.0000	1517.5155
20.0000	1516.1277
50.0002	1517.1348
100.0000	1505.5613
150.0010	1504.9663
200.0021	1504.8613
300.0071	1504.0436
400.0120	1503.2446
600.0283	1502.2393
800.0502	1501.2260
1000.0785	1498.9952
1250.1228	1502.8648
1500.1760	1509.3553
1750.2403	1515.0435
2000.3129	1518.8691
3000.7083	1536.1155
4001.7958	1554.3677
4200.0000	1557.9933

INTERPOLATED PROFILE AT RANGE 1000000 M

DEPTH (M) VELOCITY 1460 1470 1480 1490 1500 1510 1520 1530 1540 1550 1560

DEPTH (M)	VELOCITY
0.0000	1490.5330
20.0000	1489.6894
50.0002	1489.6764
100.0008	1490.2420
150.0018	1490.3794
200.0021	1491.3613
300.0071	1493.1003
400.0126	1493.7245
600.0283	1496.2876
800.0502	1499.5469
1000.0785	1500.7086
1250.1228	1504.7682
1500.1760	1509.3553
1750.2403	1514.5476
2000.3129	1519.3451
2100.0000	152[illegible] 0636

INTERPOLATED PROFILE AT RANGE 1100000 M

DEPTH (M) VELOCITY 1460 1470 1480 1490 1500 1510 1520 1530 1540 1550 1560

DEPTH (M)	VELOCITY
0.0000	1486.4466
20.0000	1485.4857
50.0002	1485.4927
100.0008	1486.9047
150.0018	1487.3924
200.0031	1488.5293
300.0071	1490.8674
400.0126	1491.7825
600.0283	1495.0713
800.0502	1498.3603
1000.0785	1501.0978
1250.1228	1505.1575
1500.1760	1509.3553
1750.2403	1514.4503
2000.3129	1519.4424
2100.0000	1521.1609

Fig. 4b — Additional portion of the output of NEWPROF shown in Fig. 4a

Subroutine CONNECT

Subroutine CONNECT uses $R1$, $N1$, $Z1$, $V1$, $R2$, $N2$, $Z2$, and $V2$ from NEWPROF and connects the points into triangular (Δ) regions. The coefficients of the triangles go into the common block /TRIANG/ (CONN 3, Appendix A). The variables in TRIANG are the following:

AP, BP	coefficients of the Δ boundary in the prime frame, which is centered at RZERO and ZZERO and rotated by an angle θ,
AL, BL	coefficients of the lower Δ boundary in the ocean frame.
ZZERO, RZERO	ocean frame coordinates of the center of the prime frame.
AA, BB	coefficients of $1/c^2$ in the prime frame, i.e., $1/c^2 = AA + BBz'$,
SST, CCT	sin and cos of θ, the angle between the ocean and the prime frames.

In the listing of the subroutine, the following conditions are true:

$$AL + BL*R = \text{equation for boundary of triangle},$$

$$AA + BZ*Z + BR*R = \frac{1}{c^2}.$$

A typical network of triangular regions is illustrated in Fig. 5.

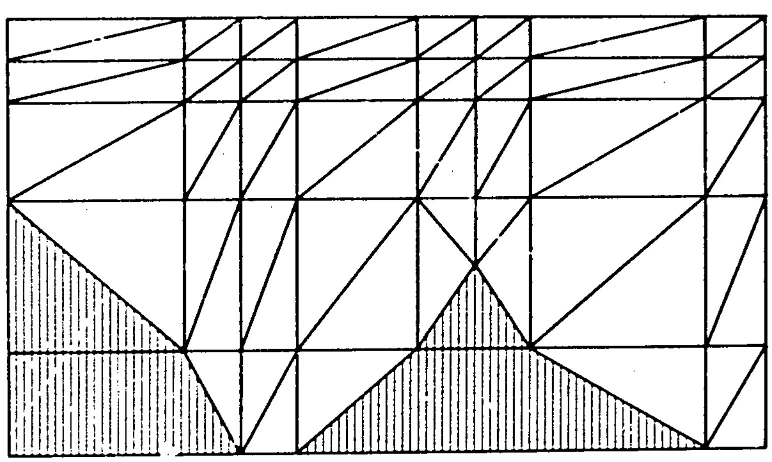


Fig. 5 — Typical network of triangular regions

Subroutine WORDSIZE

Subroutine WORDSIZE calculates some machine-dependent quantities. Four numbers are packed into array NCOUNT by using *ITN*, which is $ITN = \sqrt[4]{1/4\ JBIG}$., where JBIG is the largest integer, which will fit into one computer word. The four numbers in each location in NCOUNT are: number of turnovers for this ray, number of bottom reflections, number of turnunders, and number of surface reflections. ENTRY RAYTAPE writes one record on the ray tape. The first record will contain the title card. Each record contains:

NRAY (number of ray),
Range (meters),
Bottom depth (meters),
Tan γ (up is positive)
Ray depth (meters),
Signal strength (multiplicative factor),
NCOUNT (ray history),
Travel time (seconds),
Phase (radians).

(Tan γ through Phase:) Each one contains NRAY words. All tan γ's precede all ray depths, etc.

Subroutine ADVANCE

The basic function of subroutine ADVANCE is to advance the rays in the common block /RAYS/ from RSTART to RMAX. The procedure is as follows: First the proper triangle is found, the parabolic path is found, and intersections are calculated with the earliest intersection being used. Then surface and bottom reflections are performed. If ray is not at RMAX, the new triangle is determined, and a loop is made in the procedure to the calculation of intersections.

The explanation of various sections is as follows:

TANSUM (ADVA0012, Appendix A) is the tangent sum formula

$$\tan\,(\theta_1 + \theta_2) = \frac{\tan\theta_1 + \tan\theta_2}{1 - \tan\theta_1 * \tan\theta_2}\,.$$

DELT gives the time increment of a ray in terms of the range increment DR, the two tangents *T* and *S*, and the vertex velocity $CMIS = 1/c_m^2$.

The *DO* 100 IRAY = 1, NRAY (ADVA0015) (card sequence number) selects each ray in turn.

ADVA0018 checks to see if a ray has been terminated.

ADVA0019 through ADVA0023 move the ray variables into local variables.

The *DO* 20 *I* = 1, NRTI (ADVA0024 through ADVA0030) checks each triangle to see if the ray is in it. If a ray is on a boundary, it is in the layer it is pointing toward.

CT(cos θ), *ST*(sin θ), (rotation), and ZO and RO (displacement) define the primed frame of reference in which there is no *r'* gradient.

ZRP and *RRP* are the initial primed ray position.

CIS = $1/c2$ at the ray.

Note: that TGR from TGAM (IRAY) is + for up rays and - for down rays, whereas TGRP = *DZ'/dr'* is + for down rays and - for up rays.

ALPHA (α) is the path curvature:

$$Z' = ZRP + TGRD*(r'-RRP) + \text{ALPHA}*(r'-RRP)^2$$

$$TA = 2\alpha = \frac{d^2Z'}{dr'^2}.$$

The quadratic equation solved in advance is

$$C + Py - \alpha y^2 = 0,$$

where $y = DRP$ = change in r' = RPNEW - *RRP*. ALPHA (α) is often small and is zero for isovelocity layers. For small α the root

$$y = \left(P-\sqrt{P^2 + 4\alpha c}\ \right)/2\alpha$$

is unstable. However, if α is small, the iteration $y = (\alpha y^2 - C)/P$ converges fast. The statement *DRP* = (ALPHA*((ALPHA*DRP**2-C)/P)**2-C)/P is a double application of the above iteration and is used when

$$F = P-\sqrt{P^2 + 4\alpha C} \ll P.$$

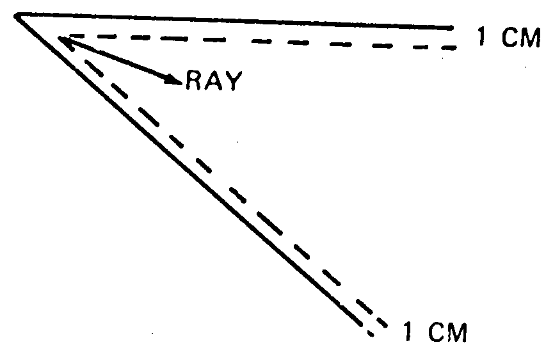
When $\alpha = 0$, special linear path statements are used (ADVA0055 through ADVA0065 and ADAV0171 through ADVA0174). After statement 40 (ADVA0085), the next position is selected.

ONUP is true if a ray is on the upper boundary of a layer, meaning within 1 centimeter of the boundary and pointing in. ONLW is true if a ray is on the lower boundary.

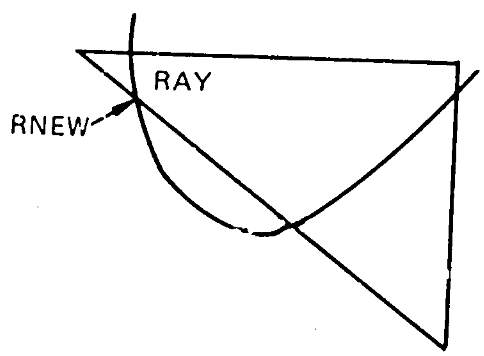
There are four possibilities, in RPNEW, ZPNEW, ZNEW, and RNEW arrays. In general, the rule is

$$\text{RNEW} = \min(\text{RNEW}(k)) \text{ such that } \text{RNEW}(k) > RR).$$

When a ray is on a boundary however the solution closest to the ray on that boundary is thrown out (ADVA0095, ADVA0096, ADVA0099, and ADVA100). Note, as shown in the following sketch, that a ray can be on both boundaries if it is on a corner.



If RNEW > RMAX, then the ray hits the vertical boundary (following sketch) and one goes to statement 50.



The cards from ADVA0129 to ADVA0163 increment the ray variables and decide on the next triangle.

ADVA0135 checks for vertices.

ADVA0136 decides whether a vertex is over or under.

ADVA0142 through ADVA0148 handles surface reflections.

ADVA0151 through ADVA0161 handles bottom reflections.

Statement 50 starts the vertical boundary section. The boundary in the primed frame is $Z' = AV + BVr'$.

If $ST = 0$, $BV \rightarrow \infty$; hence small ST's are handled by statement 60.

When two intersections are possible, the one with the smallest depth change is used.

Statement 52 checks for vertices.

The statements ADVA0204 and ADVA0205 (545) check the ray's final depth to be sure it is in the correct layer.

Volume attenuation is approximated by 0.0001 α (dB)/km $V\Delta T$ decibels, since one should have $S = \int v\, dt$ instead of $V\Delta T$.

The local variables are restored in the table ADVA0208 through ADVA0212, and a new ray is taken at statement 100.

Statements 60 through 68 (ADVA0214 through ADVA0235) use an iterative scheme to find the intersection with a vertical boundary. For $ST = 0$ or $\alpha = 0$ the first step is exact. The convergence limit is 1 centimeter, but seven steps are taken at once, so the usual error is very small.

Statement 80 terminates a ray and prints out the message RAY TERMINATED.

Statement 100 is the end of the outer loop of subroutine ADVANCE.

Subroutine PROFPLOT

Subroutine PROFPLOT plots the input velocity profiles and also the bottom track on a Calcomp plot (Fig. 6). They may be plotted in range increments of nautical miles or kilometers. In Fig. 6 the three profiles are at 0, 107.6, and 1135.4 km, which ranges are indicated by + symbols on the abscissa axis. The total plot length is specified to give a suitable scale.

Subroutine RAYZDIST

Subroutine RAYZDIST prints out a ray depth distribution (Fig. 7) each time it is called. The following items will be printed: NRAY = number of ray, NTO - number of turnovers, NTU = number of turnunders, NSR = number of surface reflections, NBR = number of bottom reflections, DEPTH = current depth of ray, THETA = ray angle at the point in degrees, TIME = travel time of ray in seconds to this range. The losses column is $10 \log_{10} SS$, and is initially

$$10 \log_{10} \left[(\cos \theta_0) \Delta\theta_0 \right] + \text{SORLEV} - \text{beam pattern}.$$

If SORLEV = beam pattern = 0 dB, and $\Delta\theta_0 = 1°$, then losses start out -17.6 dB for a horizontal ray. In the plot line, B is the bottom, + is the lower vertex depth, * is the present ray position, - is the upper vertex and S is the surface.

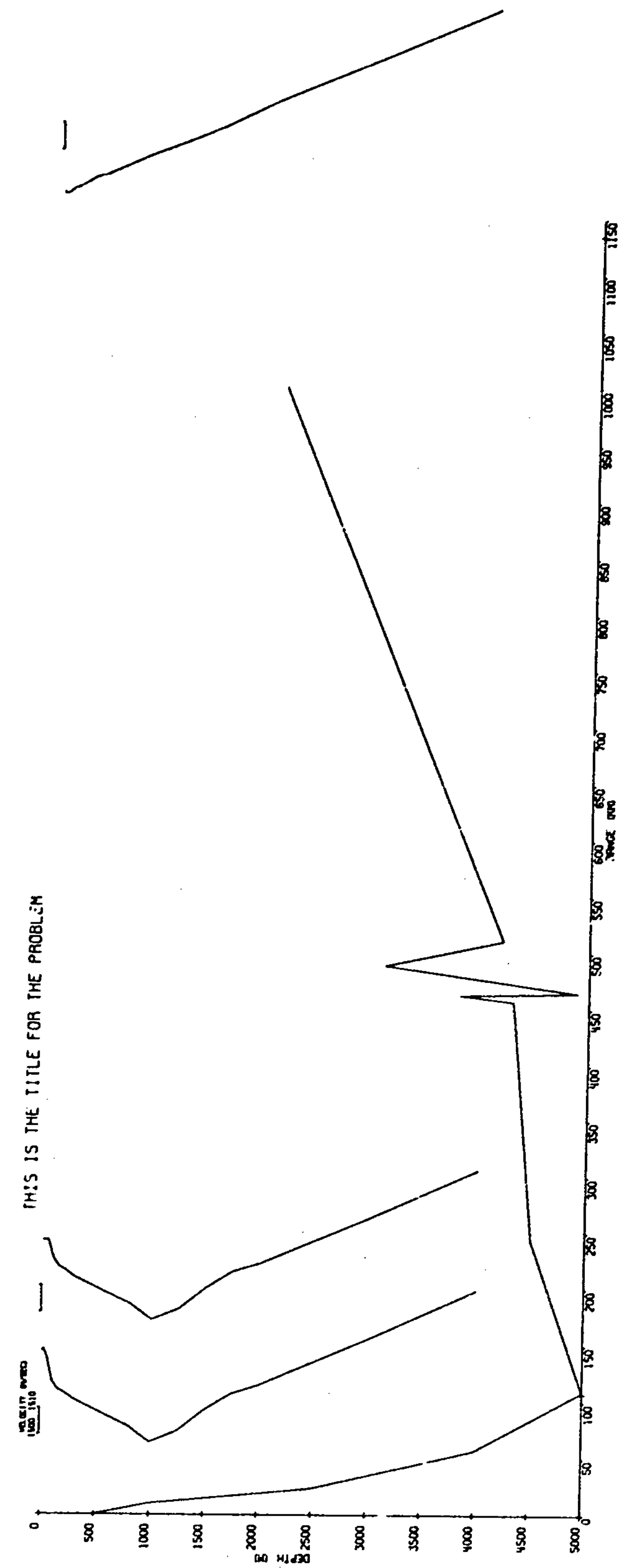


Fig. 6 — Colcomp plot of input profiles and the bottom track

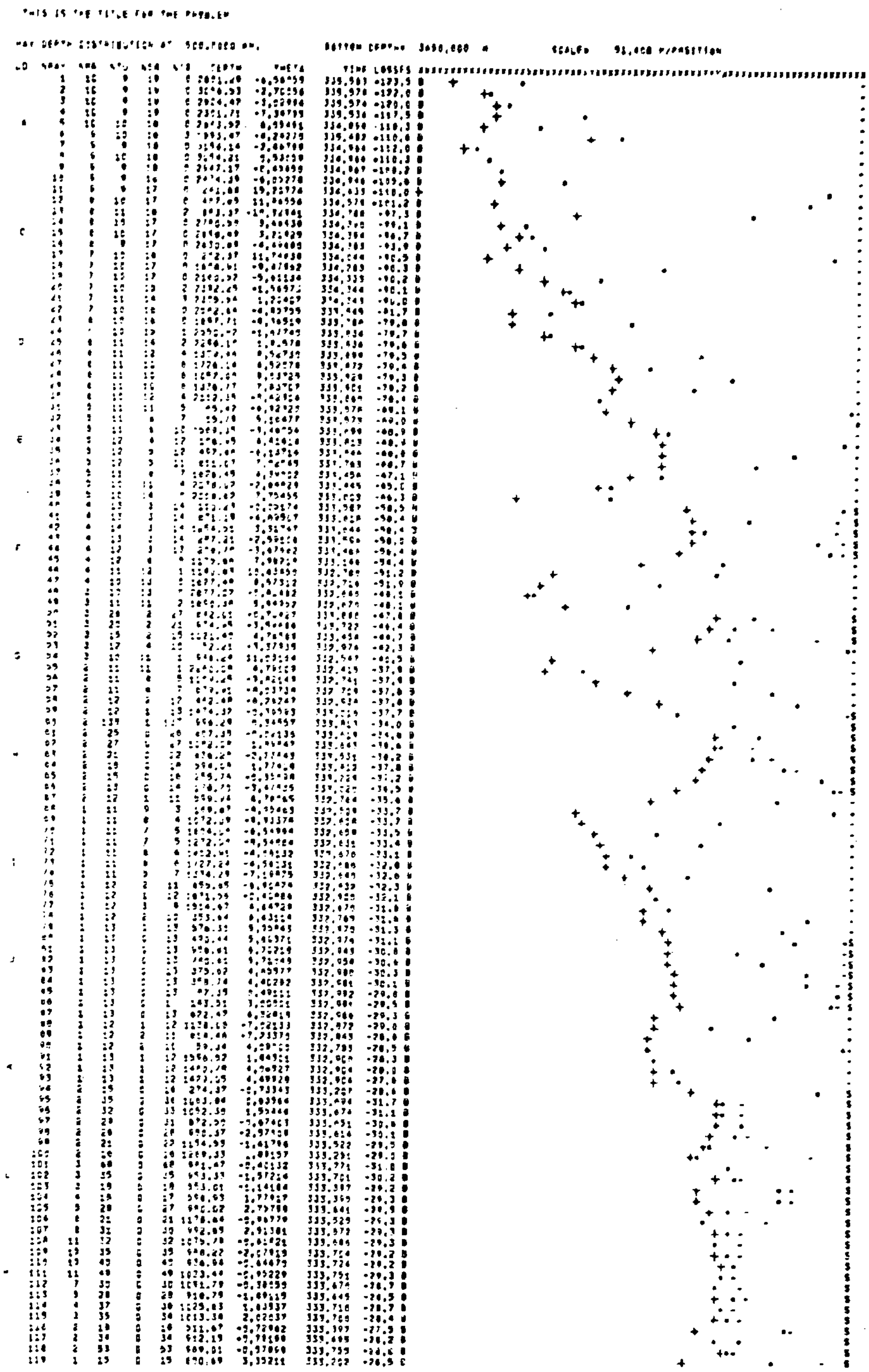


Fig. 7 — Example of the output from RAYZDIST (first of four pages)

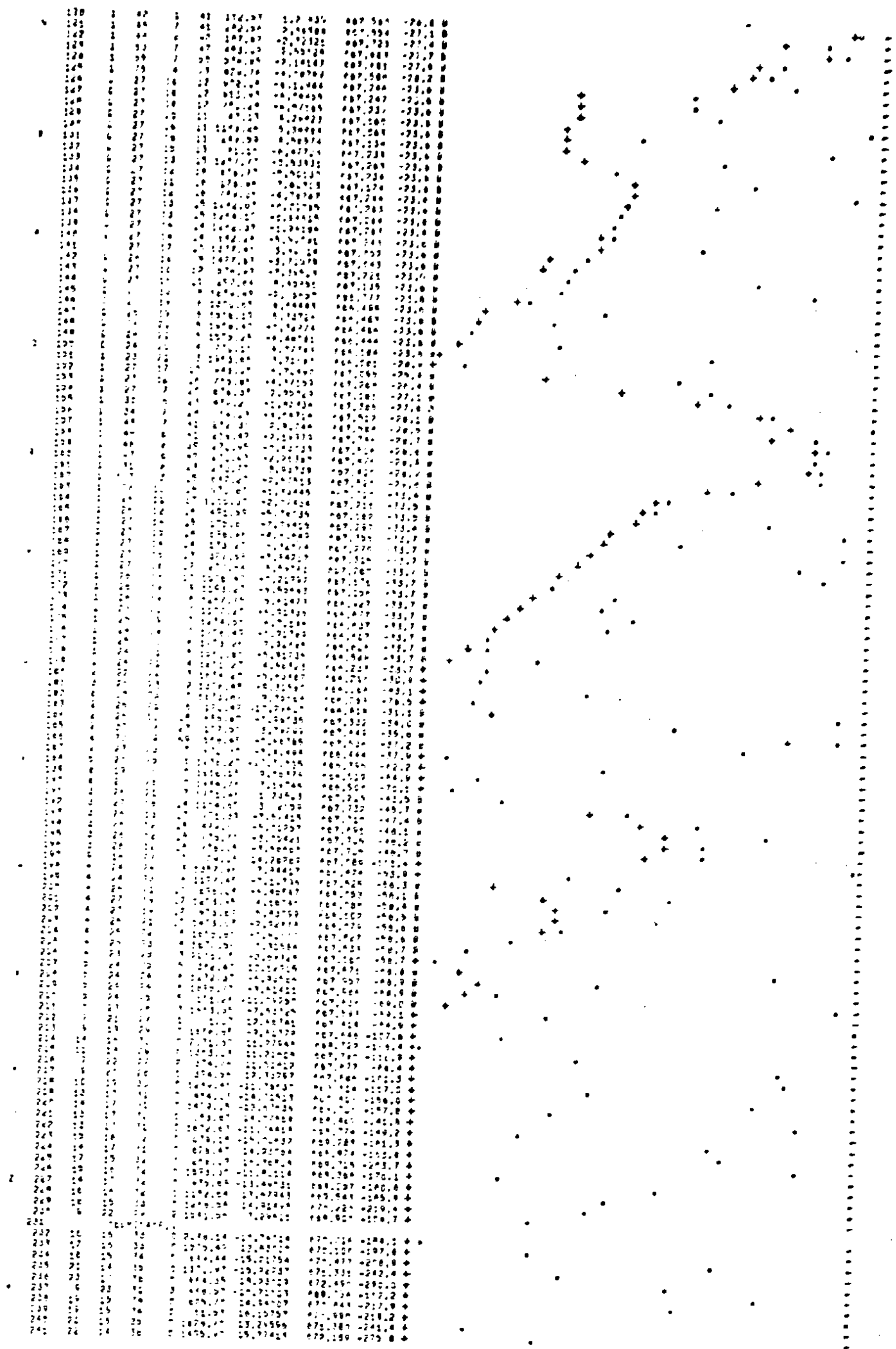


Fig. 7 (Continued) — Example of the output from RAYZDIST (second of four pages)

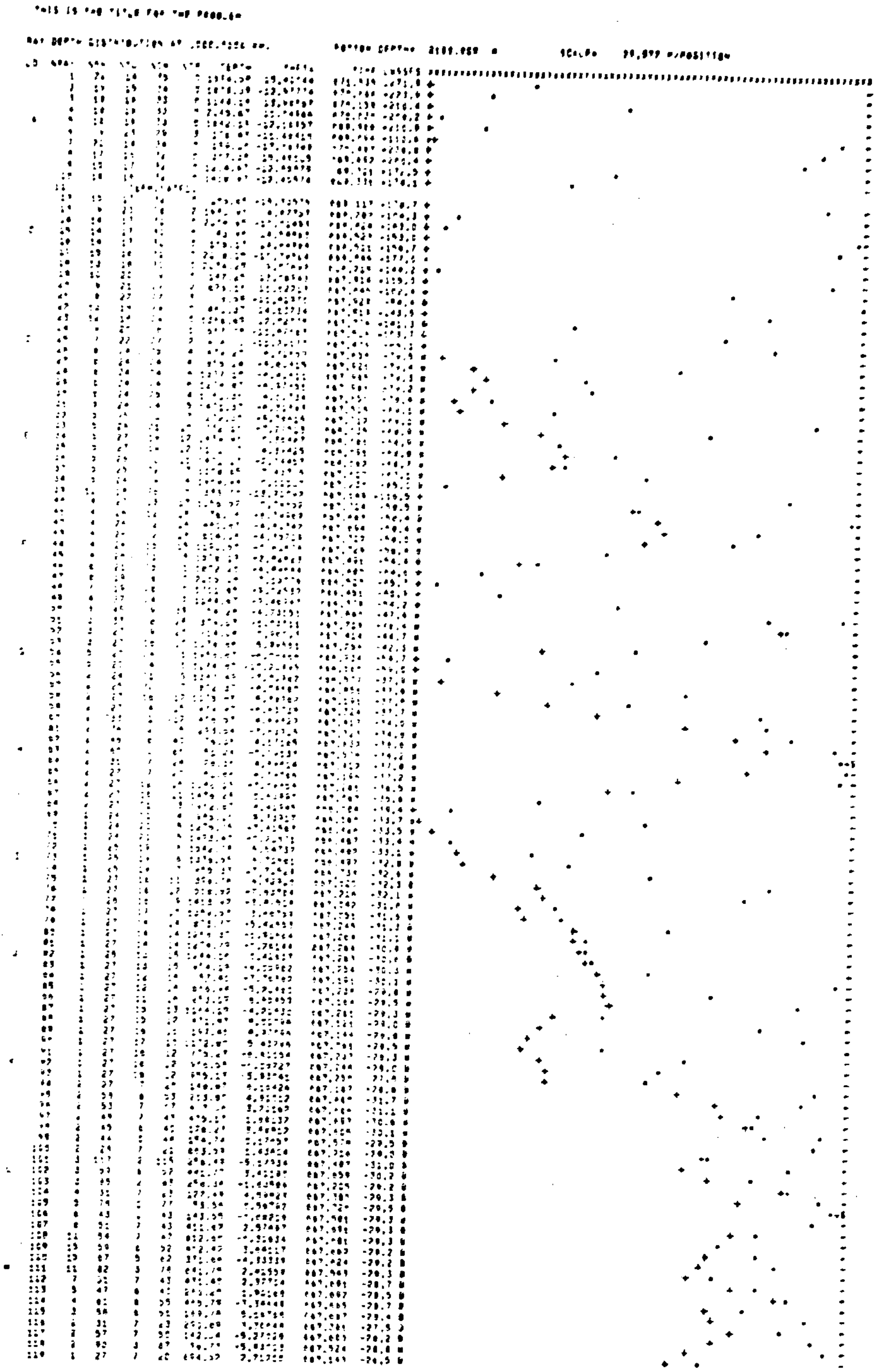


Fig. 7 (Continued) -- Example of the output from RAYZDIST (third of four pages)

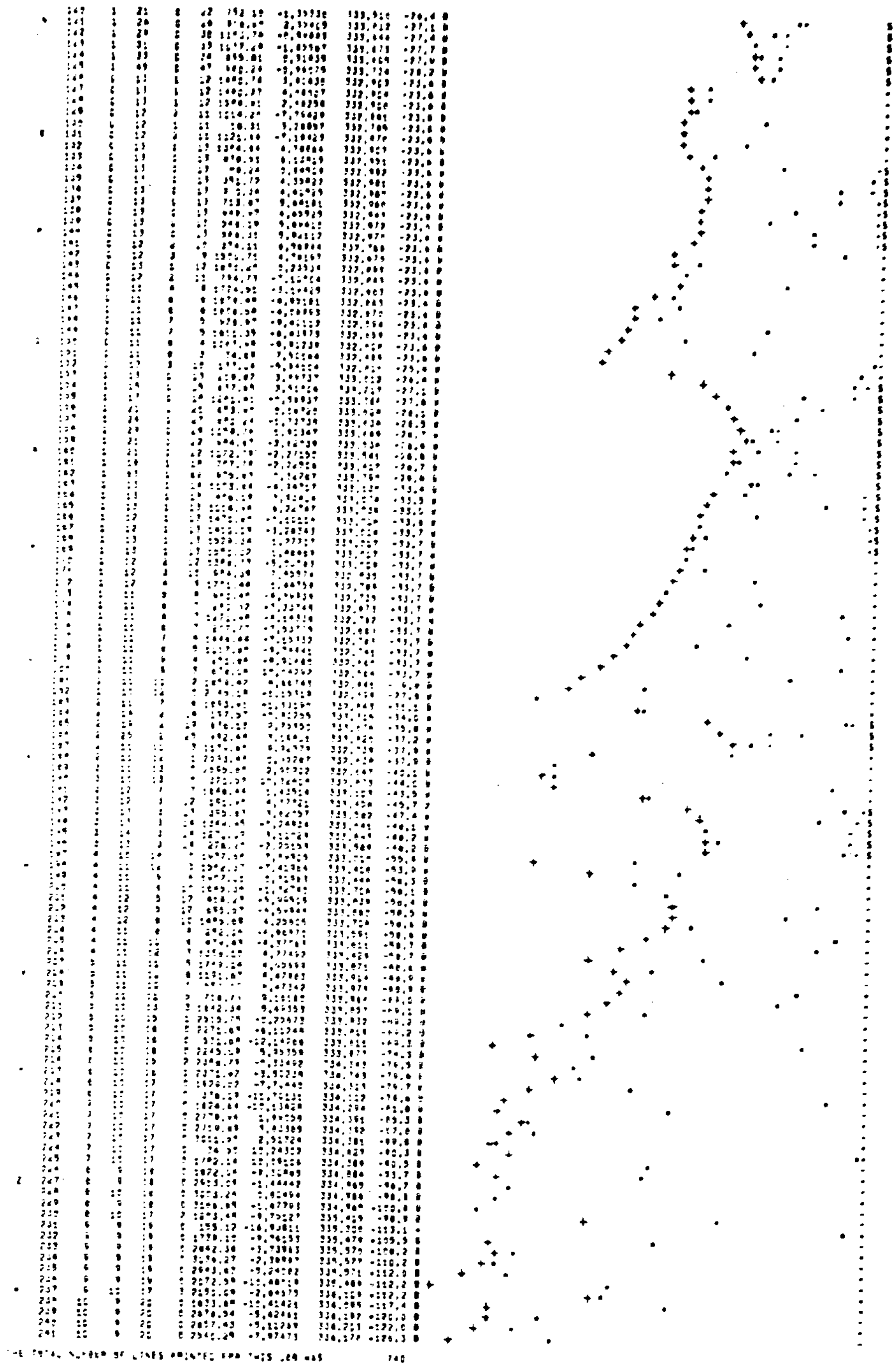


Fig. 7 (Continued) — Example of the output from RAYZDIST (fourth of four pages)

Subroutine CHANNEL

Subroutine CHANNEL calculates CM (vertex velocity) from ZR (ray depth) and T (tangent of the ray angle) and then finds ZTO (ray turnover depth) and ZTU (ray turnunder depth). The entry RCALC then calculates

$$R = \int_{ZTO}^{ZTU} \frac{1}{\tan\theta}\, dZ,$$

where R is the cycle length of the ray, which is used for the type III intensity calculations. The entry WDENS then calculates the probability density $P(Z)$ that a ray will be found at a depth z:

$$P(z) = \frac{1}{(\tan\theta)/R},$$

which is the type III depth distribution.

Subroutine VELCALC

Subroutine VELCALC calculates a velocity profile at each selected range for internal calculations (not a profile range or bottom point) using the information in the common block /TRIANG/.

Subroutine RAYPLOT

Each entry to RAYPLOT plots one line of the printer plot. In addition the first entry prints the heading for the plot, determines which rays will be plotted, and sets the scale. *NP* and ZMAX are used only on the first entry. Fig. 8 is an example of the printer plot.

Subroutine PROFPLIT

Subroutine PROFPLIT plots both the input and interpolated profiles on a Calcomp plot. They may be plotted in nautical miles or kilometers. The total plot length is specified in inches. The bottom track is also plotted.

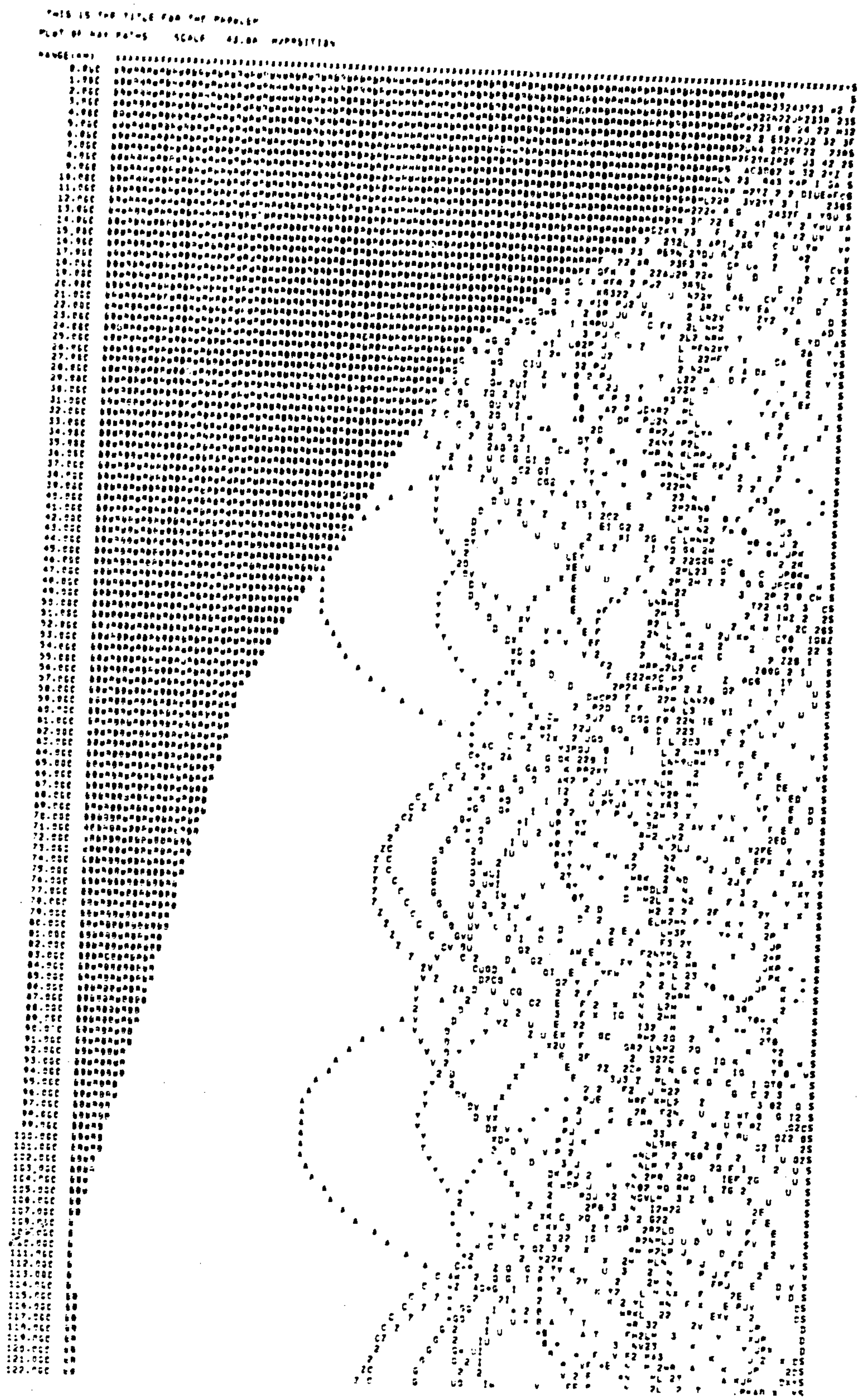


Fig. 8 — Ray plot

Subroutine ITNPRINT

Subroutine ITNPRINT prints out the intensities. If receiver depths are the same for all intensity calculations, a table of intensities such as shown in Fig. 9 is printed. Otherwise a printer plot for each range with the arrangement

Type →

Depth ↓ Intensity

is printed.

THIS IS THE TITLE FOR THE PROBLEM

RECEIVED INTENSITY VS RANGE AT DEPTHS

R(KM)	TYPE	50.000	150.000	250.000	350.000	450.000
1.000	R	-57.4	-57.5	-57.5	-57.6	-57.3
2.000	R	-62.3	-62.8	-62.7	-62.7	-62.4
3.000	R	-65.0	-66.9	-60.4	-66.0	-65.8
4.000	R	-67.6	-69.1	-68.5	-68.4	-68.3
5.000	3	-71.8	-72.3	-72.0	-71.4	-70.8
5.000	R	-69.3	-71.1	-70.6	-70.8	-70.5
6.000	R	-76.4	-69.1	-68.4	-72.6	-72.4
7.000	R	-77.4	-68.1	-71.6	-70.6	-74.2
8.000	R	-80.0	-84.6	-75.4	-70.2	-72.8
9.000	R	-78.3	-85.8	-70.2	-75.3	-75.5
10.000	3	-80.1	-77.9	-77.3	-76.6	-74.1
10.000	R	-82.9	-89.1	-78.8	-77.1	-74.0
11.000	R	-85.4	-87.4	-87.7	-80.1	-78.2
12.000	R	-91.6	-83.8	-97.7	-80.4	-81.2
13.000	R	-93.1	-85.9	-84.4	-84.0	-87.3
14.000	R	-94.9	-86.9	-97.8	-87.9	-84.7
15.000	3	-94.4	-83.7	-82.6	-81.6	-79.4
15.000	R	-94.3	-87.8	-88.3	-88.7	-89.0
16.000	R	-92.1	-98.5	-88.3	-89.3	-89.5
17.000	R	-114.7	-96.9	-96.8	-95.0	-90.5
18.000	R	-115.7	-113.7	-90.7	-89.1	-91.6
19.000	R	-115.8	-114.4	-93.3	-89.7	-89.8
20.000	3	-99.5	-86.7	-84.1	-82.3	-82.9
20.000	R	-119.4	-115.9	-114.8	-94.5	-90.9
21.000	R	-129.6	-117.5	-121.3	-122.4	-88.7
22.000	R	-138.6	-120.1	-120.3	-122.3	-122.5
23.000	R	-143.0	-119.4	-121.5	-121.6	-123.5
24.000	R	-145.4	-127.9	-121.5	-123.0	-123.0
25.000	3	-98.2	-87.8	-84.5	-79.3	-84.1
25.000	R	-143.0	-137.2	-120.8	-123.7	-123.3
26.000	R	-142.7	-139.9	-121.2	-127.9	-125.2
27.000	R	-147.1	-132.7	-120.8	-123.7	-98.9
28.000	R	-145.5	-133.8	-118.6	-124.0	-89.4
29.000	R	-147.1	-141.8	-129.8	-123.3	-89.6
30.000	3	-99.8	-88.7	-85.3	-84.6	-84.9
30.000	R	-158.9	-132.9	-119.6	-122.9	-99.4
31.000	R	-159.8	-114.7	-118.5	-123.0	-121.5
32.000	R	-160.2	-134.1	-114.6	-124.0	-111.2
33.000	R	-159.9	-145.8	-121.9	-124.2	-113.3
34.000	R	-160.0	-136.8	-123.0	-114.2	-114.3
35.000	3	-100.8	-89.3	-86.0	-85.7	-85.6
35.000	R	-166.6	-139.9	-123.5	-114.5	-92.9
36.000	R	-166.0	-165.7	-121.4	-117.9	-94.0
37.000	R	-165.6	-135.5	-127.5	-118.5	-86.3
38.000	R	-163.6	-121.8	-126.6	-116.5	-80.6
39.000	R	-164.0	-124.3	-124.1	-118.8	-85.1
40.000	3	-101.6	-89.9	-86.6	-85.8	-86.2
40.000	R	-163.1	-124.8	-101.4	-80.0	-86.3
41.000	R	-104.0	-104.3	-98.9	-78.3	-88.4
42.000	R	-102.3	-101.7	-81.3	-79.5	-87.8
43.000	R	-94.3	-94.7	-91.5	-81.1	-82.3
44.000	R	-96.2	-96.4	-84.3	-80.9	-83.6
45.000	3	-102.3	-90.4	-87.1	-86.3	-86.7
45.000	R	-97.5	-97.4	-82.9	-82.2	-83.8
46.000	R	-98.5	-95.4	-79.2	-81.3	-83.5
47.000	R	-99.1	-98.9	-83.1	-89.0	-79.0
48.000	R	-99.6	-98.8	-83.3	-81.6	-78.9
49.000	R	-100.1	-100.7	-81.6	-87.7	-84.1
50.000	3	-102.9	-90.9	-87.6	-86.0	-87.1
50.000	R	-100.2	-86.5	-78.8	-89.5	-85.2
51.000	R	-99.7	-85.7	-75.3	-88.9	-89.6
52.000	R	-101.3	-74.9	-84.3	-86.7	-88.1
53.000	R	-101.2	-79.2	-82.8	-84.4	-87.5
54.000	R	-100.9	-85.9	-82.5	-84.1	-85.2
55.000	3	-103.4	-91.3	-88.0	-84.9	-87.5
55.000	R	-120.0	-92.3	-85.1	-86.4	-85.0
56.000	R	-103.4	-91.1	-85.2	-86.7	-86.8
57.000	R	-85.1	-95.3	-94.2	-86.3	-89.2
58.000	R	-93.5	-91.0	-88.3	-101.3	-94.8
59.000	R	-99.4	-93.8	-9 .2	-100.5	-96.5
60.000	3	-103.9	-91.7	-88.3	-83.1	-87.9
60.000	R	-110.0	-93.8	-97.1	-97.6	-93.6
61.000	R	-110.1	-94.0	-97.9	-98.3	-98.9
62.000	R	-116.4	-110.1	-101.5	-100.5	-98.8
63.000	R	-107.1	-107.9	-100.7	-101.1	-101.1
64.000	R	-106.7	-108.5	-97.0	-102.0	-102.8
65.000	3	-104.5	-92.0	-88.7	-87.9	-88.3
65.000	R	-115.1	-108.9	-108.9	-99.1	-102.7
66.000	R	-128.9	-114.5	-113.7	-100.2	-100.0
67.000	R	-140.4	-126.1	-122.0	-128.5	-101.5
68.000	R	-133.0	-125.7	-119.9	-129.9	-127.7
69.000	R	-135.3	-123.3	-122.2	-130.5	-119.1
70.000	3	-105.1	-92.4	-89.0	-88.3	-88.6
70.000	R	-138.1	-130.9	-127.4	-125.0	-120.2
71.000	R	-138.9	-130.2	-125.5	-116.6	-111.6
72.000	R	-144.4	-135.2	-127.4	-120.2	-93.4
73.000	R	-142.3	-136.7	-128.5	-121.3	-87.1
74.000	R	-140.9	-143.0	-130.0	-123.7	-87.4
75.000	3	-105.3	-92.7	-89.3	-88.5	-88.9
75.000	R	-144.4	-137.2	-135.9	-124.0	-87.3
76.000	R	-155.9	-138.9	-136.3	-123.2	-81.1
77.000	R	-156.4	-146.6	-138.8	-130.2	-91.6
78.000	R	-156.8	-136.6	-130.6	-84.4	-92.9
79.000	R	-156.9	-141.0	-133.0	-82.7	-87.7
80.000	3	-105.6	-93.8	-89.6	-88.8	-89.2
80.000	R	-300.0	-143.2	-128.6	-85.9	-87.5
81.000	R	-300.0	-300.0	-90.9	-83.5	-87.4
82.000	R	-300.0	-140.5	-92.1	-86.2	-89.5
83.000	R	-171.1	-124.6	-88.6	-87.5	-89.3
84.000	R	-111.1	-111.1	-86.5	-91.8	-89.1

Fig. 9 — Example of an output from ITNPRINT (first of three pages). The symbols that the subroutine uses in the second column are R for type I random phase calculations, S for type I coherent phase calculations, 2 for type II calculations, and 3 for type III calculations.

85.000	8	-105.7	-93.2	-89.9	-88.1	-89.6
85.000	8	-113.1	-113.1	-95.4	-90.4	-83.3
86.000	8	-101.8	-102.8	-95.5	-93.9	-87.8
87.000	8	-103.8	-103.9	-87.3	-91.9	-88.7
88.000	8	-104.5	-104.5	-88.1	-87.0	-88.6
89.000	8	-105.2	-105.2	-93.7	-87.1	-91.3
90.000	3	-106.1	-93.4	-90.1	-89.3	-89.7
90.000	8	-105.6	-105.6	-87.2	-86.8	-89.2
91.000	8	-105.9	-103.7	-88.1	-88.8	-90.1
92.000	8	-106.1	-99.7	-91.2	-90.4	-83.8
93.000	8	-106.2	-106.2	-89.8	-79.0	-88.2
94.000	8	-106.1	-106.2	-84.2	-88.7	-95.5
95.000	3	-106.5	-93.7	-90.3	-89.6	-88.9
95.000	8	-106.0	-83.4	-87.2	-90.6	-92.0
96.000	8	-105.8	-91.0	-88.4	-92.6	-91.7
97.000	8	-88.2	-88.9	-89.7	-91.3	-92.5
98.000	3	-103.6	-85.3	-90.1	-90.2	-91.7
99.000	8	-103.4	-82.6	-87.9	-90.4	-90.8
100.000	3	-106.8	-93.9	-90.6	-89.8	-90.1
100.000	3	-108.8	-93.9	-90.6	-88.8	-90.1
100.000	8	-112.5	-97.8	-90.4	-88.8	-85.5
105.000	3	-107.0	-94.2	-90.8	-90.0	-90.3
110.000	3	-105.4	-94.9	-91.1	-88.4	-90.6
115.000	3	-108.2	-93.3	-91.5	-88.9	-90.8
120.000	3	-106.8	-93.4	-91.8	-89.3	-91.0
125.000	3	-107.2	-93.7	-92.0	-89.7	-91.2
130.000	3	-107.8	-91[illegible]	-92.2	-90.5	-91.4
135.000	3	-95.5	-91.[illegible]	-92.1	-90.5	-91.7
140.000	3	-99.8	-91.8	-91.6	-90.4	-91.9
145.000	3	-100.1	-92.2	-91.9	-90.8	-92.1
150.000	3	-100.3	-90.5	-92.4	-91.0	-92.3
155.000	3	-101.2	-92.5	-92.7	-91.2	-92.4
160.000	3	-101.7	-92.7	-92.9	-90.6	-92.6
165.000	3	-101.9	-91.1	-92.3	-90.9	-92.7
170.000	3	-99.2	-91.6	-92.3	-91.4	-92.9
175.000	3	-100.5	-92.8	-92.8	-91.5	-93.1
180.000	3	-101.0	-90.8	-93.1	-91.8	-93.2
185.000	3	-101.4	-91.8	-93.4	-91.9	-93.4
190.000	3	-101.6	-91.4	-90.6	-92.1	-93.4
195.000	3	-101.9	-92.3	-91.5	-92.3	-93.5
200.000	3	-97.6	-92.7	-91.8	-92.5	-93.7
200.000	3	-97.6	-92.7	-91.8	-92.5	-93.7
205.000	3	-99.5	-93.0	-92.8	-92.7	-93.8
210.000	3	-100.1	-93.3	-92.6	-93.0	-94.0
215.000	3	-100.8	-93.3	-93.1	-93.2	-94.1
220.000	3	-101.2	-93.6	-93.5	-93.3	-94.2
225.000	3	-98.3	-93.9	-91.5	-93.4	-94.4
230.000	3	-99.1	-94.2	-92.3	-93.6	-94.4
235.000	3	-99.3	-94.4	-92.5	-93.7	-94.5
240.000	3	-99.5	-94.6	-93.0	-93.7	-94.6
245.000	3	-98.1	-94.8	-93.6	-94.0	-94.8
250.000	3	-99.2	-94.7	-90.6	-94.1	-94.9
255.000	3	-99.6	-94.3	-93.1	-94.3	-95.0
260.000	3	-98.5	-94.4	-93.5	-94.4	-95.1
265.000	3	-99.2	-92.0	-93.7	-94.5	-95.0
270.000	3	-99.2	-93.7	-93.9	-94.6	-95.2
275.000	3	-99.6	-93.8	-92.1	-94.7	-95.3
280.000	3	-99.8	-94.2	-93.5	-94.8	-95.4
285.000	3	-100.0	-94.7	-92.7	-95.0	-95.5
290.000	3	-100.3	-95.0	-93.6	-95.1	-95.6
295.000	3	-100.8	-95.3	-93.8	-95.2	-95.7
300.000	3	-100.4	-93.0	-94.0	-95.3	-95.8
300.000	3	-100.4	-93.0	-94.0	-95.3	-95.8
305.000	3	-100.7	-94.4	-94.1	-95.3	-95.9
310.000	3	-100.7	-94.7	-94.1	-95.4	-96.0
315.000	3	-100.9	-94.8	-94.4	-95.5	-96.1
320.000	3	-100.8	-94.9	-94.7	-95.6	-96.2
325.000	3	-98.4	-95.1	-94.9	-95.7	-95.4
330.000	3	-99.8	-94.6	-95.1	-95.9	-95.4
335.000	3	-100.3	-93.3	-95.2	-96.0	-95.7
340.000	3	-100.6	-94.9	-95.3	-96.0	-95.9
345.000	3	-100.9	-94.7	-95.2	-96.1	-95.6
350.000	3	-101.1	-93.8	-95.4	-96.2	-95.5
355.000	3	-101.2	-94.7	-95.6	-96.2	-95.9
360.000	3	-101.4	-95.0	-95.7	-96.2	-96.1
365.000	3	-101.5	-94.5	-95.8	-96.3	-96.2
370.000	3	-101.6	-94.7	-95.9	-96.4	-96.3
375.000	3	-101.8	-94.5	-96.0	-96.5	-96.4
380.000	3	-99.5	-94.8	-96.1	-96.6	-96.5
385.000	3	-100.2	-95.0	-96.2	-96.7	-96.6
390.000	3	-100.8	-95.2	-96.2	-96.8	-95.3
395.000	3	-101.0	-95.2	-96.3	-96.8	-96.1
400.000	3	-99.7	-95.5	-96.4	-96.9	-96.5
400.000	3	-99.7	-9[illegible].5	-96.4	-96.9	-96.5
405.000	3	-98.5	-95.7	-96.5	-97.0	-96.7
410.000	3	-99.2	-95.9	-96.5	-96.2	-96.8
415.000	3	-97.8	-95.9	-96.6	-96.0	-96.9
420.000	3	-98.1	-96.1	-96.7	-96.2	-97.0
425.000	3	-97.6	-96.2	-96.8	-96.3	-97.1
430.000	3	-96.8	-96.3	-96.9	-96.5	-97.1
435.000	3	-96.9	-96.5	-97.0	-96.2	-97.2
440.000	3	-97.4	-96.6	-97.0	-96.7	-97.2
445.000	3	-97.8	-96.7	-97.1	-96.9	-97.3
450.000	3	-93.5	-96.9	-97.3	-97.0	-97.4
455.000	3	-95.2	-97.0	-96.4	-97.1	-97.5
460.000	3	-96.1	-97.0	-97.4	-97.2	-97.6
465.000	3	-96.0	-97.1	-97.5	-97.3	-97.6
470.000	3	-96.4	-97.2	-97.5	-97.4	-97.7
475.000	3	-96.6	-97.2	-97.6	-97.4	-97.7
480.000	3	-96.3	-97.3	-97.6	-97.5	-97.8
485.000	3	-96.9	-97.4	-97.7	-97.6	-97.8
490.000	3	-97.3	-97.1	-96.7	-97.3	-97.9
495.000	3	-97.5	-97.2	-97.2	-97.6	-98.0
500.000	3	-97.5	-97.4	-97.4	-97.7	-97.4
500.000	3	-97.5	-97.4	-97.4	-97.7	-97.4

Fig. 9 — Example of an output from ITNPRINT (second of three pages)

505.000	3	-96.7	-97.6	-97.5	-97.8	-97.8
510.000	3	-97.0	-97.7	-97.5	-97.8	-97.9
515.000	3	-97.2	-97.9	-97.3	-97.9	-98.0
520.000	3	-97.4	-97.9	-97.5	-97.9	-97.0
525.000	3	-97.2	-98.0	-97.7	-98.0	-97.2
530.000	3	-97.6	-97.8	-97.9	-98.1	-97.5
535.000	3	-96.8	-97.4	-98.0	-98.2	-97.6
540.000	3	-96.8	-97.7	-98.0	-98.2	-97.7
545.000	3	-97.1	-97.8	-97.9	-98.3	-97.9
550.000	3	-97.2	-97.8	-98.0	-98.3	-97.9
555.000	3	-97.3	-97.9	-98.1	-97.8	-98.0
560.000	3	-96.9	-97.8	-98.2	-98.2	-98.1
565.000	3	-96.0	-98.0	-98.3	-98.3	-98.2
570.000	3	-96.7	-98.1	-98.4	-98.1	-98.3
575.000	3	-94.9	-98.2	-98.5	-97.5	-98.3
580.000	3	-96.4	-98.2	-98.5	-97.9	-98.3
585.000	3	-96.5	-98.1	-98.5	-98.1	-98.4
590.000	3	-94.5	-98.5	-98.0	-98.2	-97.2
595.000	3	-96.4	-98.5	-98.5	-98.1	-98.1
600.000	3	-96.6	-98.4	-98.4	-98.3	-97.8
600.000	3	-96.6	-98.8	-98.4	-98.3	-97.6
605.000	3	-97.0	-98.8	-98.5	-98.3	-97.5
610.000	3	-97.2	-98.5	-98.6	-98.4	-97.9
615.000	3	-97.5	-98.8	-98.3	-98.5	-98.1
620.000	3	-97.6	-98.5	-98.5	-98.3	-98.2
625.000	3	-97.7	-98.4	-98.5	-97.9	-98.2
630.000	3	-97.8	-98.5	-98.6	-98.1	-98.3
635.000	3	-97.9	-98.5	-98.7	-97.5	-98.4
640.000	3	-98.1	-98.4	-98.7	-98.0	-98.5
645.000	3	-98.0	-98.8	-98.8	-98.2	-98.5
650.000	3	-98.3	-98.7	-98.8	-98.3	-98.6
655.000	3	-98.4	-98.8	-98.8	-98.4	-98.6
660.000	3	-98.4	-98.7	-98.8	-98.4	-98.6
665.000	3	-98.5	-98.8	-98.8	-98.4	-98.6
670.000	3	-98.6	-98.7	-98.8	-98.4	-98.6
675.000	3	-98.7	-98.3	-98.5	-98.5	-98.7
680.000	3	-98.8	-98.2	-98.4	-98.6	-98.7
685.000	3	-98.9	-98.2	-98.4	-98.6	-98.7
690.000	3	-97.8	-98.2	-98.4	-98.6	-98.7
695.000	3	-98.5	-98.1	-98.2	-98.8	-98.8
700.000	3	-98.6	-98.1	-98.2	-98.9	-98.9
700.000	3	-98.8	-98.1	-98.2	-98.8	-98.9
705.000	3	-98.4	-98.1	-98.2	-98.9	-98.9
710.000	3	-98.7	-98.1	-98.2	-98.9	-98.9
715.000	3	-98.9	-98.1	-98.3	-98.9	-98.9
720.000	3	-98.8	-98.2	-98.3	-98.9	-96.7
725.000	3	-99.3	-98.2	-98.3	-98.9	-97.9
730.000	3	-99.1	-98.2	-98.2	-98.9	-98.0
735.000	3	-99.2	-98.2	-98.2	-98.1	-98.0
740.000	3	-99.3	-98.2	-98.2	-98.5	-96.0
745.000	3	-98.3	-98.4	-98.4	-98.8	-97.1
750.000	3	-98.3	-98.4	-98.4	-97.0	-97.1
755.000	3	-98.6	-98.5	-98.5	-97.3	-97.4
760.000	3	-98.7	-98.4	-98.4	-97.2	-97.6
765.000	3	-98.7	-98.4	-98.4	-98.8	-97.6
770.000	3	-98.7	-98.5	-98.3	-96.7	-97.6
775.000	3	-98.9	-98.8	-98.3	-96.6	-97.8
780.000	3	-99.0	-97.8	-98.4	-96.3	-97.8
785.000	3	-98.5	-98.7	-98.4	-95.4	-97.9
790.000	3	-96.7	-98.7	-98.4	-98.9	-98.0
795.000	3	-98.7	-98.7	-98.3	-98.9	-98.0
800.000	3	-98.4	-98.7	-98.3	-98.9	-98.0
800.000	3	-98.6	-98.7	-98.3	-98.9	-98.0
805.000	3	-97.9	-98.7	-98.2	-98.8	-97.9
810.000	3	-98.2	-98.4	-98.1	-98.7	-97.9
815.000	3	-98.4	-98.7	-98.0	-98.7	-97.9
820.000	3	-98.4	-98.7	-97.8	-98.6	-97.9
825.000	3	-98.5	-98.7	-97.6	-98.6	-97.9
830.000	3	-98.6	-98.4	-97.3	-98.5	-97.8
835.000	3	-98.7	-98.7	-97.9	-98.8	-97.8
840.000	3	-98.5	-98.5	-97.6	-98.6	-97.9
845.000	3	-98.6	-98.5	-99.0	-98.5	-98.1
850.000	3	-99.9	-98.8	-99.0	-98.5	-98.1
855.000	3	-98.9	-98.8	-99.0	-98.5	-98.1
860.000	3	-98.9	-98.5	-99.0	-98.3	-98.3
865.000	3	-98.9	-98.5	-99.0	-98.2	-98.5
870.000	3	-98.9	-98.5	-98.9	-98.1	-98.7
875.000	3	-99.0	-98.4	-98.9	-98.1	-98.7
880.000	3	-99.1	-98.8	-98.9	-98.1	-98.7
885.000	3	-98.4	-98.4	-98.9	-98.0	-98.6
890.000	3	-98.3	-98.5	-98.8	-97.7	-98.6
895.000	3	-98.4	-98.5	-98.8	-97.4	-98.8
900.000	3	-97.6	-98.7	-98.8	-97.2	99.7
900.000	3	-97.6	-98.7	-98.8	-97.2	-98.7
905.000	3	-97.8	-98.8	-98.8	-97.1	-98.7
910.000	3	-97.9	-98.4	-98.8	-98.8	-98.6
915.000	3	-98.1	-98.8	-98.8	-98.4	-98.6
920.000	3	-98.2	-98.8	-98.6	-98.3	-98.5
925.000	3	-98.3	-98.5	-98.7	-98.2	-98.2
930.000	3	-98.3	-98.5	-98.6	-98.2	-98.6
935.000	3	-98.5	-98.5	-98.8	-98.2	-96.7
940.000	3	-98.4	-98.4	-98.6	-98.8	-98.9
945.000	3	-98.5	-98.4	-98.6	-98.3	-96.9
950.000	3	-98.8	-98.4	-98.6	-98.1	-98.9
955.000	3	-98.4	-98.4	-98.6	-98.1	-98.9
960.000	3	-98.6	-98.4	-98.6	-97.9	-98.8
965.000	3	-97.9	-98.1	-98.5	-98.9	-98.6
970.000	3	-97.9	-98.1	-98.5	-98.9	-98.8
975.000	3	-97.9	-98.1	-98.4	-98.9	-98.8
980.000	3	-98.1	-98.2	-98.4	-98.9	-98.7
985.000	3	-98.1	-98.2	-98.3	-98.8	-98.7
990.000	3	-98.1	-98.1	-98.3	-98.8	-98.6
995.000	3	-98.2	-98.1	-98.3	-98.8	-98.6
1000.000	3	-98.3	-98.1	-98.4	-98.9	-98.7
1000.000	3	-98.3	-98.1	-98.4	-98.9	-98.7

Fig. 9 — Example of an output from ITNPRINT (third of three pages)

Subroutine IVSRPLOT

Subroutine IVSRPLOT plots intensity versus range (Fig. 10). The first entry prints the heading, chooses the correct type of calculation, and then plots a line or the first range. Each succeeding call plots just a line for another range. Only one type may be plotted per data case.

Subroutine INTENSTY

Subroutine INTENSTY calculates all intensities. The switches ISCP, IT1, IT2, and IT3 determine what is calculated. When one selects coherent phase (ISCP = 1) one must also select random phase (IT1 = 1). Coherent phase intensity takes the phase of the ray into account in the calculations. If SL is a function of the random-phase sound level, then the coherent sound level is $(\sqrt{SL}*\cos(P))^2 + (\sqrt{SL}*\sin(P))^2$, where P is the phase angle. To get each, set IT2 = 1 for type II calculations and IT3 = 1 for type III calculations.

The only caustic correction which is applied to type I calculations is a ray-separation criterion: if two rays are closer together than 0.001 meter in depth, the eigenray for these two rays is thrown out. Type II and Type III intensity calculations do not have caustics.

Subroutine RECOVERY

Subroutine RECOVERY has two entry points: DUMP and RESTART. Its function is to enable one to restart a program. DUMP writes all the core locations on a tape when it is called, and RESTART restores core to its previous condition when it is called by reading the tape from DUMP.

Subroutine RETRY

Subroutine RETRY enables one to restart a program in which the multiple replacement option has been used (as was discussed for card II in the Input Description). Its chief function is to read any profile cards which have not yet been read and to write them on logical unit 6 for subroutine NEWPROF to read when required.

Subroutine CLOSEIOP

The function of subroutine CLOSEIOP is to alleviate a systems problem in punching intensity cards when using RESTART. Without this subroutine the cards would be punched in binary instead of BCD when RESTART is called. This subroutine might not be required in another computer system, if the proper moding of logical units is accomplished automatically.

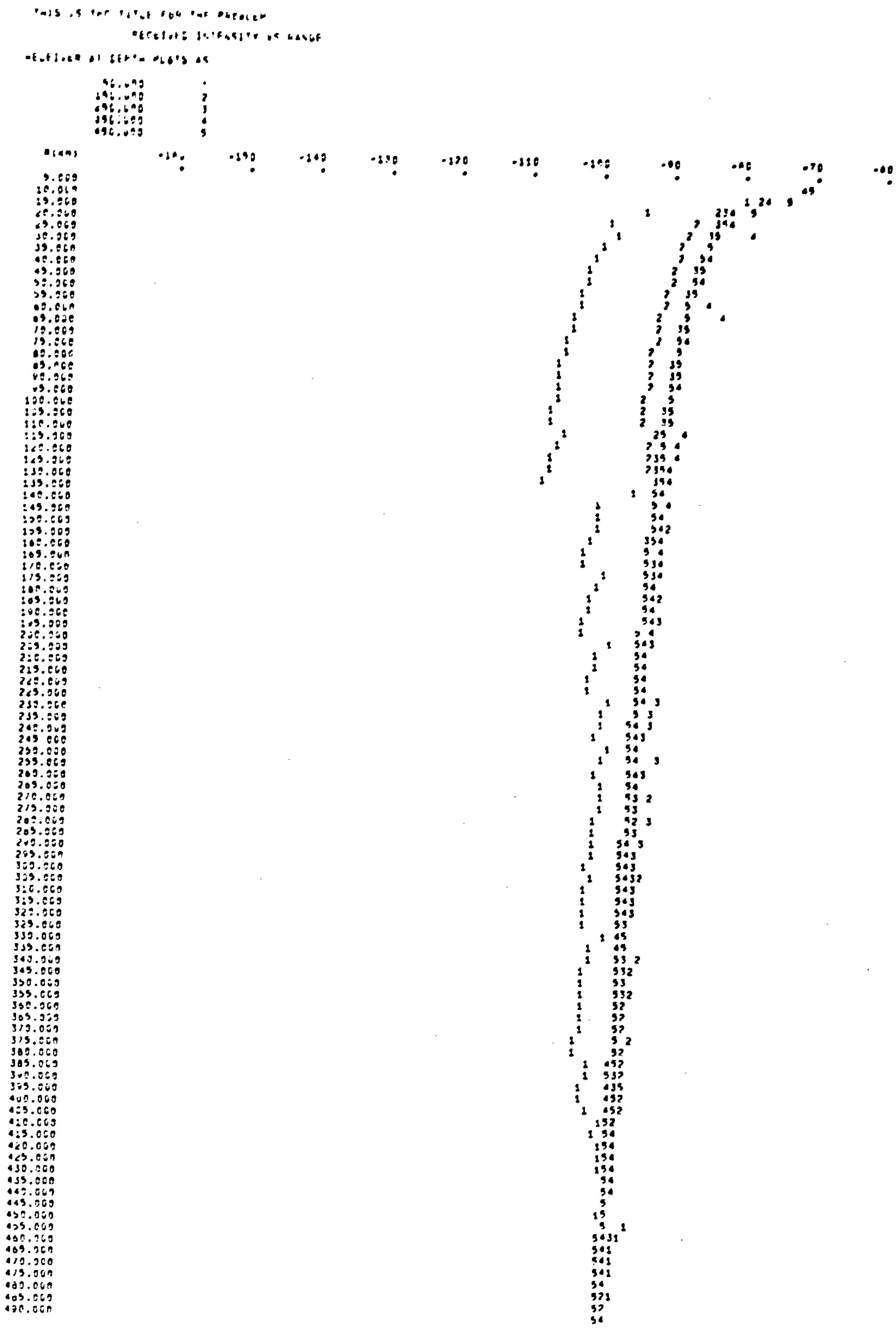


Fig. 10 — Example of the output from IVSRPLOT

Subroutine BYEBYE

Subroutine BYEBYE is called in place of the Fortran statement STOP to terminate the program. It was written to avoid a CDC3800 systems problem when DUMP is called in the executive program. It might not be necessary to have this in another computer system, in which case the STOP statement could be reinserted, if desired.

DIFFERENT INTENSITIES IN TRIMAIN

In subroutine RAYZDIST (ray depth distribution) a quantity is printed titled LOSSES (Fig. 6). This quantity is equal to 10 $\log_{10}$ (S), where S represents all the losses due to bottom interactions, surface interactions, and volume attenuation. Spreading loss is not included in these figures.

In subroutine INTENSTY a quantity is printed for the eigenray printout called SL (DB). If we let SS (I) denote the quantity called S in RAYZDIST for the current ray and SS (I-1) denote S for the previous ray, then we let $S1$ = secant (current ray angle) [SS (I-1)] and let DS = secant (previous ray angle) [$SS(I)$-$S1$]. The ray depth at a given point may be identified as $ZZ(I)$. So if we are considering ray I, then $Z1 = ZZ(I-1)$ and $DZ = ZZ(I) - Z1$. If ZR is the receiver depth, then we let $F = (ZR - Z1)/DZ$. We let RMAX be the range to this point in meters. Then we define a quantity $SL = (S1 + F\ DS)/$[RMAX ABS (DZ)]. Thus the quantity printed for SL(DB) is 10 $\log_{10}$ (SL).

The third parameter which is printed is the type I intensity and is derived in subroutine INTENSTY. This set consists of summing all the eigenrays, or the SL, for a given receiver and range point and then computing

$$10 \log \sum_{i=1}^{N} SL_i \text{ (incoherent or random phase sum)},$$

where N is the number of eigenrays determined for this point. If the Lloyd's mirror switch is not on, the final intensity value can be arrived at as stated, but if the Lloyd's mirror switch is on, each eigenray is multiplied by a factor before they are summed; thus it is not always possible to sum the eigenrays as printed to arrive at the final intensity.

The type II intensity calculation was initially proposed [2] using a Gaussian distribution, which smears a ray over a displaced bundle of intensity. DZBAR is a size parameter for that smearing and is defined by DZBAR = SDZ/SW, where we are using the mean absolute difference between ray depths, weighted by the signal strength of the ray, such that

$$SW = \sum_{i=2}^{\text{NRAY}} W_i = \sum_{i=2}^{\text{NRAY}} \min\ (SS_i, SS_i - 1),$$

which is the sum of the weights, and

$$SDZ = \sum_{i=2}^{NRAY} Wi\,(ZZ_i - ZZ_{i-1})$$

which is the sum of the weighted mean differences.

If DZBAR is less than a wavelength, then DZBAR is set equal to a wavelength. $DZM = ZB/\sqrt{\text{NRAY}}$, where ZB is the bottom depth and NRAY is the number of rays traced. If DZBAR is greater than DZM, then DZBAR = DZM. This is a check to see that DZBAR is not a large fraction of the bottom depth. If 100 rays were traced, then DZBAR would never be larger than 1/10 of the bottom depth.

If RMAX is the range ot this point, then let F = 2.0*RMAX*DZBAR. Let $ER = e^{-(ZR/\text{DZBAR})}$, where ZR is the receiver depth, let $EB = e^{-(ZB/\text{DZBAR})}$, and let $EZ = e^{-(ZZ(I)/\text{DZBAR})}$. Now $SL = B*\sec\theta*SS(I)/F$ where B is the volume attenuation. If a ray is close to the bottom, it does not get its full share of the intensity, since the intensity is distributed exponentially on either side of the ray. Thus, it is necessary to renormalize the distribution by saying $SL = SL/(1 - .5*((EB/EZ) + EZ))$.

We now want to calculate the quantity $A = e^{-(ABS(ZZ(I)-ZR)/\text{DZBAR})}$, which expression is always less than 1.0. The final expression for each ray is then $S_i = SL*A$. The final intensity at a receiver is given by computing, in subroutine ITNPRINT,

$$10 \log \sum_{i=1}^{N} Si\,.$$

In calculating the Type III intensity [2] it is assumed that a current velocity profile prevails to represent a local average over a convergence zone, which wipes out the phase of a ray. The ray turnover and turnunder depths are calculated for each ray, and then the ray cycle length is computed. Next the expression $SL = B*SS(I)/\text{RMAX}$ is computed to get cylindrical spreading. If a given receiver is between the turnunder and turnover depths, entry WDENS is called, which returns the parameter S, the signal strength parameter, which represents the probability density that the ray is at this depth. This probability density $T = 1/ABS(\text{TAN}\theta)$ is normalized in WDENS by dividing by the ray cycle length. The cylindrical spreading term is multiplied by signal-strength parameter S_i to get a contribution for each ray which is then summed as

$$10 \log \sum_{i=1}^{N} SL_i * S_i$$

to arrive at the final values.

EIGENRAY OUTPUT OPTION

The computer coding for the eigenray output option appears within the subroutine INTENSTY. If a request is made either for type I random intensity or type I coherent intensity, then it is possibel to obtain an eigenray output (Fig. 11) by setting column 25 on the output control card (card group V in Fig. 1) equal to 1. The concept of an eigenray may be envisioned as an interpolated ray which will strike a receiver and is found by linearly interpolating between two rays which bracket a receiver. For certain cases eigenrays will be formed from rays which do not bracket a receiver. This is caused primarily by consecutive rays which have different histories; in this case there is some ray between the two existing rays which would give an eigenray if it were traced. Thus the program extrapolates a value. The program prefers two rays with the same history which bracket a receiver. This represents an IQUAL of 1. If it cannot achieve this, if the next ray history is different from the current ray history, if the previous ray history is the same as the current ray history, and if the receiver is within a distance of 1/2 the ray separation, a forward extrapolation is performed and IQUAL = 2. The same condition may happen on the first two rays of a set, and in this condition IQUAL = 3. If an interpolated ray is found later, the IQUAL = 3 ray will be thrown out, and the IQUAL = 1 ray used. This is indicated by ** after the IQUAL = 1, and the ray which is replaced is the last ray with a 3* at the same receiver depth. The number which is listed for NRAY is the current ray number, and this forms an eigenray in conjunction with the previous ray. The NBR column gives the number of bottom reflections for this ray. The NTU column is the number of turnunders for this ray. NSR gives the number of surface reflections and NTO gives the number of turnovers. RANGE is the distance in meters from the source to this receiver. DEPTH is the ray depth for a given receiver at this range. THETA is an interpolated value for the ray arrival angle at the receiver. TIME is the travel time in seconds to this receiver from the source and is also an interpolated value between the travel times for two rays bracketing a receiver. *SL*(DB) is discussed in the preceeding section of this report.

EIGENRAY SET TEST CASE FOR INTENSITY

NRAY	NBR	NTU	NSR	NTO	RANGE	DEPTH	THETA	TIME	SL(DB)	IQUAL	REM
8	0	7	7	0	370000	350.0000	-10.6075	248.56510	-106.4	3	*
8	0	7	7	0	370000	700.0000	-9.6028	248.60291	-106.5	1	
17	0	11	0	10	370000	350.0000	5.4116	249.38608	-99.5	2	
17	0	11	0	10	370000	700.0000	5.1751	249.36221	-99.5	1	
28	0	7	7	0	370000	350.0000	9.4668	248.56477	-107.9	1	
28	0	7	7	0	370000	700.0000	6.9143	248.52684	-107.9	1	
17	0	22	0	21	740000	700.0000	6.7384	498.73865	-103.7	2	
26	0	22	22	0	1110000	350.0000	4.3020	746.19729	-113.1	1	
26	0	22	22	0	1110000	700.0000	4.4851	746.16336	-113.1	1	

Fig. 11 — Example of an eigenray printout

THE LLOYD'S MIRROR OPTION FOR RECEIVERS

Some examples of the Lloyd's mirror beam pattern are presented in Fig. 12. The receiver depth is at the point where all the lines converge for each plot.

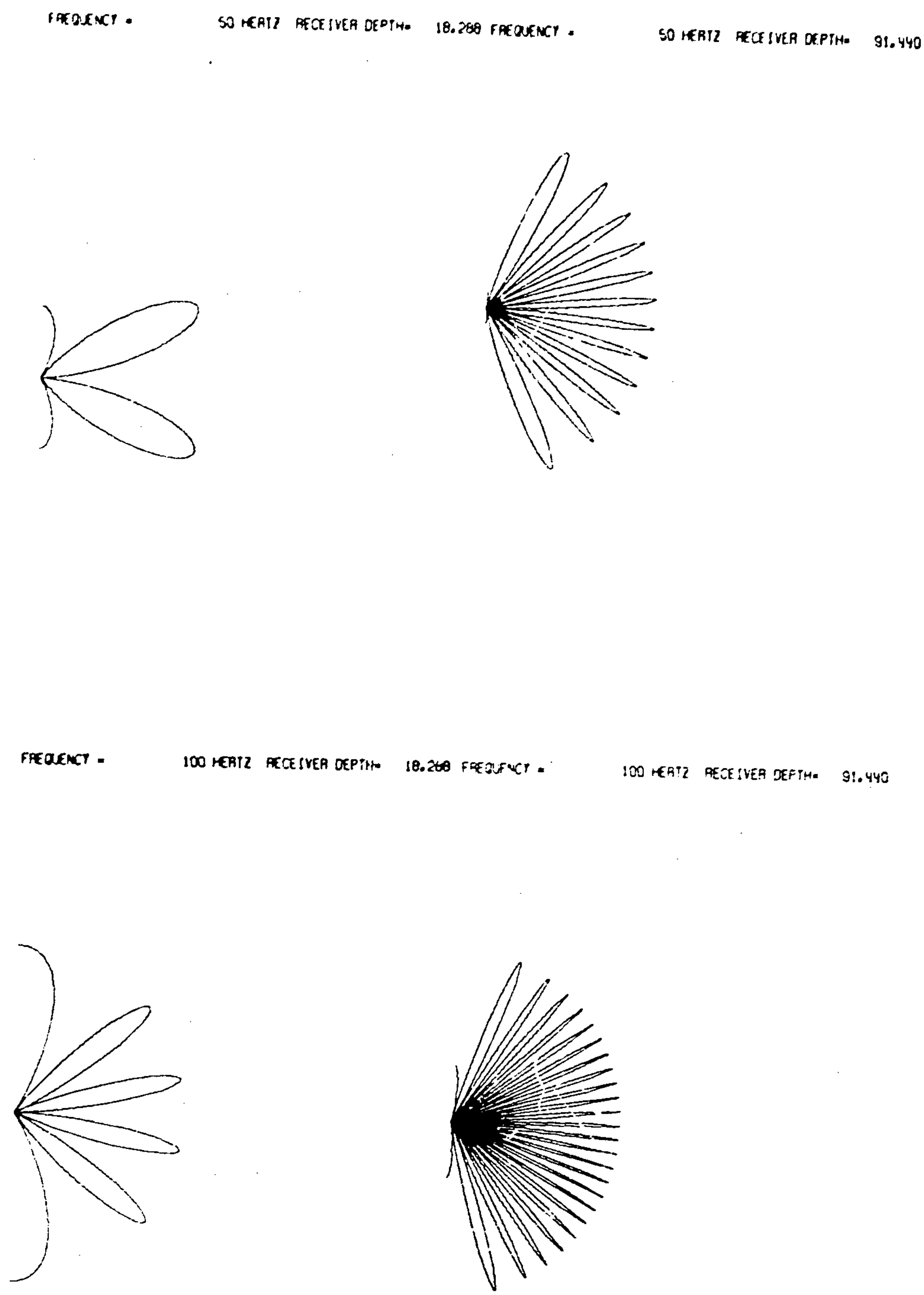


Fig. 12 — Examples of Lloyd's mirror beam patterns for receivers

The computer coding for the Lloyd's mirror option for receivers appears within the subroutine INTENSTY. The switch LLMR, in column 26 of the output control cards, is a receiver Lloyd's mirror switch. When the switch is off (0 or blank), the old intensity is returned, and when on (nonzero), the beam pattern

$$2 \sin^2 \left(\frac{2\pi z}{\lambda} \sin \theta \right) ,$$

where z is the depth, is used for type I random phase, type I coherent phase, Type II, and Type III intensity calculations for all receiver depths. For Type I and II calculations, θ is the ray angle, and for Type III calculations Snell's law is used to calculate the ray angle at the receiver. One can calculate some intensities with and some without the Lloyd's mirror by specifying them on different output control cards.

ADDITIONAL INSTRUCTIONS FOR THE RESTART OPTION

If the restart option is desired, a tape for output must be provided and a backup tape can be provided. Logical unit 15 is the primary output tape. Logical unit 16 is the backup output tape. Logical unit 17 may be used as a second backup tape, but this is optional. If the tape on logical unit 15 was bad when the program attempted the dump and it had to write on logical unit 16 or 17, then that tape would become logical unit 15 for restart. Logical units 16 and 17 may be omitted if you are sure you have a good tape on logical unit 15. The control deck should then have these cards:

7_9 EQUIP, 15 = MT, LO,**, DA

7_9 EQUIP, 16 = MT, LO,**, DA (optional)

7_9 EQUIP, 17 = MT, LO,**, DA (optional)

For dumping on tape the job request form should be as follows:

Logical Unit No.	Input	Output	Save	Tape No. (if not specified, the Computation Center sells you one and assigns a number)
15	☐	☒	☒	Number for tape
16 (Optional)	☐	☒	☒	Number for tape
17 (Optional)	☐	☒	☒	Number for tape
20 (Program tape)	☒	☐	☒	573
1 (Used only for ray tape)	☐	☒	☒	Number for tape

In addition the second card in each case should contain the word DUMP in columns 73 through 76 if a restart capability is desired. If the program runs out of time, one may restart it according to the following procedure.

1. Change the job request form for logical units 15 and 1 as follows:

Logical Unit No.	Input	Output	Save	Tape No.
15	☒	☒	☒	Number for tape
1	☒	☒	☒	Number for tape

However, the output block for logical unit 15 is checked only if a dump is desired again if the program runs out of time, and the input block for logical unit 1 is checked only if the ray tape is being restarted.

2. The first card after your run card must contain RESTART in columns 1 through 7. If a dump is desired again if the program aborts because of lack of time, DUMP is entered in columns 9 through 12 of the same card. One looks through the listing and determines what cards were read last, pulls out all these cards and places the remaining cards behind the card containing the word RESTART. If the multiple replacement option is being used, the profile remaining to be read should be read in from the case in which $LA = 1$. For the next case all cards would have to be read in again. Also the run must have progressed at least one range increment before dump can be called. Thus, if these conditions are not met, the entire deck must be resubmitted. Also, if the last data card read was an end-of-file card, then the first data card read must be the restart card and then the end-of-file card is read. If multiple replacement is being used, one should have the restart card and then a blank card followed by a card with the word START in columns 1 through 5, followed by remaining data. This can be determined by looking at the comment which is printed at the end of the program. Reference 7 is a more complete writeup on the restart option.

CAUTIONS TO THE USER

The following are some cautions to the user:

- If you have six receivers, then you must insert a blank card after the output control card containing the six receivers.
- The number of input and internally generated points in a sound-speed profile cannot exceed 50. The number of internally generated points can be reduced by reading in profiles with common depths.
- Do not read in the second speed-profile at a range less than the second bottom point; otherwise a diagnostic is printed and program aborts. Thus the range to your second bottom point should equal or be less than the range to the second profile.

- The source depth and sound-speed depth for any profile should not be the same; otherwise a diagnostic is printed and the program aborts. To correct this fault, change the source depth by 0.01 meter.
- The first bottom point must be at range zero.
- The maximum number of rays which may be traced is 1000.
- If the program runs for a long time and produces no results, you have specified too large a distance between bottom points or output values and the program is forced to set up long thin triangles. In this case there is difficulty in arriving at the proper ray intersections with the triangles. To correct this condition, insert either additional bottom points or additional output at shorter range increments.

PROGRAM TRIPLT

Program TRIPLT performs a Calcomp plot of the ray trajectories (Fig. 13). It reads an output tape from the main program and plots selected rays to a given range. Cubic splines are employed to give the proper trajectories. A maximum of 512 rays and a maximum of 2000 range increments may be plotted. A portion of the range may be plotted by specifying the number of records (one record being one range increment). A description of the input follows.

The input ray tape should be read in on logical unit 1. Thus the first equip card should be

$$7_9 \text{ EQUIP, } 1 = MT\text{, density, } RO\text{, label.}$$

Logical unit 2 should be equipped for the disk file as 7_9 EQUIP, 2 = *DF*.

Logical unit 10, the plot unit, may be equipped as 7_9 EQUIP, 10 = *PL* or 7_9 EQUIP, 10 = *MT*, *LO*, label, *DA* (to write an output tape to be plotted later).

The job request form should be checked as follows:

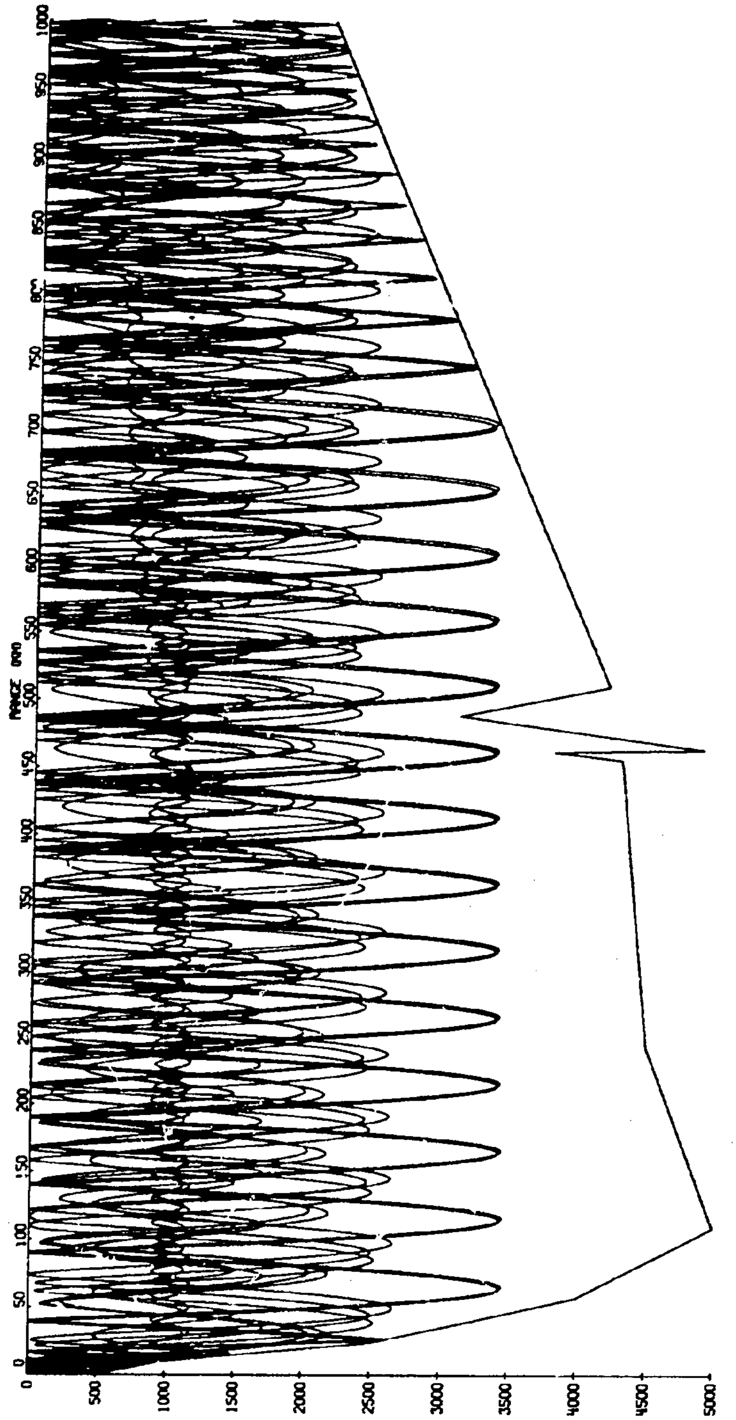


Fig. 13 — Example of a Calcomp plot

Logical Unit No.	Input	Output	Save	Tape Serial No.
1	☒	☐	☒	Input Tape No.
2	☒	☐	☐	*DF*
10	☐	☒	☒	Output Tape No.

Logical unit 10 need be specified only if writing an output tape; if the plot is to be done on line, the 7_9 EQUIP, 10 = *PL* may be used or the card may be omitted. Computer 1 should be specified on the job request form also, because it contains the plotter package. The data deck input is as follows:

First-card Columns	Variable	Meaning
1-2	ITNC	Total number of cases.

Second-card Columns	Variable	Meaning
1-8	AL	Plot length in inches, which must be ⩽120.0.
9-16	ZMAX	Maximum depth of plot, in either feet or meters.
17-20	NRMAX	Number of records to be plotted. There is one record for each range increment on the tape. Plots for a portion of the range from range ZERO may be made by specifying the number of records to that point. To plot the entire range a number may be specified which is larger than the actual number but less than 2001.
21-25	IKNM	If IKNM < O, the range scale will be plotted in nautical miles; if IKNM ⩾ O, the range scale will be in kilometers.
26-30	IFMC	If IFMC < O, the depth scale will be plotted in feet; if IFMC ⩾ O, the depth scale will be plotted in meters.

Second-card Columns	Variable	Meaning
31-35	NFSK	Number of files to skip on the tape before plotting this case.
36-40	ITTR	If ITTR < O, a title card is read to replace the title on the tape; if ITTR ⩾ O, the title from TRIMAIN will be used for the title.
41-45	NSR1	Maximum number of surface hits allowable. The ray will be terminated at this surface hit. If this is left blank, the previous limits from TRIMAIN will be used.
46-50	NBR1	Maximum number of bottom hits allowable, analogous to NSR1.
51-60	ALIM1	Maximum dB loss allowed per ray, similar to NSR1 and NBR1. It is read in as a positive floating-point number, such as 200.0.

Third-card Columns (If ITTR < O)	Variable	Meaning
1-80	TITLE	Title of the plot. This card is omitted if ITTR ⩾ O in columns 36 through 40 of the second card; if this card is omitted, the fourth card becomes the third card.

Fourth-card Columns (or Third-card Columns if ITTR ⩾ O)	Variable	Meaning
1-4	NRPLOT(1)	Number of the first ray to be plotted, which corresponds to the number of the ray in the program TRIMAIN.
5-8	NRPLOT(2)	Number of the second ray to be plotted.
...	...	

Fourth-card Columns (or Third-card Columns if ITTR ⩾ O)	Variable	Meaning
76-80	NRPLOT(20)	Number of the 20th ray to be plotted.
...	...	

Additional-card Columns	Variable	Meaning
1-80	NRPLOT(N)	Numbers of the rays to be plotted, continued 20 per card until the desired number N is reached.

An end of file card terminates each case. The cards beginning with the second card are repeated ITNC times for multiple cases.

REFERENCES

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2. "The Hudson Laboratories Ray Tracing Program," Technical Report 150, Hudson Laboratories of Columbia University, Dobbs Ferry, New York.

3. J.J. Cornyn, Grass: "A Digital-Computer Ray-tracing and Transmission-Loss Prediction System," Volume 1-Overall Description," NRL Report 7621, Dec. 1973.

4. H. Weinberg, "A Continuous-Gradient Curve Fitting Technique for Acoustic-Ray Analysis," J. Acoust. Soc. Am. **50**, 971 (1971).

5. B.G. Roberts, Jr., "Retrieval Program for Archival Nansen-Cast Data," NRL Report 7633, 1973.

6. E.L. Wright, "Ray-tracing with Horizontal and vertical Gradients," J. Acoust. Soc. Am. 48, 92(A) (1970).

7. D.P. Shannon, and A.B. Mays, "A 3800 Subroutine to Allow a Restart Capability for Computer Programs," NRL Research Computation Center Computer Note 46, 1970.

Appendix A

LISTING OF THE PROGRAM

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```
      PROGRAM TRIMAIN
      DIMENSION JUNK(10), R1(10),DR(10),R2(10),STRCD(26,10),JNRC(10),INT
     1   (10),IT(6,10),IRT(10),IRD(10),ISCPEQ(6) ,Z(2,50),V(2,50),TI(9)
      EQUIVALENCE (ISCP,ISCPEQ)
      COMMON /MIRRORS/ FSRL,RRLT(200),RPST(200)
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,
     1   ISCP,IT1,IT2,IT3,IPER,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT
      COMMON /PROFIL/ RENE,N1,Z1(50),V1(50),RTWO,N2,Z2(50),V2(50),IBOTC,
     1IPFL
      COMMON /LOUDNESS/ LNRC,RCD(100),DINT(400)
      COMMON /PRE/ IPROP,IKNM,PLTL,RM,IPCO,IFPR
      DATA (LTRT= 1),(LTER=41),(LTRP=42),(LPIN=60)
      COMMON /PATTERN/ SD,ITRP,DATD,SORLEV
      COMMON /PIDEF/ PI,DTR,TWOPI
      COMMON/LIMITS/R1,DR,R2
      COMMON /TLE/ ITITLE (10)
      COMMON/ABC/PUNCHDS (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1
      COMMON /IFC/ IFE,IA,IB,IP,ID,IS,LA
      COMMON /RANST/ RTWOM,IREC,IFSK,SDS
      PI=4.*ATAN(1.) $IFT=0 $IFT1=0 $ IPCO=0 $TWOPI=PI+PI$DTR=180./PI
    1 READ 900,ITITLE$ IOPT=ITITLE(1) $ WRITE (19) ITITLE
      REWIND 19
      IF (EOF, 60) 155, 2
    2 IF (IOPT.EQ.8HRESTART )GO TO 104     $ GO TO 122
  900 FORMAT(10A8)
  155 IF (IFE.EQ.1) GO TO 152 $ IFE=1 $ GO TO 1
  122 PRINT 901,ITITLE $ RSTART=0.0  $RMAX=0.0   $  NTPLT=0
  901 FORMAT(*1HORIZONTAL GRADIENT RAY TRACE *,10A8)
      READ 902,SD,FKHZ,IATT,SORLEV,ITBP,DATD,SLDB,IABOT,ISCP,NRECUR,
     1IBOTC,IPFL,IPROP,IKNM,PLTL,NBRS,NSRS,ALIM,IA,IB,IP,ID,IS,LA,IOPT
      AL1=ALIM       $  SDS=SD
      FSRL=10.**(-.1*SLDB) $IF(ALIM.NE.0.0)ALIM=POWRF(10.0,(-ALIM/10.0))
  902 FORMAT(F8.3,F5.3,I1,F5.2,I1,2F5.2,7I1,F8.3,2I5,F10.3,6I1,1X,A8)
      OMEGA =2000.*PI*FKHZ $IF (ALIM.EQ.0.0)ALIM=1.0E-30 $ S2=FKHZ**2
      PRINT 903,SD,SORLEV,FKHZ,ITBP,DATD,NBRS,NSRS,AL1,IA,IB,IP,ID,IS,LA
     1,IOPT
  903 FORMAT(*0SOURCE DEPTH*,F8.2,* LEVEL*,F6.1,* FREQ(KHZ)*,F6.3,*  BEA
     1M PATTERN *,I2,3X,*ANGLE=*,F5.1,5X,*NBRS=*,I5,5X,*NSRS=*,I5,5X,*DB
     2LIMIT=*,F10.3,/,5X,*IA=*,I1,5X,*IB=*,I1,5X,*IP=*,I1,5X,*ID=*,I1,
     35X,*IS=*,I1,5X,*LA=*,I1,5X,*IOPT=*,A8)
      IF (NRECUR.GT.0.AND.IBOTC.GT.0)SD=SD*(1.+.5*SD/6371221.3)
      ATT=0.0003025*S2  +44.*S2/(4100.+S2)
      IF(IATT.EQ.0) ATT=0.  $ IF (NBRS.EQ.0) NBRS=2500   $ IVSR=0
      PRINT 904,ATT,SLDB  $ IF (NSRS.EQ.0) NSRS=2500
  904 FORMAT(*0VOLUME ATTENUATION*,F10.6,* DB/KM,  SURFACE LOSS*,F7.2,
     1   * DB.*)
      CALL INITRAYS $ DO 985 J=1,10 $R1(J)=0.0 $DR(J)=0.0
  985 R2(J)=0.0 $IF(IABOT.NE.0) GO TO 15    $  RB=ISCP
      CALL BRLTRC(RB) $IF (LA.EQ.1.OR.IB.EQ.1.OR.IB.EQ.3) REWIND 9
      IF (LA.EQ.1.OR.IB.GE.2) REWIND 8   $ GO TO 18
   15 PRINT 905
      RB=1.E30
  905 FORMAT(*0BOTTOM ABSORBS ALL INCIDENT SOUND ENERGY*)
   18 N=1 $IF (IP.EQ.0.AND.LA.EQ.0.OR.LA.EQ.1) LPC=60 $IF(IP.EQ.1)LPC=4
   20 IF(LPC.EQ.60)READ(LPC,906)R1(N),DR(N),R2(N),IC,(IT(I,N),I=1,6),JVS
     1R,IRD(N),IRP,  IRT(N),IPRAY,(STRCD(I,N),I=1,6)
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      IF(LPC.EQ. 4)READ(LPC)    R1(N),DR(N),R2(N),IC,(IT(I,N),I=1,6),JVS
     1R,IRD(N),IRP,  IRT(N),IPRAY,(STRCD(I,N),I=1,6)
      IF(LA.EQ.1)WRITE(  4)    R1(N),DR(N),R2(N),IC,(IT(I,N),I=1,6),JVSA
     1,IRD(N),IRP,   IRT(N),IPRAY,(STRCD(I,N),I=1,6)
  906 FORMAT(3F6.2,I2,11I1,1X,6F8.4)
      INT(N)=0
      DO 22 I=1,5
   22 INT(N)=INT(N)+IABS(IT(I,N))
      IF (IT(5,N).GT.0) IPER=IT(5,N)
      IF(INT(N).EQ.0) GO TO 30
      PRINT 907,R1(N),DR(N),R2(N),(IT(I,N),I=1,6)
      IF(DR(N).LT.0.) DR(N)=-1.*DR(N)/R1(N)
      IH=6
   23 IF(STRCD(IH,N).GT.0.) GO TO 25
   24 IH=IH-1
      IF(STRCD(IH,N).GT.0.) GO TO 26
      IF(IH.LE.1) 26,24
   25 IL=IH+1
      IH=IH+10
      IF(LPC.EQ.60)READ (LPC,908)(STRCD(I,N),I=IL,IH)
      IF(LPC.EQ. 4)READ (LPC)    (STRCD(I,N),I=IL,IH)
      IF(LA.EQ.1)WRITE (  4)    (STRCD(I,N),I=IL,IH)
C        THE SWITCH ITIM IS NOW LLMR, THE LLOYDS MIRROR SWITCH FOR ALL
C       RECEIVERS ON A GIVEN RANGE FAN CARD
  907 FORMAT(*0OUTPUT RANGES*,3F8.2,5H ISCP,I2,4H IT1,I2,4H IT2,I2,4H IT
     13,I2,5H IPER,I2,5H LLMR,I2)
  908 FORMAT(10F8.2)
      GO TO 23
   26 JNRC(N)=IH
      PRINT 909,(STRCD(I,N),I=1,IH)
      IF (NRECUR.LE.0) GO TO 29
      DO 31 I=1,IH
   31 STRCD (I,N)=STRCD(I,N)*(1.+.5*STRCD(I,N)/6371221.3)
  909 FORMAT(*0RCD*,10F9.2)
   29 IF(JVSR.EQ.0) GO TO 27
      PRINT 910,JVSR
  910 FORMAT(*0INTENSITY VERSUS RANGE PLOT WILL BE MADE FOR TYPE*,I3)
      IF(IVSR.NE.0) PRINT 911
  911 FORMAT(5H ***,*CAUTION9.. ONLY THE LAST I VS R PLOT WILL BE MADE*)
      IVSR=JVSR
      NVSR=N
   27 IF(IRP.EQ.0) GO TO 28
      NTPLT=15
      ZMAX=0.
      DRPLT=1.
      RLPLT=1.E6
      PRINT 915
   28 IF(IRD(N).NE.0) PRINT 912
      IF(IRT(N).NE.0) PRINT 913
  915 FORMAT (*0RAY PLOT WILL BE MADE*)
  912 FORMAT(*0RAY DEPTH DISTRIBUTION WILL BE MADE*)
  913 FORMAT(*0RAY TAPE WILL BE MADE*)
      GO TO 40
   30 IF(IRP.EQ.0) GO TO 33
      NTPLT=STRCD(1,N)+.1
      IF(NTPLT.LT.1) NTPLT=15
```

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```
      ZMAX=STRCD(2,N)
      DRPLT=DR(N)
      RLST=R2(N)
      RLPLT=RLST
      PRINT 915
      PRINT 914,R1(N),DR(N),R2(N)
33    IF(IRD(N)+IRT(N).EQ.0) GO TO 35
      PRINT 914,R1(N),DR(N),R2(N)
914   FORMAT(*0OUTPUT RANGES*,3F10.4)
      IF(IRD(N).NE.0) PRINT 912
      IF(IRT(N).NE.0) PRINT 913
      GO TO 40
35    N=N-1
40    IF(IC.EQ.0) GO TO 45
      N=N+1
      IF (N.GT.10)41,20
  41  PRINT 42
  42  FORMAT (1H0,*NUMBER OF OUTPUT CONTROL CARDS EXCEEDS 10, PROGRAM
     1ABORTED*)
      CALL BYEBYE
45    NR=N   $ IF (LA.EQ.1.OR.IP.EQ.1) REWIND 4
      JRT=0
      RMAX1=0.
      D=1.0  $  D1=DRPLT  $  DELTM=0.0   $ ICA=0  $DELTA=0.0
      DO 47 I=1,NR
      IF (DR(I).LT.D) D=DR(I)      $ IF (DR(I).LT.D1) D1=DR(I)
      IF(R2(I).GT.RLST) RLST=R2(I)
      IF(IT(2,I).EQ.0) GO TO 47
      IF(R2(I).GT.RMAX1) RMAX1=R2(I)
47    JRT=JRT+IRT(I)
      D=D/2.0
      CALL INIT
      CALL NEWPROF(ZM)
      CALL NEWPROF
      CALL CONNECT
      IF(ZMAX.EQ.0.) ZMAX=ZM
      RPLT=1.E6
      IF(NTPLT.EQ.0) GO TO 49
      RPLT=DRPLT
      CALL RAYPLOT(NTPLT,ZMAX)
49    IF(JRT.EQ.0) GO TO 51
      CALL RAYTAPE
51    NOLD=-10
      J=0
      NINT=1
C        IF ALL THE INTENSITY CALCULATIONS HAVE THE SAME RCDS
C        A TABULAR FORMAT WILL BE USED
      DO 55 I=1,NR
      IF(INT(I).EQ.0) GO TO 55
      IF(J.EQ.0) J=I
      IF(J.EQ.I) GO TO 55
      IF(JNRC(I).NE.JNRC(J)) GO TO 54
      K=JNRC(I)
      DO 53 L=1,K
      IF(ABS(STRCD(L,I)-STRCD(L,J)).GT..1) GO TO 54
53    CONTINUE
```

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```
      GO TO 55
54    NINT=2
      GO TO 95
55    CONTINUE
95    RMAX=0.
100   RN=1.E6
      DO 103 I=1,NR
      IF(R1(I).LT.RN) RN=R1(I)
103   CONTINUE
      RSTART=RMAX
      RMAX=AMIN1(.001*RTW0,RPLT,RN)*1000.
      RT=.001*(RMAX+1.)
      IF(RT.GT.RLST+D)     GO TO 140
      IF (IOPT.NE.8HDUMP     ) GO TO 104
      TILTP=TILT
      TILT=TIMELEFT(1)
      DELT=TILTP-TILT
      IF (DELT.LT.0.0) GO TO 108
      ICA=ICA+1
      FICA=ICA
      DELTA=DELTA+DELT
      DELTM=DELTA/FICA
  108 RER=(RLST-(RSTART/1000.0))/D1
      TOTIME=RER*DELTM*2.0
      TOTIMM=TOTIME/60.0
      IF (TILT.LE.90.0+DELTM.AND.TOTIME.GE.30.0*DELTM) 107,104
  107 IF (JRT.NE.0) BACKSPACE 1    $ CALL DUMP
      PRINT 105,TILT,TOTIMM
  105 FORMAT(1H0,*PROGRAM ABORTED, INSUFFICIENT RUN TIME,  TIME REMAININ
     1G=*,F10.3,* SECONDS*,5X,*ESTIMATED TIME TO FINISH RUN=*,F10.3,
     2* MINUTES6)
      PRINT 101,RTW0M
  101 FORMAT (1H0,*REMOVE DATA DECK THROUGH PROFILE AT RANGE*,F10.3,* KM
     1 BEFORE RESTARTING CASE*,/)
      IF (IFE.EQ.1) PRINT 106
      IF (IS.EQ.1.AND.IFE.EQ.0) PRINT 112
  112 FORMAT (1H0,*INSERT BLANK CARD AFTER RESTART CARD, FOLLOWED BY A C
     1ARD WITH WORD START IN COLUMS 1-8, FOLLOWED BY REMAINING DATA*,/)
  106 FORMAT (1H0,*INSERT END OF FILE CARD AFTER RESTART CARD BEFORE RES
     1TARTING CASE*,/)
      IF (IFE.EQ.1) GO TO 111
  109 READ 900,JUNK
      IF (EOF,60)111,109
  111 CALL BYEBYE
  104 IF (IOPT.NE.8HRESTART ) GO TO 102
      IF (IOPT.EQ.8HRESTART ) CALL RESTART  $  CALL CLOSEIOP
      PRINT 901,ITITLE         $  DO 113 J=1,10
  113 JUNK(J)=ITITLE(J)   $ READ (19) ITITLE
      REWIND 19
      IF (ITITLE(1).EQ.8HRESTART ,AND.IS.EQ.1.AND.IFE.EQ.0) CALL RETRY
      IOPT1=ITITLE(2)
      IF (IOPT1.EQ.8H        ) IOPT=IOPT1    $ DO 114 J=1,10
  114 ITITLE(J)=JUNK(J) $ IF (JRT.EQ.0) GO TO 102  $ DO 121 J=1,IFSK
  121 CALL SKIPFILE (1)     $ DO 123 J=1,IREC
  123 READ (1)
  102 CALL ADVANCE $IF(RMAX+7.1.LT.RTW0) GO TO 110      $  CALL NEWPROF
```

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       CALL CØNNECT
 110   IF(RT.LT.RPLT) GØ TØ 115      $  CALL RAYPLØT
       RPLT=RPLT+DRPLT
       IF(RPLT.GT.RLPLT+.1) RPLT=1.E6
 115   IF(RT.LT.RN) GØ TØ 135
       DØ 130 I=1,NR
       IF(R1(I).GT.RT) GØ TØ 130
       IF(INT(I).EQ.0) GØ TØ 125
       IF(I.EQ.NØLD) GØ TØ 120
       LNRC=JNRC(I)
       DØ 117 J=1,LNRC
 117   RCD(J)=STRCD(J,I)
       DØ 119 J=1,6
 119   ISCPEQ(J)=IT(J,I)
 120   CALL INTENSTY
       CALL ITNPRINT(NINT)
       IF(I.EQ.NVSR) CALL IVSPPLØT(IVSR)
       NØLD=I
 125   IF(IRD(I).NE.0) CALL RAYZDIST (NTPLT)
       IF(IRT(I).NE.0) CALL RAYTAPE
       IF(DR(I).LT.0.) GØ TØ 126
       R1(I)=R1(I)+DR(I)
       GØ TØ 127
 126   R1(I)=-R1(I)-DR(I)
 127   IF(R1(I).GT.R2(I)+.001) R1(I)=1.E6
 130   CONTINUE
 135   IF(RT.GT.RB) CALL NWBRLT(RB)
       GØ TØ 100
 140   IF(JRT.EQ.0) GØ TØ 150
       ENDFILE LTRT
       ENDFILE LTRT
       BACKSPACE LTRT
 150  IF (INCR.GT.1.AND.INCR.LE.16) 151,153
 151  INCRC=INCR-1
      WRITE (36,919) (PUNCHDR(II),II=1,INCRC)
 919  FØRMAT (16F5.1)
 153  IF (IFE.EQ.1) GØ TØ 158
      IF (LA.EQ.1.ØR.IS.EQ.1) GØ TØ 160
 157  READ 900,JUNK
      IF (EØF,60) 158,157
 160  IF (LA.EQ.1.ØR.IS.EQ.0.AND.LA.EQ.0) LPM=60
      IF (IS.EQ.1) LPM=6
 176  IF(LPM.EQ.60)READ (LPM,1903) NCUR,RB,TI
      IF(LPM.EQ. 6)READ (LPM)      NCUR,RB,TI
      IF(EØF,LPM ) 177,178
 177  IF (LA.EQ.1) ENDFILE 6
      REWIND 6
      GØ TØ 158
 178  IL=1  $ IF (LA.EQ.1) WRITE (6)      NCUR,RB,TI
 179  IH=IL+4
      IF(LPM.EQ.60)READ(LPM,1900)(Z(2,I),V(2,I),I=IL,IH)
      IF(LPM.EQ. 6)READ(LPM)      (Z(2,I),V(2,I),I=IL,IH)
      IF(LA.EQ.1)WRITE (  6)      (Z  (2,I),V  (2,I),I=IL,IH)
      IF(V  (2,IH).LE.0.) GØ TØ 176
      IL=IL+5
      GØ TØ 179
```

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```
1903 FØRMAT(I1,F7.3,9A8)
1900 FØRMAT(10F8.4)
 158 IFPR1=IFPR  $ IF (IFPR.NE.1) IFPR=1  $ IF (IPFL.EQ.0) GØ TØ 159
     IF (IFPR1.EQ.0.AND.IPFL.EQ.1) CALL PRØFPLØT (2.0,5,1)
     IF (IPFL.EQ.2.AND.IFPR1.EQ.0) CALL PRØFPLIT (2.0,5,1)
 159 IFC=1  $  IFT1 =IFT1+1  $  IF (IS.EQ.0) GØ TØ 1
 161 READ 900,JUNK  $ IF (EØF,60) 1,161
 152 IF (IPCØ.NE.0) CALL STØPPLØT
     CALL BYEBYE
     END
```

```
5.4DS   TRIMAIN                                                   07/25/73      ED
                                            IDENT      TRIMAIN
     PROGRAM LENGTH                04624
     ENTRY POINTS      TRIMAIN     01572
     BLOCK NAMES
                       MIRRORS     00621
                       INFO        00024
                       PROFIL      00316
                       LOUDNESS    00765
                       PRO         00006
                       PATTERN     00004
                       PICEF       00003
                       LIMITS      00036
                       TLE         00012
                       ABC         00026
                       IFC         00037
                       RANST       00004
     EXTERNAL SYMBOLS
                       Q8QENTRY
                       THEND.
                       Q2Q07111
                       Q1Q10100
                       Q8QDICT.
                       INITRAYS
                       BRLTRD
                       BYEBYE
                       INIT
                       NEWPROF
                       CONNECT
                       RAYPLOT
                       RAYTAPE
                       TIMELEFT
                       DUMP
                       RESTART
                       CLOSEIOP
                       RETRY
                       SKIPFILE
                       ADVANCE
                       INTENSTY
                       ITNPRINT
                       IVSRPLOT
                       RAYZDIST
                       NWBRLT
                       PROFPLOT
                       PROFPLIT
                       STRFPLOT
                       POWRF
                       MINIF
                       ATANF
                       Q8QIFEOF
                       EFT.
                       ESP.
                       REW.
                       TSW.
                       TSB.
                       STW.
                       STB.


                       SLE.
                       SLI.
                       QNSINGL.
```

```
i  CLOSEIOP                                                      07/12/73      ED 00000       PAGE NO.      1
                                        IDENT     CLOSEIOP
 PROGRAM LENGTH                00012                                                             CIOP   1
 ENTRY POINTS      CLOSEIOP    00004
 EXTERNAL SYMBOLS
                   IOP.
                                        ENTRY     CLOSEIOP
                                        EXT       IOP.                                           CIOP   2
  00000                       SAVEAQ    BSS       2                                              CIOP   3
  00002    50  1  77777       SAVE12    ENI       **,1                                           CIOP   4
           50  0  00000                                                                          CIOP   5
  00003    77  2  00000                 DLDA      SAVEAQ
           12  0 P00000                                                                          CIOP   6
  00004    00  0  00000       CLOSEIOP  OCT       0
           00  0  00000                                                                          CIOP   7
  00005    77  2  04000                 DSTA      (*)SAVEAQ
           20  0 P00000                                                                          CIOP   8
  00006    56  1 P00002                 SIU       SAVE12+1
           50  1  00017                 ENI       15,1                                           CIOP   9
  00007    04  1  00043     *           ENQ       35,1                                           CIOP  10
           50  0  00000                                                                          CIOP  11
  00010    63  0  00031     *           63        318
           03  0 X77777                 03        ($)IOP.                                        CIOP  12
  00011    55  1 P00007                 IJP       *-2,1                                          CIOP  13
           75  0 P00002                 UJP       SAVE12                                         CIOP  14
                                        END                                                      CIOP  15
                                                                                                 CIOP  16
```

```
.5,4A                                                          06/04/73
          SUBROUTINE RETRY
          DIMENSION TITLE (8),ZIL(2,50),VIL(2,50)
       15 READ 1,ID
        1 FORMAT (A8)
          IF (EOF,60) 15,14
       14 IF (ID.EQ.8HSTART    ) GO TO 75
          GO TO 15
       75 LPN=60
    76    IF(LPN.EQ.60)READ (LPN ,903) NCUR,RB,TITLE
          IF(EOF,LPN ) 77,78
       77 ENDFILE 6
          REWIND 6
          GO TO 82
    78    IL=1   5                  WRITE (6)       NCUR,RB,TITLE
    79    IH=IL+4
          IF(LPN.EQ.60)READ (LPN ,900) (ZIL(2,I),VIL(2,I),I=IL,IH)
          WRITE (  6)        (ZIL(2,I),VIL(2,I),I=IL,IH)
          IF(VIL(2,IH).LE.0.) GO TO 76
          IL=IL+5
          GO TO 79
   900    FORMAT(10F8.4)
      903 FORMAT (I1,F7.3,9A8)
       82 RETURN
          END
```

```
IDS      RETRY
                                                              06/04/73        FC      0
     PROGRAM LENGTH                   00546    IDENT      RETRY
     ENTRY POINTS        RETRY        00540
     EXTERNAL SYMBOLS
                         THEND,
                         Q8QDICT,
                         Q8QIFERR
                         EFT,
                         REW,
                         TSH,
                         STB,
                         SLB,
                         SLI,
                         QNSINGL,
```

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```
      SUBROUTINE INITRAYS
      DIMENSION VBP(91)
      COMMON /PATTERN/ SD,ITBP,DATE,SBPLEV
      COMMON /PIDEF/ PI,DTR,TWOPI
      COMMON /RAYS/ NRAY,TGAM(1000),ZZ(1000),SS(1000),TIME(1000),
     1   NCTR(1000),PHASE(1000)
      COMMON /IFC/ IFE,IA,IB,IP,IC,IS,LA
      NRAY=0
      OG=1000.
      PRINT 905
905   FORMAT ( *      GAMLD      GAMDD       DGAMD     IC    SL  PHASE *)
      IF (IA.EQ.0.AND.LA.EQ.0.OR.LA.EQ.1.OR.IA.EQ.2)  LPC=60
      IF (IA.EQ.1.OR.IA.EQ.3) LPC=2
10    IF(LPC.EQ.60)READ (LPC,900)GAMLD,GAMDD,DGAMD,IC,SL,PH
      IF(LPC.EQ. 2)READ (LPC)    GAMLD,GAMDD,DGAMD,IC,SL,PH
      IF(LA.EQ.1)WRITE (  2)     GAMLD,GAMDD,DGAMD,IC,SL,PH
      PRINT 906,GAMLD,GAMDD,DGAMD,IC,SL,PH
906   FORMAT (1H0, 3F10.4, I5, 2F7.2 )
      SL=10.**(.1*(SL+SBPLEV))
      IFF=1
      IF(ABS(OG-GAMDD).LT..001) GO TO 20
      IF(NRAY.EQ.0) GO TO 15
      NRAY=NRAY+1
      SS(NRAY)=0.
15    OG=-DGAMD+GAMDD
      SOG=SIN(OG/DTR)
      IFF=0
20    G=OG+DGAMD
      S=SIN(G/DTR)
      NRAY=NRAY+1
      IF(NRAY.GT.1000) GO TO 100
      TGAM(NRAY)=S/SQRT(1.-S*S)
      ZZ(NRAY)=SD
      TIME(NRAY)=0.
      NCTR(NRAY)=0
      PHASE(NRAY)=PH/DTR
      SS(NRAY)=SL*.5*ABS(S-SOG)
      IF(IFF.NE.0) SS(NRAY-1)=SS(NRAY-1)+SL*.5*ABS(S-SOG)
      IFF=1
      OG=G
      SOG=S
      IF ( (G + .0000001) .LT. GAMLD ) GO TO 20
      IF(IC.NE.0) GO TO 10
23    IF(ITBP.EQ.0) GO TO 35
      IL=1
25    IH=IL+19
      IF (IA.EQ.0.AND.LA.EQ.0.OR.LA.EQ.1.OR. A.EQ.1) LP =60
      IF (IA.GE.2) LP=7
      IF(LP.EQ.60)READ(LP ,901)(VBP(I),I=IL,IH)
      IF(LP.EQ. 7)READ(LP )    (VBP(I),I=IL,IH)
      IF(LA.EQ.1)WRITE(  7)    (VBP(I),I=IL,IH)
      PRINT 907,(VBP(I),I=IL,IH)
907   FORMAT(*0VBP *,20F5.1)
      IF(VBP(IH).EQ.0.) GO TO 27
      IL=IL+20
      GO TO 25
```

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```
 27     IH=IH+1
        IF(IH.EQ.1) GE TO 28
        IF(VBP(IH).EQ.0.) GE TE 27
 28     DE 29 I=IH,90
 29     VBP(I+1)=VBP(IH)
        DE 31 I=1,NRAY
        D=ABS(DIR*ATAN(TGAM(I))+DATD)
        N=D
        D=D-N
        D=(1.-D)*VBP(N+1)+D*VBP(N+2)
 31     SS(I)=SS(I)+10.**(-1.E-1*D)
 35     PRINT 902
        PRINT 903,(I,TGAM(I),SS(I),PHASE(I),I=1,NRAY)
        IF (LA.EQ.1.ER.IA.EQ.1.ER.IA.EQ.3) REWIND 2
        IF (LA.EQ.1.ER.IA.GE.2) REWIND 7
        RETURN
 100    IF(IC.EQ.0) GE TO 23
        READ 904,IC
        GE TE 100
 900    FERMAT (3F10.4, I5, 2F5.2 )
 901    FERMAT(20F4.1)
 902    FERMAT(*0  INITIAL TAN GAMMA, SIGNAL LEVEL, AND PHASE*//)
 903    FERMAT ( 2(I10, 3F15.5 ))
 904    FERMAT(18X,I2)
        END
```

```
5  INITRAYS
                                                                    06/04/73          ED      0
   PROGRAM LENGTH                             IDENT          INITRAYS
   ENTRY POINTS          INITRAYS    01026
   BLOCK NAMES                       00220

                         PATTERN     00004
                         PICEF       00003
                         RAYS        13561
                         IFC         00007
   EXTERNAL SYMBOLS
                         THEND,
                         02007111
                         01010100
                         01003100
                         Q8SDICT,
                         SQRTF
                         SINF
                         ATANF
                         REW,
                         TSH,
                         TSB,
                         STH,
                         STB,
                         ONSINGL,
```

4A

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```
      SUBROUTINE BRLTRD(R6) $ COMMON /PIDEF/ PI,DTR,TWOPI
      COMMON /INFO/ IDUM(2),OMEGA,IDMM(17)
      COMMON /MIRNRS/ NSRL,SMLT(200),BPST(200)
      DIMENSION DB(50),LG(50),DTSTR(600),BR(91,4),BP(91,4),ISW(4),
     1   RBL(50),ICL(50)   ,DTH (600)
      COMMON/ABC/PUNCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1
      COMMON /IFC/ IFE,IA,IJ,IP,IC,IS,LA
      EQUIVALENCE (LB,DTSTR(551)),(DG,DTSTR(501)),(ICL,DTSTR(451)),
     1   (RBL,DTSTR(401)),(ISW,DTSTR(397)),(BR,DTSTR),(ISCP,DTSTR(396)),
     2   (IE,DTSTR(395)),(IB,DTSTR(394)),(K,DTSTR(393)),
     3   (IL,DTSTR(392)),(IM,DTSTR(391)),(IC,DTSTR(390))
      EQUIVALENCE (N,DTSTR(389)),(T,DTSTR(388)),(F,DTSTR(387)),(PHI,
     1   DTSTR(386)),(DLE,DTSTR(385)),(R,DTSTR(384)),
     2   (RN,DTSTR(383)) $ EQUIVALENCE (BP,DTSTR(183))
      DATA ((DTSTR(I),I=501,600)=
     1  19.,  35.,  40.,  52.,  6(90.),
     2  19.,  25.,  35.,  45.,  55.,  5(90.),
     3  11.,  20.,  25.,  35.,  45.,  56.,  4(90.),
     4  11.,  20.,  30.,  40.,  55.,  5(90.),
     5   5.,  7,5, 16,5, 17.5,  19.,  20.,  21., 22,5,  2(90.),
     1   0.,  3,7,  4,5,  7(6.),
     2   0.,  2,3,  4,6,  6.5,  6(8.),
     3   0.,   3.,  4,4,  6.7,  8,5,  5(10.),
     4   2.,  5,2,  7,7,  9.8,  6(12.),
     5   4.,  5,2,  12.,  12,8, 13,4, 13,7, 13,9,  3(14.)      )
      DATA ((DTSTR(I),I=401,500)=
     1  16.,  30.,  40.,  50.,  55.,  5(90.),
     2  17.,  20.,  30.,  40.,  50.,  55.,  4(90.),
     3  13.,  20.,  35.,  45.,  52,5,  5(90.),
     4  7,5,  11.,  20.,  25.,  30.,  34.,  4(90.),
     5  2,5,  5.,  7.5,  15.,  17.5,  20.,  22.,  3(90.),
     1   0.,  2,6,  4,4,  5,6,  6(6.),
     2   0.,  1,3,  4,6,   7.,  8,5,  5(9.),
     3   3.,  5,3,  8,7, 10.3,  6(11.),
     4   3.,   4.,  10,4, 12,7, 13,7,  5(14.),
     5   6.,  8,7,  10.,  14,1,  15.,  15,8,  4(16.)      )
      DATA ((DTSTR(I),I=301,400)=
     1  19.,  25.,  35.,  45.,  51.,  5(90.),
     2  18.,  25.,  35.,  45.,  55.,  5(90.),
     3  14.,  20.,  30.,  40.,  50.,  53.,  4(90.),
     4   8.,  11.,  20.,  22.5,  26.,  5(90.),
     5  2,5,  4,5,  7.5,  10.,  14,5,  17,5,  20.,  23.,  2(90.),
     1   0.,  1,5,  3,5,  5.1,  6(6.),
     2   0.,  2,8,  5,6,  7.6,  6(9.),
     3   3.,   5.,  7,5,  9.4,  10,8,  5(11.),
     4   5.,  6,1,  12,2, 13.2,  6(14.),
     5   9.,  10.,  12.,  13.9,  16.,  17,1,  17,7,  3(18.)      )
      DATA ((DTSTR(I),I=201,300)=
     1  18.,  23.,  30.,  40.,  50.,  55.,  4(90.),
     2  17.,  20.,  25.,  30.,  35.,  45.,  55.,  3(90.),
     3  13.,  25.,  30.,  35.,  42,5,  45.,  50.,  3(90.),
     4   9.,  12,5,  20.,  22.5,  27.,  5(90.),
     5  2,5,  4,5,  7.5,  10.,  14.5,  17,5,  20.,  23.,  2(90.),
     1   0.,   2.,   4.,   6.,  7,4,  5(8.),
     2   0.,  1,7,  3,9,  5.6,  6,8,  8,8,  4(10.),
     3   3.,  6,6,   8.,  9.1,  10,4,  10,7,  4(11.),
```

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4    7.,   8.,  12.,  13,1,  6(14,),
5    9.,  10.,  12.,  13,9,  16.,  17.1,  17,7,  3(18,)         )
  DATA  ((DTSTR(I),I=101,200)=
1  2,5,  10.,  12,5,  15.,  20.,  25.,  30.,  35.,  40.,  90.,
2  2,5,  7,5,  12,5,  20.,  25.,  32,5,  37,5,  42,5,  2(90.),
3  2,5,  5.,  7,5,  12,5,  17,5,  22,5,  27,5,  32,5,  2(90.),
4  2,5,  7,5,  10.,  11,5,  13.,  15.,  20.,  24.,  2(90.),
5  2,5,  5.,  8,5,  10.,  12,9,  15.,  20.,  22,5,  27,5,  90.,
1  3,5,  5,4,  6.,  6,6,  7,7,  8,6,  9,4,  9,8,  2(10.),
2  6,5,  8.,  9,5,  11.,  11,9,  13.,  13,4,  3(13,5),
3  7.,  9,4,  11,5,  14.,  14,7,  15,1,  15,4,  3(15,5),
4  9.,  13,5,  15,2,  16.,  16,6,  17.,  17,4,  3(17,5),
5  11.,  13,6,  16.,  17.,  18,1,  18,8,  19,6,  19,8,  2(20.)     )
  DATA ((DTSTR(I),I=1,100)=
1  7,5,  11.,  13,5,  15.,  17,5,  20.,  25.,  27,5,  2(90.),
2  7,5,  10.,  11,5,  14.,  15.,  17,5,  20.,  25.,  29,5,  90.,
3  7,5,  12.,  15.,  18.,  20.,  22,5,  25.,  27.,  90.,  90.,
4  7,5,  10.,  14,5,  17,5,  20.,  22,5,  25.,  28.,  90.,  90.,
5  2,5,  5,5,  8.,  10.,  15.,  17,5,  20.,  23.,  90.,  90.,
1  6,5,  6,6,  9,8,  10,8,  11.,  11,7,  12,7,  3(13.),
2  7.,  8,8,  10.,  10,6,  11,1,  11,9,  12,5,  13,4,  2(14.),
3  8.,  11.,  12,8,  14.,  14,8,  15,4,  15,8,  3(16.),
4  9.,  11.,  13,5,  14,8,  15,6,  16,2,  16,6,  3(17.),
5  10.,  13.,  15.,  16.,  17,8,  18,4,  18,7,  3(19.)    )
   IF (IFT,EQ,1) GO TO 2
   DO 1 J=1,600
 1 DTH(J)=DTSTR(J)
   IFT=1
   GO TO 3
 2 DO 4 J=1,600
 4 DTSTR(J)=DTH(J)     $ IE=0
 3 FR=OMEGA/TWOPI $ IF(FR,LT,200,) GO TO 25
   IF(FR,GT,1500,) GO TO 10 $ IF(FR,LT,750,) GO TO 5 $ IG=301
   GO TO 20
5      IG=401 $ GO TO 20
10     IF(FR,LT,2750,) GO TO 15 $ IG=101 $ IF(FR,GT,6000,) IQ=1
       GO TO 20
15     IG=201
20     DO 24 I=5(1,500 $ DTSTR(I)=DTSTR(IQ)
24     IG=IG+1
25     DO 30 I=1,500
30     DTSTR(I)=0, $ ISCP=RE
       IF (IW,EQ,0,AND,LA,EQ,0,OR,LA,EQ,1,OR,IJ,EQ,2)  LPB=60
       IF (IW,EQ,1,OR,IJ,EQ,3) LPB=9
40     IB=IB+1 $ IF(LPB,EQ,60)READ (LPB,900)RBL(IB),ICL(IB)
       IF(LPB,EQ, 9)READ (LPB)     RBL(IB),ICL(IB)
       IF(LA,EQ,1)WRITE  (  9)     RBL(IB),ICL(IB) $ IF(RBL(IB)) 41,41,42
41     RBL(IB)=1,E30
42     IF(ICL(IB)) 43,43,44
43     ICL(IB)=0 $ GO TO 60
44     IF(ICL(IB)-9) 46,46,45
45     ICL(IB)=ICL(IB)/10
46     IF(ICL(IB)-5) 60,60,47
47     K=ICL(IB)-5 $ IF(ISW(K)) 48,48,60
48     ISW(K)=1 $ IL=1
49     IH=IL+19 $ IF(LPB,EQ,60)READ (LPB,901)(BR(I,K),I=IL,IH)
```

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      IF (LPB,EQ,9)READ (LPB)(BR (I,K),I=IL,IH)
      IF (LA,EQ,1)WRITE (  9)    (BR(I,K),I=IL,IH)  $ IL=IL+20
      IF(BR(IH,K)) 51,51,49
 50   IF(BR(IH,K)) 51,51,53
 51   IH=IH-1 $ IF(IH) 52,52,50
 52   IH=1
 53   DO 54 I=IH,90
 54   BR(I+1,K)=BR(IH,K) $ IL=1 $ IF(ISCP) 60,60,55
 55   IH=IL+19 $IF (IJ,EQ,0,AND,LA,EQ,0,OR,LA,EQ,1,OR,IJ,EQ,1) LPP=60
      IF(IJ,GE,2)LPP=8$ IF(LPP,EQ,60)READ  (LPP,901)    (BP(I,K),I=IL,IH)
      IF (LPP,EQ,8) READ (LPP) (BP(I,K),I=IL,IH)
      IF (LA,EQ,1) WRITE(8)     (BP(I,K),I=IL,IH)   $ IL=IL+20
      IF(BP(IH,K)) 55,60,55
 60   IF(RBL(IB),LT,1,E15) GO TO 40 $ DO 65 K=6,9
      IF(ISW(K-5)) 65,65,61
 61   PRINT 902,K $ PRINT 903,(I,BR(I+1,K-5),BP(I+1,K-5),I=IE,90)
 65   CONTINUE $ PRINT 900 $ DO 70 I=2,IB $ RN=RBL(I-1)
      PRINT 904,R,RN,ICL(I+1)
 70   R=RN $ PRINT 905,R,ICL(IB) $ IE=1
 75   IC=ICL(IE) $ IF(IC) 76,76,80
 76   DO 77 I=1,200 $ BRLT(I)=1,
 77   BPST(I)=0, $ GO TO 100
 80   DO 99 I=1,200 $ T=DTR*ATAN(,01*(I-1)) $ K=IC-5 $ IF(K) 81,81,95
 81   IL=10*IC $ IF(DG(IL-9),GE,T) GO TO 93
 82   IF(DG(IL-8),GE,T) GO TO 92 $ IL=IL+1 $ GO TO 82
 92   DCB=DB(IL-9)+(T-DG(IL-9))*(DB(IL-8)-DB(IL-9))/(DG(IL-8)-DG(IL-9))
      GO TO 94
 93   DCB=DB(IL-9)
 94   PHI=0, $ GO TO 9H
 95   N=T $ F=T-N $ DCB=BR(N+1,K)+F*(BR(N+2,K)-BR(N+1,K)) $ PHI=0,
      IF(ISCP,NE,0) PHI=BP(N+1,K)+F*(BP(N+2,K)-BP(N+1,K))
 98   BPST(I)=PHI
 99   BRLT(I)=10,**(-,1*DCB)
100   RB=RBL(IE) $ RETURN $ ENTRY NWBRLT $ IE=IE+1
      IF(IC-ICL(IE)) 75,100,75
900   FORMAT(F8,4,I2)
901   FORMAT(20F4,2)
902   FORMAT(35HUUSER SUPPLIED BOTTOM LOSS TABLE CLASS  ,I5/1X
     1  3(2HGA,6X,2HDB,7X,3HPHI,10X))
903   FORMAT(3(I3,F10,3,F6,3,9X))
904   FORMAT(5H FROM,F10,2,3H TO,F10,2,16H KM BOTTOM CLASS,I5)
905   FORMAT(5H FROM,F10,2,3H TO,3X,23HEND OF RUN BOTTOM CLASS,I5)
      END
```

```
   BRLTRD
                                                                      06/04/73        ED     0
                                              IDENT       BRLTRD
PROGRAM LENGTH                       03503
ENTRY POINTS       BRLTRD            03361
                   [illegible]BRLT   03371
BLOCK NAMES
                   PIDEF             00003
                   INFO              00024
                   MIRRORS           00021
                   ABC               00026
                   IFC               00007
EXTERNAL SYMBOLS
                   01010100
                   THEND,
                   01003100
                   02007111
                   ROTLICT,
                   ATANF
                   TSR,
                   TSB,
                   STR,
                   STB,
                   ONSINGL,
```

UNCLASSIFIED

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```
      SUBRØUTINE WØRD SIZE
      CØMMØN /RAYS/ NRAY,TGAM(1000),ZZ(1000),SS(1000),TIME(1000),
     1   NCØUNT(1000),PHASE(1000)
      CØMMØN /INFØ/ RSTART,RMAX,ØMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,
     1   ISCP,IT1,IT2,IT3,IPER,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT
      CØMMØN /TRIANG/ AP(100,2),BP(100,2),AL(100),BL(100),ZZERØ(100),
     1   RZERØ(100),AA(100),BB(100),SST(100),CCT(100),NTRI
      CØMMØN /TLE/ STITLE (10)
      CØMMØN/ABC/PUNCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1
      CØMMØN /RANST/ RDUM,IREC,IFSK,SDUM
      DATA (JBIG=37777777777777778),(IENT=0) ,(IFSK=-1)
      ENTRY INIT
      IF (IFT1.EQ.0) GØ TØ 2
      JBIG=3777777777777778       $  IENT=0
    2 ITN=SQRT(SQRT(JBIG/4.))
      ITN2=ITN**2
      ITN3=ITN2*ITN
      IBIG=ITN3*ITN
      RETURN
      ENTRY RAY TAPE
      ZB=AL(NTRI)*BL(NTRI)*RMAX
      IF (IENT.NE.0) GØ TØ 1
      WRITE (LTRT)STITLE,ALIM,NBRS,NSRS,ITN
      IENT=1    $ IREC=1   $  IFSK=IFSK+1
    1 WRITE (LTRT) NRAY,RMAX,ZB,(TGAM(I),I=1,NRAY),(ZZ(I),I=1,NRAY),
     1   (SS(I),I=1,NRAY),(NCØUNT(I),I=1,NRAY),(TIME(I),I=1,NRAY),
     2   (PHASE(I),I=1,NRAY)      $  IREC=IREC+1
      RETURN
      END
```

```
S  WORDSIZE                                                        07/02/73       ED     0
                                           IDENT       WORDSIZE
   PROGRAM LENGTH                00217
   ENTRY POINTS      INIT        00012
                     RAYTAPE     00044
                     WORDSIZE    00005
   BLOCK NAMES
                     RAYS        13561
                     INFO        00024
                     TRIANG      02261
                     TLE         00012
                     ABC         00026
                     RANST       00004
   EXTERNAL SYMBOLS
                     01010100
                     THEND,
                     OBSDICT,
                     SORTF
                     STB,
                     SLE,
                     ONSINGL,
```

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                                                          07/30/73
      SUBROUTINE NEWPROF(ZMAX)
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,
     1   ISCP,IT1,IT2,IT3,IPER,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT
      COMMON /PROFIL/ R1,N1,Z1(50),V1(50),R2,N2,Z2(50),V2(50),IBOTC,IPFL
      COMMON/INPUT/ RBOT(250),ZBOT(250),ZIL(2,50),VIL(2,50),NN(2),ICON(2
     1,50)
      COMMON /TLE/STITLE (10)
      COMMON /PRO/ IPROP,IKNM,PLTL,RM,IPCO,IFPR
      DIMENSION TITLE(9),PH(3),LIN (114)
      COMMON/ABC/PUNCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1
      COMMON /IFC/ IFE,IA,IB,IK,ID,IS,LA
      COMMON /RANST/ RS,IDUM,IDUMM,SDS
      DATA (NBPT=0),(IFEOF=0)  ,(LIN=114(1H )),(IFT2=0),(IBH=0)
      IFE=IFEOF $IF (IFT1.EQ.IFT2) GO TO 952     $IBH=0  $ IFT2=IFT1
  952 IF (IFT1.EQ.0.OR.IBH.EQ.1) GO TO 950   $ NBPT=0 $IFEOF=0 $IFE=IFEOF
      IBH=1  $ N2=0 $ R2=0.0 $ N1=0 $ R1=0.0  $  IFPR=0
      DO 951 J=1,114
  951 LIN(J)=1H
  950 IF(NBPT.GT.0) GO TO 20
C        FIRST ENTRY.  READ IN BOTTOM TRACK
      IL=1 $ IF (ID.EQ.0.AND.LA.EQ.0.OR.LA.EQ.1) LPI=60$IF(ID.EQ.1)LPI=5
    2 IH=IL+4
      IF(LPI.EQ.60)READ (LPI ,900) (RBOT(I),ZBOT(I),I=IL,IH)
      IF(LPI.EQ. 5)READ (LPI)      (RBOT(I),ZBOT(I),I=IL,IH)
      IF(LA.EQ.1)WRITE (  5)       (RBOT(I),ZBOT(I),I=IL,IH)
      IF(RBOT(IH).LE.0.) GO TO 3 $ IL=IL+5 $ GO TO 2
    3 IH=IH-1   $IF(RBOT(IH).LE.0.) GO TO 3      $ NBPT=IH
      IF (LA.EQ.1.OR.ID.EQ.1) REWIND 5
      PRINT 901,(RBOT(I),ZBOT(I),I=1,NBPT)   $ IF (IBOTC.LE.0) GO TO 1
      DO 5 I=1,NBPT
    5 ZBOT(I)=ZBOT(I)*(1.+.5*ZBOT(I)/6371221.3)
    1 CONTINUE  $      WRITE (35,611),STITLE,(RBOT(J),ZBOT(J),J=1,NBPT)
  611 FORMAT (10A8,/,(10F8.3))
  911 FORMAT (10F8.3)
      ZMAX=0.  $DO 4 I=1,NBPT
      IF(ZBOT(I).GT.ZMAX) ZMAX=ZBOT(I)
    4 CONTINUE
      IBPT=0 $ IF (IS.EQ.0.AND.LA.EQ.0.OR.LA.EQ.1) LPN=60
      NN(2)=0 $ IF (IS.EQ.1) LPN=6
      DO 55 I=1,2
      DO 55 J=1,50
      ZIL(I,J)=0.0
      VIL(I,J)=0.0
   55 ICON(I,J)=0
      NN(1)=0
      NIB=0
      DO 56 J=1,50
      Z1(J)=0.0
      V1(J)=0.0
      Z2(J)=0.0
   56 V2(J)=0.0
      ASSIGN 6 TO IRET
      GO TO 70
C        AT 70 IS THE READIN AND CONNECT ROUTINE.  RETURN IS TO IRET
    6 ASSIGN 20 TO IRET
      GO TO 70
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 20     IBPT=IBPT+1
        IF(IBPT.LE.NBPT) GØ TØ 21
        RBT=.001+R2+100.
        IFPR=1
        GØ TØ 22
 21     RBT=RBØT(IBPT)
        ZBT=ZBØT(IBPT)
        IF (RM.LE.RBT.AND.IFEØF.EQ.1.AND.RS.NE.0.0) IFPR=1
 22     IF(RBT.LE.RB) GØ TØ 25
C          GET NEW INPUT PRØFILE
        ASSIGN 23 TØ IRET
        GØ TØ 70
   23   IF (IBPT.GT.NBPT) GØ TØ 25
        IBPT=IBPT+1
        ZBT=ZBT+(RA-RBT)*(ZBT-ZBØT(IBPT))/(RBT-RBØT(IBPT))
C          THIS IS THE BØTTØM DEPTH AT PRØFILE RANGE
        RBT=RA
 25     R1=R2
        N1=N2
C          MØVE PRØFILE 2 TØ PRØFILE 1
        DØ 27 I=1,N2
        Z1(I)=Z2(I)
 27     V1(I)=V2(I)
        R2=1000.+RBT
        FA=(RB-RBT)/(RB-RA)
        FB=1.-FA
        N2=1
   29   IF (ICØN(1,N2).GT.NN(1)) ICØN (1,N2)=NN(1)
        IF (ICØN(2,N2).GT.NN(2)) ICØN (2,N2)=NN(2)
        Z=FA*ZIL(1,ICØN(1,N2))+FB*ZIL(2,ICØN(2,N2))
        V=FA*VIL(1,ICØN(1,N2))+FB*VIL(2,ICØN(2,N2))
        IF (N2.GT.1.AND.Z.LT.Z2(N2-1)) 125,126
  125   Z=Z2(N2-1)
        V=V2(N2-1)
  126   IF(Z.GT.ZBT-1.) GØ TØ 35
        Z2(N2)=Z
        V2(N2)=V
        N2=N2+1
        IF(N2.LE.NIB) GØ TØ 29
C          EXTRAPØLATIØN TØ BØTTØM
        Z2(N2)=ZBT
        M=N2-1
 31     M=M-1
        Z=Z2(M)
        IF(ABS(Z-Z2(N2-1)).LT.1.E-5*Z) GØ TØ 31
        V=V2(M)
        V2(N2)=V2(M)   +(ZBT-Z)*(V2(N2-1)-V)/(Z2(N2-1)-Z)
        GØ TØ 40
 35     Z2(N2)=ZBT
        V2(N2)=V2(N2-1)+(ZBT-Z2(N2-1))*(V-V2(N2-1))/(Z-Z2(N2-1))
C          REMØVE DUPLICATE PØINTS
 40     M=2
        IDC=0
   42   IF (Z2(M).GT.Z2(M-1)+0.0001) GØ TØ 45
        IDC=1
        N2=N2-1
```

```
      DO 44 I=M,N2
      Z2(I)=Z2(I+1)
44    V2(I)=V2(I+1)
45    M=M+1
      IF(M.LE.N2) GO TO 42
      IF (IDC.GT.0) GO TO 40
      IF (Z2(N2+1).EQ.0.0) GO TO 46
      N5=N2+1
      DO 47 I=N5,50
      Z2(I)=0.0
   47 V2(I)=0.0
   46 IF (IPROP.EQ.0.OR.IPROP.EQ.1) GO TO 54
      PRINT 902,R2
      PRINT 914
      DO 7 J=1,N2
      NV=V2(J)-1455.5
      IF (NV.LT.4.OR.NV.GT.114) GO TO 48
      LIN(NV)=1H*
      PRINT 915,Z2(J),V2(J),LIN
      LIN(NV)=1H
      GO TO 7
   48 PRINT 915,Z2(J),V2(J)
    7 CONTINUE
   54 IF (IPFL.EQ.1) CALL PROFPLOT (RB,N3,INPF)
      IF (IPFL.EQ.2) CALL PROFPLIT (RB,N3,INPF)
      IF (RS.GE.RBOT(2).OR.IFEOF.EQ.1) RETURN $ PRINT 275 $ CALL BYEBYE
  275 FORMAT (5X,*PROGRAM ABORTED, TWO SOUND SPEED PROFILES INPUT BEFORE
     1 SECOND BOTTOM POINT*)
70    IF(NN(2).EQ.0) GO TO 75    $ NB=NN(2)  $ DO 71 I=1,NB
      ZIL(1,I)=ZIL(2,I)
71    VIL(1,I)=VIL(2,I)
      RA=RB
75    NN(1)=NN(2)
      IF(IFEOF.EQ.0) GO TO 76
      RB=RB+1.E6
      GO TO 82
76    IF(LPN.EQ.60)READ (LPN ,903) NCUR,RB,TITLE
      IF(LPN.EQ. 6)READ (LPN)       NCUR,RB,TITLE
      IF(EOF,LPN ) 77,78
77    IFEOF=1    $ IFE=IFEOF
      RB=RA+1.E6  $ IF (LA.EQ.1) ENDFILE  6
      IF (LA.EQ.1.OR.IS.EQ.1) REWIND 6  $ GO TO 82
78    IL=1   $ IF (LA.EQ.1) WRITE (6)      NCUR,RB,TITLE    $ RS=RB
79    IH=IL+4
      IF(LPN.EQ.30)READ (LPN ,900) (ZIL(2,I),VIL(2,I),I=IL,IH)
      IF(LPN.EQ. 6)READ (LPN)       (ZIL(2,I),VIL(2,I),I=IL,IH)
      IF(LA EQ 1)WRITE (  6)       (ZIL(2,I),VIL(2,I),I=IL,IH)
      IF(VIL(2,IH).LE.0.) GO TO 81
      IL=IL+5
      GO TO 79
81    IH=IH-1
      IF(VIL(2,IH).LE.0.) GO TO 81
      NN(2)=IH
      N3=IH
      INPF=0
      IF (IPROP.EQ.0) GO TO 74
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      PRINT 904,RB,TITLE
      PRINT 914
   74 DO 28 I=1,IH
      IF (VIL(2,I).LT.1400.0.OR.VIL(2,I).GT.1650.0) 58,57
   58 PRINT 920,RB,ZIL(2,I),VIL(2,I)
  920 FORMAT(1H1,5X,*INPUT ERROR IN PROFILE AT RANGE*,F10.4,5X,*VALUE AT
     1 DEPTH*,F10.3,*=*,F10.3,* M/SEC*)
      CALL BYEBYE
   57 IF (ZIL(2,I).NE,SDS) GO TO 257 $ PRINT 258,ZIL(2,I),RBSCALL BYEBYE
  258 FORMAT (5X,*PROGRAM ABORTED, INPUT PROFILE DEPTH*,F10,3,1X,*=SOURC
     1E DEPTH, AT RANGE*,F10.3,* KM*)
  257 IF (I,EQ.1) GO TO 157 $IF (ZIL(2,I).LT.ZIL (2,I-1)) GO TO 58
  157 IF (IPROP,EQ.0) GO TO 28  $NV=VIL(2,I)-1455.5
      IF (NV.LT,4,OR.NV,GT.114) GO TO 38  $ LIN(NV)=1HV
      PRINT 915,ZIL(2,I),VIL(2,I),LIN
      LIN (NV)=1H
      GO TO 28
   38 PRINT 915,ZIL(2,I),VIL(2,I)
   28 CONTINUE
      IF (NCUR.GT,0) GO TO 89
      DO 80 I=1,IH
      VIL(2,I)=VIL(2,I)*(1.+ZIL(2,I)/6371221.3)
   80 ZIL(2,I)=ZIL(2,I)*(1.+.5*ZIL(2,I)/6371221.3)
   89 IF (IPFL.EQ.1) CALL PROFPLOT (RB,N3,INPF)
      IF (IPFL.EQ.2) CALL PROFPLIT (RB,N3,INPF)
      IF(NN(1).EQ.0)                   GO TO IRET,(6,20,23)
82    ICON(1,1)=1
      ICON(2,1)=1
      NA=2
      NB=2
      NIB=2
   83 IF (ZIL(2,NIB).EQ,ZIL(1,NIB)) GO TO 92
      IF(NB,LE.NN(2)) GO TO 84
      IP=2
      GO TO 88
84    IF(NA,LE.NN(1)) GO TO 85
      IP=1
      GO TO 88
85    DVMA=VIL(1,NA)-VIL(1,NA-1)
      DVLA=DVMA
      DVHA=DVMA
      IF(NA,GT.2) DVLA=VIL(1,NA-1)-VIL(1,NA-2)
      IF(NA,LT.NN(1)) DVHA=VIL(1,NA+1)-VIL(1,NA)
      DVMB=VIL(2,NB)-VIL(2,NB-1)
      DVLB=DVMB
      DVHB=DVMB
      IF(NB,GT.2) DVLB=VIL(2,NB-1)-VIL(2,NB-2)
      IF(NB,LT.NN(2)) DVHB=VIL(2,NB+1)-VIL(2,NB)
      PM(1)=ABS(ZIL(1,NA-1)-ZIL(2,NB))
      IF(DVLA*DVMB.GE,0,.AND.DVMA*DVHB,GE,0.) PM(1)=PM(1)-250.
      PM(2)=ABS(ZIL(1,NA)-ZIL(2,NB-1))
      IF(DVMA*DVLB.GE,0,.AND.DVHA*DVMB,GE,0.) PM(2)=PM(2)-250.
      PM(3)=ABS(ZIL(1,NA)-ZIL(2,NB))
      IF(DVMA*DVMB.GE.0,.AND.DVHA*DVHB,GE,0.) PM(3)=PM(3)-250.
      BP=PM(1)
      IP=1
```

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```
      DØ 87 I=2,3
      IF(PM(I).GE.BP) GØ TØ 87
      IP=I
      BP=PM(I)
87    CØNTINUE
88    GØ TØ (90,91,92),IP
90    ICØN(1,NIB)=NA-1
      ICØN(2,NIB)=NB
      NB=NB+1
      GØ TØ 93
91    ICØN(1,NIB)=NA
      ICØN(2,NIB)=NB-1
      NA=NA+1
      GØ TØ 93
92    ICØN(1,NIB)=NA
      ICØN(2,NIB)=NB
      NA=NA+1
      NB=NB+1
93    IF(NA.GT.NN(1).AND.NB.GT.NN(2)) GØ TØ IRET,(6,20,23)
      NIB=NIB+1
      IF (NIB.LE.50) GØ TØ 83
      PRINT 905
      CALL BYEBYE
900   FØRMAT(10F8.4)
901   FØRMAT(24H0LISTING ØF BØTTØM TRACK/1H0,4X,5(6H R(KM),6X,4HZ(M),4X)
     1   //(1X,10F10.3))
902   FØRMAT(30H0INTERPØLATED PRØFILE AT RANGE,F10.0,2H M//)
903   FØRMAT(I1,F7.3,9A8)
904   FØRMAT(23H1INPUT PRØFILE AT RANGE,F11.3,3H KM,5X,9A8//)
914   FØRMAT (3X,*DEPTH (M)*,2X,*VELØCITY*,*1460*,6X,*1470*,6X,*1480*6X,
     1*1490*,6X,*1500*,6X,*1510*,6X,*1520*,6X,*1530*,6X,*1540*,6X,*1550*
     2,6X,*1560*,6X,*1570*,//)
915   FØRMAT (1X,F11.4,F10.4,114A1)
905   FØRMAT ( 29H0TØØ MANY PØINTS INTERPØLATED)
      END
```

```
DS    NEWPROF                                               07/30/73        ED      0
                                        IDENT       NEWPROF
      PROGRAM LENGTH               03072
      ENTRY POINTS      NEWPROF    00471
      BLOCK NAMES
                        INFO       00024
                        PROFIL     00316
                        INPUT      01442
                        TLE        00012
                        PRO        00006
                        ABC        00026
                        IFC        00007
                        RANST      00004
      EXTERNAL SYMBOLS
                        THEND,
                        01010100
                        CBODICT,
                        PROFPLOT
                        PROFPLIT
                        BYEBYE
                        CBCIFEOF
                        EFT,
                        REW,
                        TSW,
                        TSB,
                        STW,
                        STB,
                        SLB,
                        SLI,
                        CNSINGL,
```

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```
      SUBROUTINE CONNECT
      COMMON /PROFIL/ R1,N1,Z1(50),V1(50),R2,N2,Z2(50),V2(50),IBOTC,IPFL
      COMMON /TRIANG/ AP(100,2),BP(100,2),AL(100),BL(100),ZZERO(100),
     1   RZERO(100),AA(100),BB(100),SST(100),CCT(100),NTRI
      NA=NB=1
      NTRI=0
      IADD=0
 10   NTRI=NTRI+1
      IF(NB.EQ.N2) GO TO 12
      IF (IADD.EQ.1.OR.NA.EQ.N1) GO TO 30
 12   RZERO(NTRI)=R2
      ZZERO(NTRI)=Z2(NB)
      AL(NTRI)=Z1(NA+1)
      BL(NTRI)=(Z2(NB)-Z1(NA+1))/(R2-R1)
      AA(NTRI)=1./V2(NB)**2
      BZ=(1.D0/V1(NA)**2-1.D0/V1(NA+1)**2)/(Z1(NA)-Z1(NA+1))
      BR=(1.D0/V2(NB)**2-1.D0/V1(NA)**2-BZ*(Z2(NB)-Z1(NA)))/(R2-R1)
      NA=NA+1
      IADD=1
      GO TO 40
 30   RZERO(NTRI)=R1
      ZZERO(NTRI)=Z1(NA)
      AL(NTRI)=Z1(NA)
      BL(NTRI)=(Z1(NA)-Z2(NB+1))/(R1-R2)
      AA(NTRI)=1./V1(NA)**2
      BZ=(1.D0/V2(NB)**2-1.D0/V2(NB+1)**2)/(Z2(NB)-Z2(NB+1))
      BR=(1.D0/V1(NA)**2-1.D0/V2(NB)**2-BZ*(Z1(NA)-Z2(NB)))/(R1-R2)
      NB=NB+1
      IADD=0
      GO TO 40
 40   BB(NTRI)=SIGN(SQRT(BZ**2+BR**2),BZ)
      IF(BB(NTRI).EQ.0.) GO TO 41
      SST(NTRI)=BR/BB(NTRI)
      CCT(NTRI)=BZ/BB(NTRI)
      GO TO 42
 41   CCT(NTRI)=1.
      SST(NTRI)=0.
 42   AL(NTRI)=AL(NTRI)-BL(NTRI)*R1
      TANT=SST(NTRI)/AMAX1(CCT(NTRI),1.E-100)
      BP(NTRI,2)=(BL(NTRI)+TANT)/(1.-BL(NTRI)*TANT)
      B=BL(NTRI-1)
      IF(NTRI.EQ.1) B=0
      BP(NTRI,1)=(B+TANT)/(1.-B*TANT)
      AP(NTRI,1)=AP(NTRI,2)=0.
      IF(NA.LT.N1.OR.NB.LT.N2) GO TO 10
      RETURN
      END
```

```
DS    CONNECT
                                                         06/04/73         ED      0
                                          IDENT       CONNECT
    PROGRAM LENGTH                00414
    ENTRY POINTS      CONNECT     00003
    BLOCK NAMES
                      PROFIL      00316
                      TRIANG      02261
    EXTERNAL SYMBOLS
                      01C1021J
                      01C04210
                      OBSDICT,
                      SQRTF
                      MAXIF
```

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```
      SUBROUTINE PREFPLOT (RI,N3,INPF)
      COMMON /PREFIL/ R1,N1,Z1(50),V1(50),R2,N2,Z2(50),V2(50),IBOTC,IPFL
      DIMENSIONXT(10),X(4),XP(50),Y(50),PLTARRAY(254),ZDEPTH (250),XRANG
     1E (250),XL(50),YL(400),YP(10)
      COMMON/INPUT/ RBOT(250),ZBOT(250),ZIL(2,50),VIL(2,50),NN(2),ICON(2
     1,50)
      COMMON /LIMITS/RO(10),DR(10),RO2(10)
      COMMON /PRO/ IPROP,IKNM,PLTL,RM,IPCO,IFPR
      COMMON /TLE/STITLE (10)
      COMMON/ABC/PUNCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1
      DATA (IPLOT=0),(IST=0),(IFT2=0),(IBH=0),(IJ=0)
      IF (IPCO.EQ.1.AND.IPLOT.EQ.0.OR.IST.EQ.1) GO TO 100
      IF (IPLOT.EQ.1) GO TO 1 $ CALL PLOTS (PLTARRAY,254,3)
  100 IF (IFT1.EQ.IFT2) GO TO 952  $IBH=0  $ IFT2=IFT1
  952 IF (IFT1.EQ.0.AND.IJ.EQ.1.OR.IBH.EQ.1) RETURN
      IBH=1  $ IPLOT=1  $ IPCO=1 $IST=0   $ IJ=1
      RM= MAX1F(RO2(1),RO2(2),RO2(3),RO2(4),RO2(5),RO2(6),RO2(7),RO2(8),
     1RO2(9),RO2(10)) $ IDI=0 $ K=0
   20 K=K+1 $IF (RM.GT.RBOT(K)) 20,21
   21 ZMAX=ZBOT(1)
      DO22 J=2,K
   22 ZMAX= MAX1F(ZBOT(J),ZMAX)
      IF (ZMAX.LE.  250.0.AND.ZMAX.GT.    0.0 ) ZMAX=  250.0
      IF (ZMAX.LE.  500.0.AND.ZMAX.GT. 250.0 ) ZMAX=  500.0
      IF (ZMAX.LE. 1000.0.AND.ZMAX.GT. 500.0 ) ZMAX= 1000.0
      IF (ZMAX.LE. 2000.0.AND.ZMAX.GT.1000.0 ) ZMAX= 2000.0
      IF (ZMAX.LE. 4000.0.AND.ZMAX.GT.2000.0 ) ZMAX= 4000.0
      IF (ZMAX.LE. 5000.0.AND.ZMAX.GT.4000.0 ) ZMAX= 5000.0
      IF (ZMAX.LE.10000.0.AND.ZMAX.GT.5000.0 ) ZMAX=10000.0
      DO 25 J=1,11
      A=(ZMAX/10.0)*(J-1)
      IF (J.EQ.6) CALL SYMBOL (-1.00,5.0,0.14,9HDEPTH (M),90.0,9)
      XL(J)=0.0
      Y(J)=(11-J)
   25 CALL NUMBER(-0.80,Y(J),0.140,A,0.0,4HF5.0)
      CALL LINE (XL,Y,11,1,3,0.105,1)
      DO 26 J=1,250
   26 YL(J)=0.0
      IF (PLTL.GT.156.0) CALL BYEBYE
      RSCALE=PLTL/RM
      NTM=AMIN1(PLTL+1.,40.5)
      RT=1.
      RMAN=RM
      IF (IKNM.GT.0) RMAN=RM  /1.852
56    NT=RMAN/RT
      IF(NT.LE.NTM) GO TO 57
      RT=2.*RT
      NT=RMAN/RT
      IF(NT.LE.NTM) GO TO 57
      RT=2.5*RT
      NT=RMAN/RT
      IF(NT.LE.NTM) GO TO 57
      RT=2.*RT
      GO TO 56
C        PLOT SURFACE AXIS
57    CALL PLOT(0., 0.,3)
```

```
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          XN=0.
          RSCALE1=RSCALE
          IF (IKNM.GT.0) RSCALE1=1.852*RSCALE
          DX=RT*RSCALE1
          R=0.
          IF=0
   58     CALL PLOT(XN,0.,2)
          CALL PLOT(XN,-0.05,2)
          RK=R
          CALL NUMBER(XN-,48,-0,19,1,4E-1,RK,0.,4HF4,0)
          IF(R.LT.RMAN/2.) GP TO 59
          IF(IF,EQ.1) GO TO 59
          IF (IKNM.EQ,0) 4,7
        7 CALL SYMBOL(XN-0.30,-0.40,0.14,10HRANGE (NM),0.,10)
          GO TO 8
        4 CALL SYMBOL(XN-0.30,-0.40,0,14,10HRANGE (KM),0.,10)
        8 CALL SYMBOL (XN-7.20,10,15,0.21,STITLE,0.,80)
          IF=1
   59     CALL PLOT(XN,0.,3)
          IF(R.GE.RMAN) GO TO 60
          XN=XN+DX
          R=R+RT
          GO TO 58
       60 IDP=0
        1 IF (IFPR.EQ,1) GO TO 5
          X(3)=(R2/1000,0)*RSCALF
          IF (INPF.EQ,0) X(3)=RI*RSCALE
          X(1)=X(3)+1,5
          IF (INPF.EQ,1) GO TO  2    $ IF (X(3).GT,PLTL) GO TO 35
          DO 15 J=1,N3
       15 XP(J)=((0,5*VIL(2,J)-735.0)*0.1)+X(3)
          IDI=IDI+1
          XL(IDI)=X(3)
          IF (IDI.GE,2) GO TO 50
          CALL SYMBOL (X(1)+0,02,10.27,0.10,16HVELOCITY (M/SEC),0.0,16)
          TX=0.5
       50 N=2
          DO 55 J=1,N
          XT(J)=X(1)+(J-1)*TX
          YP(J)=10.02
          XM=1500.0
          DX=10,0
          PL=XM+(J-1)*DX
          IF (IDI.EQ.1) CALL NUMBER(XT(J)-0,07,10,10,.105,PL,0,0,4HF4,0)
       55 CONTINUE
          IF(X(3).LE,PLTL) CALL LINE (XT,YP,N,1,13.0,07,1)
          IF (INPF.EQ,1) GO TO 2
          DO 3 I=1,N3 $Y(I)=10,0*(1,0-(ZIL(2,I)/ZHAX))
        3 IF (Y(I).LT,0.0) Y(I)=0,0
          IF(X(3).LE,PLTL) CALL LINE (XP,Y,N3,1,-2,0,0,0)
       35 INPF=1
          GO TO 5
        2 DO 6 I=1,N2 $Y(I)=10,0*(1,0-(Z2(I)/ZMAX))
        6 IF (Y(I).LT,0.0) Y(I)=0,0
          IDP=IDP+1
          ZDEPTH(IDP)=Y(N2)
          XRANGE (IDP)=X(3)
        5 IF (IFPR.EQ,0) GO TO 30
          CALL LINE (XRANGE,ZDEPTH,IDP,1,1,0,0,0)
          CALL LINE (XL,    YL,IDI,  1,3,0.140,-1)
          CALL PLOTS (0,0)  $  CALL PLOT (PLTL+10.0,0.,-3)  $ IST=1
       30 RETURN
          END
```

```
DS  PREFPLOT
                                                                   07/25/73        ED      0
                                               IDENT      PROFPLOT
    PROGRAM LENGTH                  03700
    ENTRY POINTS     PREFPLOT       02503
    BLOCK NAMES
                     PROFIL         00316
                     INPUT          01442
                     LIMITS         00036
                     PRO            00006
                     TLE            00012
                     ABC            00026
    EXTERNAL SYMBOLS
                     01010100
                     SBODICT,
                     PLOTS
                     SYMBOL
                     NUMBER
                     LINE
                     BYEBYE
                     PLOT
                     MIN1F
                     MAX1F
```

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```
      IF (PL.GE.1400.0.AND.PL.LE.1500.0) PL=PL-1400.0
   55 CALL NUMBER (XT(J)-0.07,10.10,0.07,PL,0.0,4HF2.0)
      CALL LINE (XT,YP,N,1,13,0.07,1)
      IF (INPF.EQ.1) GO TO 2
   60 INPF=1
      IDI=IDI+1
      XI(IDI)=X(3)
      IF (X(3).GE.RJ/4.0.AND.ITL.EQ.0) 35,5
   35 ITL=1
      IF (IKNM.EQ.0) CALL SYMBOL (RJ/2.0-0.6,-0.40,0.14,10HRANGE (KM),0.
     10,10)
      IF (IKNM.GT.0) CALL SYMBOL (RJ/2.0-0.6,-0.40,0.14,10HRANGE (NM),0.
     10,10)
      CALL SYMBOL (RJ/2.0-4.8,10.20,0.14,STITLE,0.0,80)
      GO TO 5
    2 DO 6 I=1,N2
      Y(I)=10.0*(1.0-(Z2(I)/ZMAX))  $IF(Y(I).LT.0.0) Y(I)=0.0
      XL(I)=X(3)
    6 CALL NUMBER (X(2)+X(1),Y(I),0.07,Z2(I),0.0,4HF4.0)
      CALL LINE (XL,Y,N2,1,3,0.07,1)
      CALL LINE (XP,Y,N2,1,1,0.07,1)
      CALL NUMBER (X(3)-0.30,-0.25,0.105,X(4),0.0,4HF4.0)
      IDP=IDP+1
      ZDEPTH(IDP)=Y(N2)
      XRANGE (IDP)=X(3)
      IF (X(3).GE.RJ/4.0.AND.ITL.EQ.0) 45,5
   45 ITL=1
      IF (IKNM.EQ.0) CALL SYMBOL (RJ/2.0-0.6,-0.40,0.14,10HRANGE (KM),0.
     10,10)
      IF (IKNM.GT.0) CALL SYMBOL (RJ/2.0-0.6,-0.40,0.14,10HRANGE (NM),0.
     10,10)
      CALL SYMBOL (RJ/2.0-0.6,10.20,0.14,STITLE,0.0,48)
    5 IF (IFPR.EQ.0) GO TO130
      CALL LINE (XRANGE,ZDEPTH,IDP,1,1,0.0,0)
      CALL LINE (XRANGE,YL,IDP,1,3,0.105,1)
      CALL LINE (XI,YL,IDI,1,3,0.21,1)
      CALL PLOTS (0,0)  $  CALL PLOT (PLTL+10.0,0.0,-3)  $ IST=1
  130 RETURN
      END
```

```
)S  PROFPLIT                                              07/25/73        ED      0
                                          IDENT       PROFPLIT
 PROGRAM LENGTH                 03745
 ENTRY POINTS       PROFPLIT    02654
 BLOCK NAMES
                    PROFIL      00316
                    INPUT       01442
                    LIMITS      00036
                    PRO         00006
                    TLE         00012
                    ABC         00026
 EXTERNAL SYMBOLS
                    Q1Q10100
                    Q8QDICT,
                    PLOTS
                    SYMBOL
                    NUMBER
                    LINE
                    BYEBYE
                    SCALE
                    PLOT
                    MAX1F
```

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```
      SUBROUTINE ADVANCE
      COMMON /TRIANG/ AP(100,2),BP(100,2),AL(100),BL(100),ZZERO(100),
     1   RZERO(100),AA(100),BB(100),SST(100),CCT(100),NTRI
      COMMON /RAYS/ NRAY,TGAM(1000),ZZ(1000),SS(1000),TIME(1000),
     1   NCOUNT(1000),PHASE(1000)
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,
     1   ISCP,IT1,IT2,IT3,IPER,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT
      COMMON /PIDEF/ PI,DTR,TWOPI
      COMMON /MIRRORS/ SL,BRLT(200),BPST(200)
      COMMON/ABC/PUNCHOB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1
      DIMENSION RPNEW(4),RNEW(4),ZNEW(4),ZPNEW(4)
      LOGICAL ONUP,ONLW
      TANSUM(A,B)=(A+B)/(1.-A*B)
      DELT(DR,T,S)=ABS(DR)*SQRT(CHIS)*(1.+(T*(T+S)+S*S)/3.)
C        LOOP OVER ALL THE RAYS
      DO 100 IRAY=1,NRAY     $ IHIST=0      $ SSR=SS(IRAY)
      IF (NBRS.EQ.2500.AND.NSRS.EQ.2500) GO TO 10
      NN=NCOUNT(IRAY) $M=NN/ITN $NN=M/ITN $NSR=M-NN*ITN $M=NN/ITN $NBR=M
   10 IF(ABS(SSR).LT.ALIM.OR.NBR.GT.NBRS.OR.NSR.GT.NSRS) GO TO 100
      ZR=ZZ(IRAY)    $  RR=RSTART
      TGR=TGAM(IRAY)
      TRAY=TIME(IRAY)
      PHR=PHASE(IRAY)
      NCTR=NCOUNT(IRAY)
      DO 20 I=1,NTRI
C        FIND CORRECT LAYER
      P=ZR-AL(I)-BL(I)*RR
      IF(P-.0001.GT.0.) GO TO 20
      NTRR=I
      IF(ABS(P).GT..0001.OR.TGR.GT.-BL(I)) GO TO 30
   20 CONTINUE
      GO TO 80
   30 CT=CCT(NTRR)
      IF(IPRAY.NE.0) PRINT 666,IRAY,NTRR,ZR,RR,TGR,NCTR
      ST=SST(NTRR)
      Z0=ZZERO(NTRR)
C        TRANSFORM TO PRIMED COORDINATES
      R0=RZERO(NTRR)
      ZRP=CT*(ZR-Z0)+ST*(RR-R0)
      RRP=CT*(RR-R0)-ST*(ZR-Z0)
      CIS=AA(NTRR)+BB(NTRR)*ZRP
      TANT=ST/AMAX1(CT,1.E-300)
      TGRP=TANSUM(TANT,-TGR)
      CHIS=CIS/(1.+TGRP**2)
C        CALCULATE PARABOLIC RAY PATH,  ALPHA IS THE CURVATURE
      ALPHA=.25*BB(NTRR)/CHIS
      TA=2.*ALPHA
C        FIND INTERSECTIONS WITH UPPER AND LOWER LAYER BOUNDARIES
      DO 40 I=1,2
      APNTR=AP(NTRR,I)
      BPNTR=BP(NTRR,I)
      C=APNTR+BPNTR*RRP-ZRP
      P=BPNTR-TGRP
      IF(ABS(ALPHA).GT.1.E-25) GO TO 303
C        RAY PATH IS LINEAR FOR THESE STATEMENTS
      DRP=-C/P
```

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```
      K=2*I-1
      RPNEW(K)=RRP+CRP
      ZPNEW(K)=ZRP+TGRP*CRP
      ZNEW(K)=CT*ZPNEW(K)-ST*RPNEW(K)+Z0
      RNEW(K)=CT*RPNEW(K)+ST*ZPNEW(K)+R0
      ZNEW(K+1)=1.E300
      ZPNEW(K+1)=1.E300
      RNEW(K+1)=1.E300
      RPNEW(K+1)=1.E300
      GO TO 40
C        SOLVE QUADRATIC EQUATION FOR PARABOLIC RAY PATH
  303 DISC=P*P-4.*ALPHA*C
      IF(DISC.LT.0.) GO TO 32
      DISC=SQRT(DISC)
      DO 31 J=1,2
      K=2*I+J-2
      S=2*J-3
      F=P-S*DISC
      DRP=F/TA
C        ITERATION TO IMPROVE ACCURACY FOR SMALL CURVATURE RAYS
      IF(ABS(F).LT..1*ABS(P)) DRP=(ALPHA*((ALPHA*DRP**2-C)/P)**2-C)/P
  305 RPNEW(K)=RRP+DRP
      ZPNEW(K)=ZRP+DRP*(TGRP+ALPHA*DRP)
      ZNEW(K)=CT*ZPNEW(K)-ST*RPNEW(K)+Z0
   31 RNEW(K)=CT*RPNEW(K)+ST*ZPNEW(K)+R0
      GO TO 40
   32 DO 33 J=1,2
      K=2*I+J-2
   33 RNEW(K)=-1.E300
   40 CONTINUE
      ONLW=ABS(ZR-AL(NTRR)-BL(NTRR)*RR).LT..01.AND.TGR.GT.-BL(NTRR)
C        SELECT CORRECT INTERSECTION AS NEXT POSITION
      IF(NTRR.EQ.1) GO TO 405
      ONUP=ABS(AL(NTRR-1)+BL(NTRR-1)*RR-ZR).LT..01
     1   .AND. TGR.LT.-BL(NTRR-1)
      GO TO 41
  405 ONUP=ABS(ZR).LT..01.AND.TGR.LT.0.
   41 IUP=IDN=-1
      IF(.NOT.ONUP) GO TO 411
      IUP=1
      IF(ABS(RR-RNEW(1)).LT.ABS(RR-RNEW(2))) IUP=2
      IF(RNEW(IUP).LT.RR.OR.RNEW(IUP).GT.RMAX) IUP=0
  411 IF(.NOT.ONLW) GO TO 412
      IDN=3
      IF(ABS(RR-RNEW(3)).LT.ABS(RR-RNEW(4))) IDN=4
      IF(RNEW(IDN).LT.RR.OR.RNEW(IDN).GT.RMAX) IDN=0
  412 IF(IUP.GE.0) GO TO 414
      IUP=0
      RTRY=RMAX
      DO 413 I=1,2
      IF(RNEW(I).LT.RR.OR.RNEW(I).GT.RTRY) GO TO 413
      RTRY=RNEW(I)
      IUP=I
  413 CONTINUE
  414 IF(IDN.GE.0) GO TO 415
      IDN=0
```

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      RTRY=RMAX                                                         ADVA0112
      DO 415 I=3,4                                                      ADVA0113
      IF(RNEW(I).LT.RH.OR.RNEW(I).GT.RTRY) GO TO 415                    ADVA0114
      IDN=I                                                             ADVA0115
      RTRY=RNEW(I)                                                      ADVA0116
 415  CONTINUE                                                          ADVA0117
 416  IF(IDN.EQ.0) GO TO 420                                            ADVA0118
      IF(IUP.NE.0) GO TO 418                                            ADVA0119
 417  ITRY=IDN                                                          ADVA0120
      RTRY=RNEW(IDN)                                                    ADVA0121
      GO TO 429                                                         ADVA0122
 418  IF(RNEW(IUP).GE.RNEW(IDN)) GO TO 417                              ADVA0123
 419  ITRY=IUP                                                          ADVA0124
      RTRY=RNEW(IUP)                                                    ADVA0125
      GO TO 429                                                         ADVA0126
 420  IF(IUP.EQ.0) GO TO 50                                             ADVA0127
      GO TO 419                                                         ADVA0128
 429  TGRPN=TA*(RPNEW(ITRY)-RRP)+TGRP                                   ADVA0129
      TRAY=TRAY+DELT(RPNEW(ITRY)-RRP,TGRP,TGRPN)                        ADVA0130
      TGRN=-TANSUM(TGRPN,-TANT)                                         ADVA0131
      RH=RTRY                                                           ADVA0132
      ZH=ZNEW(ITRY)                                                     ADVA0133
C        CHECK FOR SURFACE AND BOTTOM HITS, TURNOVERS AND TURNUNDERS    ADVA0134
      IF(TGR*TGRN.GE.0.) GO TO 44                                       ADVA0135
      IF(TGR.GT.0.) GO TO 43                                            ADVA0136
      NCTR=NCTR+ITN2                                                    ADVA0137
      GO TO 44                                                          ADVA0138
 43   NCTR=NCTR+1                                                       ADVA0139
 44   IF(ITRY.GT.2) GO TO 45                                            ADVA0140
      NTRR=NTRR-1                                                       ADVA0141
      IF(NTRR.GT.0) GO TO 46                                            ADVA0142
      NTRR=1                                                            ADVA0143
      SSR=SSR+SL                                                        ADVA0144
      PHR=PHR+PI                                                        ADVA0145
      NCTR=NCTR+ITN                                                     ADVA0146
      TGR=-TGRN                                                         ADVA0147
      GO TO 30                                                          ADVA0148
 45   NTRR=NTRR+1                                                       ADVA0149
      IF(NTRR.LE.NTRI) GO TO 46                                         ADVA0150
      NTRR=NTRI                                                         ADVA0151
      NCTR=NCTR+ITN3                                                    ADVA0152
      TGRAZE=TANSUM(TGRN,BL(NTRI))                                      ADVA0153
      S=100.*ABS(TGRAZE)+1.                                             ADVA0154
      N=S                                                               ADVA0155
      S=S-N                                                             ADVA0156
      IF(N.GT.199) N=199                                                ADVA0157
      SSR=SSR+((1.-S)*BRLT(N)+S*BRLT(N+1))                              ADVA0158
      PHR=PHR+((1.-S)*BPST(N)+S*BPST(N+1))                              ADVA0159
      TGR=-TANSUM(TGRAZE,BL(NTRI))                                      ADVA0160
      IF(TGR.LT.-BL(NTRI)) 80,30                                        ADVA0161
 46   TGR=TGRN                                                          ADVA0162
      GO TO 30                                                          ADVA0163
C        CALCULATE RAY INTERSECTION WITH VERTICAL BOUNDARY, R=RMAX      ADVA0164
 50   IF(ABS(ST).LT.2.E-4) GO TO 60                                     ADVA0165
      BV=-CT/ST                                                         ADVA0166
      AV=(RMAX-RO)/ST                                                   ADVA0167
```

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```
      C=AV*RRP+BV-ZRP
      P=AV-TGRP
      IF(ABS(ALPHA).GT.1.E-25) GO TO 501
C        LINEAR RAYS
      RPNEW(1)=RRP+C/P
      RPNEW(2)=1.E100
      GO TO 505
C        PARABOLIC RAYS
501   DISC=P*P+4.*ALPHA*C
      IF(DISC.LT.0.) GO TO 80
      DISC=SQRT(DISC)
      S=1.
      DO 503 I=1,2
      F=P+S*DISC
      DRP=F/TA
      IF(ABS(F).LT..1*ABS(F)) DRP=(ALPHA*((ALPHA*DRP**2-C)/P)**2-C)/P
      RPNEW(I)=RRP+DRP
503   S=-S
505   DO 51 I=1,2
      ZPNEW(I)=ZRP+(RPNEW(I)-RRP)*(TGRP+ALPHA*(RPNEW(I)-RRP))
51    ZNEW(I)=CT*ZPNEW(I)+ST*RPNEW(I)+Z0
      I=2
C        SELECT CORRECT INTERSECTION
      IF(ABS(ZNEW(1)-ZR).LT.ABS(ZNEW(2)-ZR)) I=1
      TGRPN=TA*(RPNEW(I)-RRP)+TGRP
      TRAY=TRAY+DELT(RPNEW(I)-RRP,TGRP,TGRPN)
      TGRN=-TANSUM(TGRPN,-TANT)
C        CHECK FOR TURNOVERS AND TURNUNDERS
52    IF(TGR*TGRN.GE.0.) GO TO 54
      IF(TGR.LT.0.) GO TO 53
      NCTR=NCTR+1
      GO TO 54
53    NCTR=NCTR+ITN2
54    TGAM(IRAY)=TGRN
      IF(NTRR.LE.1) GO TO 545
C        CHECK THAT RAY IS WITHIN THE PROPER LIMITS
      IF(ZNEW(I).LT.AL(NTRR-1)+BL(NTRR-1)*RMAX-.1) GO TO 80
545   IF(ZNEW(I).GT.AL(NTRR)+BL(NTRR)*RMAX+.1) GO TO 80
C        THROW IN VOLUME ATTENUATION
      IF(IATT.NE.0)SSR=SSR*10.**(-.0001*ATT*(TRAY-TIME(IRAY))/SQRT(CIS))
55    SS(IRAY)=SSR
      ZZ(IRAY)=ZNEW(I)
      TIME(IRAY)=TRAY
      NCOUNT(IRAY)=NCTR
      PHASE(IRAY)=PHR
      GO TO 100
60    IHIST=60
C        WHEN SMALL OR ZERO HORIZONTAL GRADIENTS, EQUATION FOR SECTION
C        50 IS SINGULAR,  THIS IS AN ITERATIVE SOLUTION FOR SUCH A CASE
C        GUESS VALUE FOR ITERATION
      ZNW=ZR-TGR*(RMAX-RR)
66    DO 67 I=1,7
      RPNW=CT*(RMAX-R0)-ST*(ZNW-Z0)
      DRP=RPNW-RRP
      TGRPAV=TGRP+ALPHA*DRP
      DZP=DRP*TGRPAV
```

```
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          ZPNW=ZRP+CZP
          ZNW2=CT*ZPNW-ST*RPNW+ZC                                                    ADVA0224
          D=ABS(ZNW2-ZNW)                                                            ADVA0225
          IF(I.EQ.3) DD=D                                                            ADVA0226
   47     ZNW=ZNW2                                                                   ADVA0227
C            CHECK FOR CONVERGENCE                                                   ADVA0228
          IF(D.LT.1.01) GO TO 68                                                     ADVA0229
          IF(D.LT.1.5*DD) GO TO 66                                                   ADVA0230
          IHIST=23                                                                   ADVA0231
          GO TO 80                                                                   ADVA0232
   68     RPNEW(1)=RPNEW(2)=RPNW                                                     ADVA0233
          GO TO 505                                                                  ADVA0234
C            PRINT ERROR MESSAGE                                                     ADVA0235
   80     SGR=0.                                                                     ADVA0236
          PRINT 81,IRAY,IHIST,RR,ZR,TGR                                              ADVA0237
          PRINT 82, RMAX,ZNEW(I),TGRN                                                ADVA0238
  666     FORMAT(* RAY*,I5,* IN LAYER*,I5,* Z=* ,F10.2,* R=*,F10.2,* TGR=*,F         ADVA0239
        1   10.5,*  NCIR= *,O16)                                                     ADVA0240
   81     FORMAT(* RAY *,I5,* TERMINATED*,5X,*IHIST=*,I2,5X,*STARTING RANGE=         ADVA0241
        1*,F12.2,5X,*RAY DEPTH=*,F12.2,5X,*STARTING TANGENT=*,F12.6)                 ADVA0242
   82     FORMAT(5X,*MAXIMUM RANGE=*,F12.2,5X,*NEW RAY DEPTH=*,F10.2,5X,*FIN         ADVA0243
        1AL TANGENT=*,F12.6)                                                         ADVA0244
          GO TO 55                                                                   ADVA0245
  100     CONTINUE                                                                   ADVA0246
          RETURN                                                                     ADVA0247
          END                                                                        ADVA0248
                                                                                     ADVA0249
```

```
DS    ADVANCE                                                        06/04/73        ED      0

                                                  IDENT       ADVANCE
     PROGRAM LENGTH                     01720
     ENTRY POINTS        ADVANCE        00125
     BLOCK NAMES
                         TRIANG         02261
                         RAYS           13561
                         INFO           00024
                         PIDEF          00003
                         MIRRORS        00621
                         ABC            00026
     EXTERNAL SYMBOLS
                         THEND,
                         03010140
                         03000040
                         01010100
                         01003100
                         02007111
                         0830ICT,
                         SQRTF
                         MAX1F
                         STH,
                         ONSINGL,
```

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```
      SUBROUTINE CHANNEL(ZR,T,ZTO,ZTU)
      COMMON /VELPRF/ N,Z(100),C(100)
      CALL VELCALC
 20   DO 25 I=2,N
      IF(ZR.GT.Z(I)) GO TO 25
      IZ=I
      F=(ZR-Z(I-1))/(Z(I)-Z(I-1))
      CH=SQRT(1.+T*T)*(F*C(I)+(1.-F)*C(I-1))
      GO TO 30
 25   CONTINUE
      ZTU=ZTO=-1.
      RETURN
 30   IN=IZ-1
 31   IF(C(IN).GT.CH) GO TO 35
      IN=IN-1
      IF(IN.NE.0) GO TO 31
      ZTO=0.
      GO TO 40
 35   F=(CH-C(IN+1))/(C(IN)-C(IN+1))
      ZTO=F*Z(IN)+(1.-F)*Z(IN+1)
 40   IN=IZ
 41   IF(C(IN).GT.CH) GO TO 45
      IN=IN+1
      IF(IN.LE.N) GO TO 41
      ZTU=Z(N)
      RETURN
 45   F=(CH-C(IN-1))/(C(IN)-C(IN-1))
      ZTU=F*Z(IN)+(1.-F)*Z(IN-1)
      RETURN
      ENTRY RCALC
      IF(ZTO.GT.-.5) GO TO 50
      RCYCLE=1.E300
      RETURN
 50   IN=1
      RCYCLE=0.
      TG2=0.
      DO 60 I=1,N
      IF(Z(I).GT.ZTO.AND.Z(I).LT.ZTU) GO TO 55
      IF(IN.EQ.1) GO TO 60
      RCYCLE=RCYCLE+(ZTU-Z(I-1))/(.5*TG1)
      RETURN
 55   TG1=SQRT((CH/C(I))**2-1.)
      IF(I.EQ.1) GO TO 59
      IF(IN.EQ.1) GO TO 56
      DR=(Z(I)-Z(I-1))/(.5*(TG1+TG2))
      GO TO 57
 56   DR=(Z(I)-ZTO)/(.5*TG1)
 57   RCYCLE=RCYCLE+DR
 59   TG2=TG1
      IN=2
 60   CONTINUE
      RETURN
      ENTRY WUENS
      IF(RCYCLE.GT.1.E100) GO TO 71
      IN=IZ
 65   IF(Z(IN).GT.ZR) GO TO 70
```

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```
      IF(Z(IN+1).GT.ZR) GO TO 75                                    CHAN0056
      IN=IN+1                                                       CHAN0057
      IF(IN.GE.N) GO TO 71                                          CHAN0058
      GO TO 65                                                      CHAN0059
   70 IF(Z(IN-1).LE.ZR) GO TO 74                                    CHAN0060
      IN=IN-1                                                       CHAN0061
      IF(IN.GE.1) GO TO 65                                          CHAN0062
   71 T=0.                                                          CHAN0063
      RETURN                                                        CHAN0064
   74 IN=IN-1                                                       CHAN0065
   75 V=C(IN)+(C(IN+1)-C(IN))*(ZR-Z(IN))/(Z(IN+1)-Z(IN))            CHAN0066
      T=1./(SQRT((CM/V)**2-1.)*RCYCLE)                              CHAN0067
      RETURN                                                        CHAN0068
      END                                                           CHAN0069
```

UNCLASSIFIED

```
S    CHANNEL                                                06/04/73        ED     0

                                            IDENT       CHANNEL
     PROGRAM LENGTH             00506
     ENTRY POINTS    CHANNEL    00003
                     RCALC      00151
                     WDENS      00257
     BLOCK NAMES
                     VELPRF     00511
     EXTERNAL SYMBOLS
                     OBSDICT,
                     VELCALC
                     SQRTF
```

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```
      SUBROUTINE VELCALC
      COMMON /INFO/ CODUC,RMAX,DCDCDC(18)
      COMMON /VELPRF/ N,Z(100),C(100)
      COMMON /THIANG/ AP(100,2),BP(100,2),AL(100),BL(100),ZZERO(100),
     1   RZERO(100),AA(100),BB(100),SST(100),CCT(100),NTRI
      COMMON/ABC/PUNCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1
      DATA (ROLD=-1.E300),(IFT2=0),(IBH=0)
      IF (IFT1.EQ.IFT2) GO TO 13
      IBH=0
      IFT2=IFT1
   13 IF (IFT1.EQ.0.OR.IBH.EQ.1) GO TO 3
      ROLD=-1.E300
      IBH=1
    3 IF(ABS(RMAX-ROLD).LT.1.) GO TO 20
      ROLD=RMAX
      N=NTRI+1
      DO 10 I=1,N
      IF(I.EQ.1) GO TO 1
      J=I-1
      ZZ=AL(J)+BL(J)*RMAX
      GO TO 2
 1     J=1
      ZZ=0.
 2    ZP=CCT(J)*(ZZ-ZZERO(J))+SST(J)*(RMAX-RZERO(J))
      C(I)=1./SQRT(AA(J)+BB(J)*ZP)
 10   Z(I)=ZZ
 20   RETURN
      END
```

```
DS   VELCALC                                                     06/04/73       ED      0
                                              IDENT       VELCALC
    PROGRAM LENGTH                   00132
    ENTRY POINTS      VELCALC        00006
    BLOCK NAMES
                      INFO           00024
                      VELPRF         00311
                      TPIANG         02261
                      ABC            00026
   EXTERNAL SYMBOLS
                      Q8CDICT,
                      SQRTF
```

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```
      SUBROUTINE INTENSTY
C        JUNE 14, 1971 LLOYDS MIRROR ADDED FOR ALL RECEIVERS AND TYPES
C        UNUSED SWITCH IFLIMS IS NOW LLMR, 0 FOR NO LLOYDS MIRROR, AND
C        NON-ZERO FOR LLOYDS MIRROR.  THIS SWITCH IS THE COLUMN AFTER
C        IPER ON THE INPUT CARDS
C        6/15/71 RECEIVERS BELOW BOTTOM FIXED
      COMMON /LOUDNESS/ LNRC,RCD(100),TYPEISC(100),TYPEIRP(100),
     1   TYPEII(100),TYPEIII(100)
      COMMON /TLE/STITLE (10)
      COMMON /RAYS/ NRAY,TGAM(1000),ZZ(1000),SS(1000),TIME(1000),
     1   NCOUNT(1000),PHASE(1000)
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,
     1   ISCP,IT1,IT2,IT3,IPER, LLMR ,LTRT,LTER,LTRP,LPIN,IATT
      COMMON /PIDEF/ PI,DTR,TWOPI
      COMMON /VELPRF/NN,Z(100),C(100)
      COMMON /TMPSTR/ DUD(182)
      DIMENSION QUAD(100),IHP(100),SINT(100,4),SSL(100),QUS(100),TYPS(10
     10)
      EQUIVALENCE (QUAD,DUD)
      COMMON/ABC/PUNCHDB (10),INCR,NBRS,NSRS,ALIM,IFT,IFT1
      DATA (IENT=0),(IFT2=0),(IBH=0),(IHP=100(0))
      SEC(T)=FVA*SQRT(1.+T*T)
      IF (IFT1.EQ.IFT2) GO TO 2 $ IBH=0 $ IFT2=IFT1
    2 IF (IFT1.EQ.0.OR.IBH.EQ.1) GO TO 3 $ IENT=0 $ IBH=1
    3 FVA=1.
      IF(IATT.EQ.0.AND.ATT.NE.0.) FVA=10.**(-.0001*ATT*RMAX)
      CALL VELCALC $WAVE=TWOPI*C(1)/OMEGA $AK=TWOPI/WAVEL  $ FLM=1.
      DO 5 I=1,LNRC
    5 TYPEISC(I)=TYPEIBP(I)=TYPEII(I)=TYPEIII(I)=QUAD(I)=0.
      IF(IT1.EQ.0.AND.IT2.EQ.0) GO TO 60
      SW=0.
      SDZ=0.
      DO 10 I=2,NRAY
      W=AMIN1(SS(I),SS(I-1))
      SDZ=SDZ+W*ABS(ZZ(I)-ZZ(I-1))
   10 SW=SW+W
      DZBAR=SDZ/SW
      IF(DZBAR.LT.WAVEL) DZBAR=WAVEL
      CALL CHANNEL(1.,1000.,ZS,ZB)
      DZM=ZB/SQRT(FLOAT(NRAY))
      IF(DZBAR.GT.DZM) DZBAR=DZM
      IF(IT1.EQ.0) GO TO 45
      DO 20 I=1,NRAY
      N=NCOUNT(I)
      M=N/ITN
      NTO=N-M*ITN
      N=M/ITN
      NSR=M-N*ITN
      M=N/ITN
      NTU=N-M*ITN
      NBR=M
      IF(I.EQ.1) GO TO 19
      NDTUO=IABS(NTO-NTOO)+IABS(NTU-NTUO)
      NDSBR=IABS(NSR-NSRO)+IABS(NBR-NBRO)
      ID=NDSBR
      ID=ID+NDTUO
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```
      IF(ID.GT.3) ID=3
      W=AMIN1(SS(I),SS(I-1))
      IF(W.LE.ALIM.OR.NBR.GT.NBRS.OR.NSR.GT.NSRS) ID=3
      NCOUNT(I)=NCOUNT(I)+ID*IBIG
19    NSRO=NSR
      NBRO=NBR
      NTUO=NTU
      NTOO=NTO
20    CONTINUE      $ DO 21 I=1,LNRC
      SSL(I)=0.0
      QUS(I)=0.0
      TYPS(I)=0.0
   21 IHP(I)=0  $  IPR=0
      INW=NCOUNT(2)/IBIG
      DO 30 I=2,NRAY
      NCOUNT(I)=NCOUNT(I)-INW*IBIG
      INXT=NCOUNT(I+1)/IBIG  $ IF(I+2.LE.NRAY) INXTT=NCOUNT(I+2)/IBIG
      IF(INW.GE.2) GO TO 29
      IQ1=0 $ IQ2=0 $ IQ3=0
      Z1=ZZ(I-1)
      S1=SEC(TGAM(I-1))*SS(I-1)
      DS=SEC(TGAM(I))*SS(I)-S1
      T1=TIME(I-1)
      DT=TIME(I)-T1
      TG1=TGAM(I-1)
      DTG=TGAM(I)-TG1
      DZ=ZZ(I)-Z1  $ DO 25 J=1,LNRC $ IQ1=0 $ IQ2=0 $ IQ3=0
      ZR=RCD(J) $ IF(ZR.GT.Z6) GO TO 25
      F=(ZR-Z1)/DZ  $ DZ1=ZZ(I+1)-ZZ(I)  $  F1=(ZR-ZZ(I))/DZ1
      IF(F.LT.-0.5.OR.F.GT.1.5) GO TO 25
      IF (INW.EQ.0.AND.F.LE.1.0.AND.F.GE.0..AND.IHP(J).EQ.0) 23,24
   23 IQ1=1
      GO TO 26
   24 IF (F.GT.1.0.AND.INW.EQ.0  .AND.INXT.NE.INW.AND.IHP(J).EQ.0) 31,32
   31 IQ2=1
      GO TO 26
   32 IF (F.LT.0.0.AND.IPR.NE.INW.AND.INW.EQ.0)    33,34
   33 IQ3=1
      GO TO 26
   34 IQ1=0 $IQ2=0 $IQ3=0
      GO TO 25
   26 SL=(S1+F*DS)/(RMAX*ABS(DZ))
      IF (SL.LE.0.0) GO TO 25$ IF (ABSF(DZ).LT.0.001) GO TO 25
      TG=TG1+F*DTG      $  IF (IQ1.EQ.1) IHP(J)=1
      TH=DTR*ATANF(TG) $ IF(INW.GE.1.AND.INXT.GE.1) GO TO 25
      IF(LLMR.NE.0) FLM=2.*SIN(ZR*AK*TG/SQRT(1.+TG**2))**2
      T=T1+F*DT
      IF (IQ1.EQ.1.AND.SINT(J,   EQ.0.0) SINT(J,4)=FLM
      IF (IQ1.EQ.1.AND.SINT(J,1).EQ.0.0) SINT(J,1)=SL
      IF (IQ2.EQ.1.AND.SINT(J,1).EQ.0.0.AND.SINT(J,2).EQ.0.0.AND.SINT(J,
     13).EQ.0.0) SINT(J,4)=FLM
      IF (IQ2.EQ.1.AND.SINT(J,1).EQ.0.0.AND.SINT(J,2).EQ.0.0.AND.SINT(J,
     13).EQ.0.0) SINT(J,2)=SL
      IF (IQ3.EQ.1.AND.SINT(J,1).EQ.0.0.AND.SINT(J,2).EQ.0.0.AND.SINT(J,
     13).EQ.0.0) SINT(J,4)=FLM
      IF (IQ3.EQ.1.AND.SINT(J,1).EQ.0.0.AND.SINT(J,2).EQ.0.0.AND.SINT(J,
```

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          13).EQ.0.0) SINT(J,3)=SL
          IF(IPER.EQ.0) GO TO 28
          IF (IENT.EQ.0) WRITE(LTER,1899),STITLE
          IF (IENT.EQ.0) WRITE( 49,1879),STITLE
     1879 FORMAT (10A8)
     1899 FORMAT (1H1,* EIGENRAY SET      *,10A8)
          IF(IENT.EQ.0) WRITE(LTER,899)
          PR=10.*ALOG10(SL)
          N=NCOUNT(I)
          IENT=1
          M=N/ITN
          NTO=N-M*ITN
          N=M/ITN
          NSR=M-N*ITN
          M=N/ITN
          NTU=N-M*ITN
          NBR=M
          IF (IQ3.EQ.1) IQUAL=3
          IF (IQ2.EQ.1) IQUAL=2
          IF (IQ1.EQ.1) IQUAL=1
          IREM=2H
          IF (IQ3.EQ.1.AND.SINT(J,3).NE.0.0) IREM=2H*
          IF (SINT(J,3).NE.0.0.AND.IQ1.EQ.1) IREM=2H**
          WRITE(LTER,900) I,NBR,NTU,NSR,NTO,RMAX,ZR,TH,T,PR,IQUAL,IREM
          RMKM=RMAX/1000.0
          WRITE(49,1878 ) I,NBR,NTU,NSR,NTO,RMKM,ZR,TH,T,PR
     1878 FORMAT (5I5,F10.4,F10.4,F10.4,F15.5,F10.1)
      899 FORMAT(*0NRAY  NBR  NTU  NSR  NTO*,10X,*RANGE     DEPTH     THETA
         1     TIME*, 9X,*SL(DB)*,5X,*IQUAL*,4X,*REM*)
      900 FORMAT(5I5,F15.0,F10.4,F10.4,F13.5,F10.1,6X,I5,5X,A2)
       22 FLM=SINT(J,4)
          IF (SINT(J,1).NE.0.) SL=SINT(J,1)
          IF (SINT(J,2).NE.0..AND.SINT(J,1).EQ.0.0) SL=SINT(J,2)
          IF (SINT(J,3).NE.0..AND.SINT(J,1).EQ.0.0) SL=SINT(J,3)
          IF (SINT(J,3).EQ.0.0) GO TO 27
          IF (IQ1.EQ.1.AND.SINT(J,1).NE.0.0) 71,72
       71 TYPEIRP(J)=SSL(J)
          IF (ISCP.EQ.0) GO TO 27
          TYPEISC(J)=TYPS(J)
          QUAD(J)=QUS(J)
          GO TO 27
       72 SSL(J)=TYPEIRP(J)
       27 TYPEIRP(J)=TYPEIRP(J)+SL*FLM
          IF(ISCP.EQ.0) GO TO 25
          PR=SQRT(SL)
          P=OMEGA*T+PHASE(I)
          IF (IQ3.EQ.1.AND.IQ1.EQ.0) QUS(J)=QUAD(J)
          QUAD(J)=QUAD(J)+PR*SIN(P)
          IF (IQ3.EQ.1.AND.IQ1.EQ.0) TYPS(J)=TYPEISC(J)
          TYPEISC(J)=TYPEISC(J)+PR*COS(P)
   25     IF (INXT.GE.1.OR.IPR.NE.INW.AND.INW.NE.INXT)IHP(J)=0
   29     IPR=INW
          INW=INXT
          IF (INW.EQ.0.OR.INW.LT.1.AND.INXTT.LT.1) GO TO 30
          DO 28 LL=1,LNRC
          SINT(LL,1)=0.0
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      SINT(LL,2)=0.0
      SINT(LL,3)=0.0
      SINT(LL,4)=0.0
   28 CONTINUE
30    CONTINUE
35    DO 37 I=1,LNRC
      TYPEISC(I)=TYPEISC(I)**2.+QUAD(I)**2
37    QUAD(I)=EXP(-RCD(I)/DZBAR)
      IF(IT2.EQ.0) GO TO 60
      F=2.*RMAX*DZBAR
      EB=EXP(-ZB/DZBAR)
      DO 50 I=1,NRAY
      IF(ABS(SS(I)).LT.ALEM)   GO TO 50
      EZ=EXP(-ZZ(I)/DZBAR)
      SL=SEC(TGAM(I))*SS(I)/F
      SGK=TGAM(I)*AK/SQRT(1.+TGAM(I)**2)
      SL=SL/(1.-.5*(EB/EZ+EZ))
      DO 40 J=1,LNRC
      IF(RCD(J).GT.ZB) GO TO 50
      ER=QUAD(J)
      IF(LLMR.NE.0) FLM=2.*SIN(RCD(J)*SGK)**2
      IF(ER.GT.EZ) GO TO 39
      S=SL*ER/EZ
      GO TO 40
39    S=SL*EZ/ER
40    TYPEII(J)=TYPEII(J)+S*FLM
50    CONTINUE
60    IF(IT3.EQ.0) RETURN
      DO 70 I=1,NRAY
      CALL CHANNEL(ZZ(I),TGAM(I),ZTO,ZTU)
      CALL RCALC
      IF(LLMR.NE.0) CALL MDENS(ZZ(I),CTRR)
      SL=FVA*SS(I)/RMAX
      DO 65 J=1,LNRC
      IF(RCD(J).GT.ZTU) GO TO 70
      IF(RCD(J).LT.ZTO) GO TO 65
      CALL MDENS(RCD(J),S)
      IF(LLMR.EQ.0) GO TO 64
      TG=TGAM(I)*CTRR/S
      FLM=2.*SIN(AK*RCD(J)*TG/SQRT(1.+TG**2))**2
      S=S*FLM
64    TYPEIII(J)=TYPEIII(J)+S*SL
65    CONTINUE
70    CONTINUE
      RETURN
      END
```

```
5.4DS  INTENSTY
                                                              01/02/75        ED      0
                                              IDENT      INTENSTY
   PROGRAM LENGTH                  03451
   ENTRY POINTS      INTENSTY      01540
   BLOCK NAMES
                     LOUDNESS      00765
                     TLE           00012
                     RAYS          13561
                     INFO          00024
                     PIDEF         00003
                     VELPRF        00311
                     TMPSTR        00266
                     ABC           00026
   EXTERNAL SYMBOLS
                     Q2Q07111
                     THEND.
                     Q8QDICT.
                     VELCALC
                     CHANNEL
                     RCALC
                     WDENS
                     ALOG10
                     SQRTF
                     SINF
                     MINIF
                     EXPF
                     COSF
                     ATANF
                     STH.
                     SLO.
                     QNSINGL.
```

```
,4A                                                 06/04/73
      SUBROUTINE ITNPRINT (NINT)
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,
     1   ISCP,IT1,IT2,IT3,IPER,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT
      COMMON /TMPSTR/ DLC(182)
      COMMON/LIMI../ R1 (10), DR (10), R2 (10)
      COMMON/ABC/PUNCHD5 (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1
      COMMON /TLE/STITLE (10)
      DATA(INCR=1)
      DIMENSION LINE(90),DB(4),FMT(6),AAL(400),IS(4),ABDDD(182)
      EQUIVALENCE (LINE,DDD)
      COMMON /LOUDNESS/ LNRC,RCD(100),AL(100,4)
      EQUIVALENCE (AL,AAL)
      DATA (HA6=3HA7,),(HF6=5HF7.1,),(B=1H ),(IS=1HS,1HR,1H2,1H3)
      DATA (FMT(1)=6H(F8.3,),(FMT(6)=8H6X,90A1))
      DIMENSION ITT(4)
      EQUIVALENCE (ISCP,ITT)
      DATA (IENT=0),(IFT2=0),(IBH=0)
      IF (IFT1.EQ.IFT2) GO TO 3 $ IBH=0 $ IFT2=IFT1
    3 IF (IFT1.EQ.0.OR.IBH.EQ.1) GO TO 2  $ INCR=1 $ IENT=0 $ HA6=3HA7,
      HF6=5HF7.1,  $ B=1H  $IS(1)=1HS $ IS(2)=1HR $ IS(3)=1H2 $IS(4)=1H3
      FMT(1)=6H(F8.3, $ FMT(6)=8H6X,90A1)     $ IBH=1
    2 IF(NINT.EQ.1) GO TO 40  $ AM=0. $ DO 10 I=1,400
      IF(AAL(I).GT.AM) AM=AAL(I)
10    CONTINUE $ DBM=10.*AINT(ALOG10(AM))    $ DBL=DBM-90.
      RK=.001*RMAX
      ISK=0
      IF (IENT.EQ.0) WRITE (39,1) STITLE
      IF(LNRC.GE.35) ISK=1
      WRITE (39,900),ISK,RK,DBL,DBM
      DO 30 I=1,LNRC
      DO 15 J=1,90
15    LINE(J)=1H
      DO 25 J=1,4
      IF(AL(I,J).LT.ALIM)     GO TO 20
      FMT(J+1)=HF6
      DB(J)=10.*ALOG10(AL(I,J))
      IL=(DB(J)-DBL)+1.5
      IF(IL.LE.0.OR.IL.GT.90) GO TO 25
      LINE(IL)=IS(J)
      GO TO 25
20    FMT(J+1)=HA6
      DB(J)=B
25    CONTINUE
30    WRITE (39,FMT) RCD(I),DB,LINE    $ IENT=1
      RETURN
40    IF(IENT.NE.0) GO TO 41
      WRITE(39,1),STITLE
    1 FORMAT (1H1,10A8)
      WRITE (36,920),STITLE,LNRC,ITT(1),ITT(2),ITT(3),ITT(4)
      IF (IENT.EQ.0) WRITE (35,941) STITLE,(RCD(J),J=1,19)
  941 FORMAT (10A8,/,(10F8.3))
      IF (IENT.EQ.0.AND.ITT(1).GT.0) WRITE (45,912) ,STITLE
  912 FORMAT (* COHERENT PHASE VALUES*,/,10A8)
      IF (IENT.EQ.0.AND.ITT(2).GT.0) WRITE (46,913),STITLE
  913 FORMAT (* RANDOM PHASE VALUES*,/,10A8)
      IF (IENT.EQ.0.AND.ITT(3).GT.0) WRITE (47,914),STITLE
```

,4A 06/04/73

```
  914 FERMAT (* TYPE 2 VALLES*,/,10A8)
      IF (IENT,EO,2,AND,ITT(4),GT,0) WRITE (48,915) ,STITLE
  915 FERMAT (* TYPE 3 VALLES*,/,10A8)
      IENT=1
      WRITE(39,905) (HCD(I),I=1,LNRC)
      WRITE (39,908)
900   FERMAT(11*INTENSITIES AT*,F10,3,* KM, */*0  DEPTH    ISC    IRP
     1  II    III    *,F6,1,84X,F6,1)
905   FERMAT(*0RECEIVED INTENSITY VS RANGE*,15X,*AT DEPTHS*/
     1   *0   R(KM)    TYPE   *,13F9,3,/,19X,13F9,3)
908   FERMAT(1X)
41    RK=RMAX/1000.
      IP=0
      DE 50 I=1,4
      IF(ITT(I),EO,0) GE TE 50
      DE 45 J=1,LNRC
      DLD(J)=                    10,*ALEG10(AMAX1(ALIM   ,AL(J,I)))
      PUNCHDH(INCR)=ABSF(DDD(J))
      ABDDD(J)=PUNCHDH(INCR)
      INCR=INCR+1
      IF   (INCR,LT,17) GE TE 45
      INCR=1
      WRITE (36,909) (PUNCHDE(II),II=1,16)
   45 CENTINUE
      IF (I,EO,1,AND,ITT(1),GT,0) WRITE (45,911) (ABDDD(J),J=1,19)
      IF (I,EO,2,AND,ITT(2),GT,0) WRITE (46,911) (ABDDD(J),J=1,19)
      IF (I,EO,3,AND,ITT(3),GT,0) WRITE (47,911) (ABDDD(J),J=1,19)
      IF (I,EO,4,AND,ITT(4),GT,0) WRITE (48,911) (ABDDD(J),J=1,19)
      IF(IP,EO,0) GE TO 46
      WRITE (39,906) IS(I),(DDD(J),J=1,LNRC)
906   FERMAT(16X,A1,2X,13F9,1,/,19X,13F9,1)
      GE TE 50
46    IP=1
      WRITE(39,907) RK,IS(I),(DDD(J),J=1,LNRC)
907   FERMAT(F9,3,7X,A1,2X,13F9,1,/,19X,13F9,1)
   50 CENTINUE
  909 FERMAT( 16F5,1)
  911 FERMAT (10F8,3)
  920 FERMAT (10A8,/,5I5)
      RETURN
      END
```

```
S  ITNPRINT
                                                              06/04/73          ED      0
                                           IDENT       ITNPRINT
   PROGRAM LENGTH                  01560
   ENTRY POINTS      ITNPRINT      00511
   BLOCK NAMES
                     INFO          00024
                     TMPSTR        00266
                     LIMITS        [illegible]
                     ABC           00026
                     TLE           00012
                     LOUDNESS      00765
   EXTERNAL SYMBOLS
                     THEND,
                     01010100
                     OBJDICT,
                     ALOG10
                     MAX1F
                     STH,
                     SLB,
                     ONSINGL,
```

4A 06/04/73

```
      SUBROUTINE IVSRPLOT(ITP)
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,
     1   ISCP,IT1,IT2,IT3,IPER,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT
      COMMON /LOUDNESS/ LNRC,RCD(100),AL(100,4)
      COMMON /TMPSTR/ DDD(182)
      COMMON /TLE/STITLE (10)
      COMMON/ABC/PUNCHOB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1
      DATA (IENT=0),(IFT2=0),(IBH=0)
      DIMENSION LINE(105)
      EQUIVALENCE (LINE,DDD)
      IF (IFT1.EQ.IFT2) GO TO 13
      IBH=0
      IFT2=IFT1
   13 IF (IFT1.EQ.0.OR. IBH.EQ.1) GO TO 3
      IENT=0
      IBH=1
    3 IF(IENT.NE.0) GO TO 10
      WRITE (38,1 ).STITLE
    1 FORMAT (1H1,10A8)
      IENT=1
      IT=ITP+1
      IF(IT.EQ.5) IT=1
      DO 2 I=1,11
 2    LINE(I)=-170+10*I
      N=MINO(LNRC,9)
      WRITE(38,900) (RCD(I),I,I=1,N)
      WRITE (38,901) (LINE(I),I=1,11)
      DO 25 I=1,11
   25 LINE(I)=1H+
      WRITE (38,903) (LINE(I),I=1,11)
900   FORMAT(*0*,15X,*RECEIVED INTENSITY VS RANGE*/*ORECEIVER AT DEPTH P
     1LOTS AS*//(F18.3,I9))
901   FORMAT(*0   R(KM)*,5X,11I10)
  903 FORMAT (14X ,11(9X,A1))
10    IF(IT.LE.0.OR.IT.GT.4) RETURN
      DO 15 I=1,105
15    LINE(I)=48
      DO 20 I=1,N
      DB=10.*ALOG10(AMAX1(1.E-25,AL(I,IT)))
      IP=161.5+DB
      IF(IP.LE.0.OR.IP.GT.105) GO TO 20
      LINE(IP)=I
20    CONTINUE
      RK=RMAX/1000.
      WRITE(38,902) RK,LINE
902   FORMAT(F9.3,14X,105R1)
      RETURN
      END
```

```
;  IVSRPLOT                                                  06/04/73        ED       0

                                                 IDENT        IVSRPLOT
   PROGRAM LENGTH                      00432
   ENTRY POINTS        IVSRPLOT        00064
   BLOCK NAMES
                       INFO            00024
                       LOUDNESS        00765
                       TMPSTR          00266
                       TLE             00012
                       ABC             00026
   EXTERNAL SYMBOLS
                       THEND,
                       Q1Q10100
                       Q8CDICT,
                       ALOG10
                       XMINOF
                       MAX1F
                       STH,
                       SLO,
                       QNSINGL,
```

,4A 06/04/73

```
      SUBROUTINE RAY PLOT(NP,ZMAX)
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,
     1   ISCP,IT1,IT2,IT3,IPER,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT
      COMMON /RAYS/ NRAY,TGAM(1000),ZZ(1000),SS(1000),TIME(1000),
     1   NCOUNT(1000),PHASE(1000)
      COMMON /TMPSTR/ DDD(182)
      COMMON/ABC/PUNCHOB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1
      DIMENSION IR(25),ISYM(25),LINE(115),INUM(9)
      COMMON /TRIANG/ AP(100,2),BP(100,2),AL(100),BL(100),ZZERO(100),
     1   RZERO(100),AA(100),BB(100),SST(100),CCT(100),NTRI
      EQUIVALENCE (LINE,DDD)
      DATA (ISYM=1HA,1HC,1HD,1HE,1HF,1HG,1HH,1HI,1HJ,1HK,1HL,1HM,1HN,1HO
     1  ,1HP,1HQ,1HR,1HT,1HU,1HV,1HW,1HX,1HY,1HZ,1H*)
      COMMON /TLE/STITLE (10)
      DATA (IENT=0),(IBLANK=1H ),(IHB=1HB),(IS=1HS),(IFT2=0),(IBH=0)
      DATA (INUM=1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1H9)
      IF (IFT1.EQ.IFT2) GO TO 2
      IBH=0
      IFT2=IFT1
    2 IF (IFT1.EQ.0.OR.IBH.EQ.1) GO TO 3
      IENT=0 $ IBH=1
    3 IF(IENT.NE.0) GO TO 10
      WRITE (LTRP,1) STITLE
      IENT=1
      ANP=FLOAT(NRAY)/FLOAT(NP)
      DO 5 I=1,NP
      A=ANP*(FLOAT(I)-.5)+1.
      IR(I)=A
      IF(IR(I).GT.NRAY) IR(I)=NRAY
5     CONTINUE
      SZ=ZMAX/114.
      WRITE (LTRP,900) SZ
10    ZB=AL(NTRI)+BL(NTRI)*RMAX
      RKM=.001*RMAX
      IB=(ZMAX-ZB)/SZ+1.5
      IB1=1
      IF(IB.LE.0) GO TO 12
      IF(IB.GT.115) IB=115
      DO 11 I=1,IB
11    LINE(I)=IHB
      IB1=IB+1
12    DO 15 I=IB1,114
15    LINE(I)=IBLNK
      LINE(115)=IS
      DO 20 I=1,NP
      K=IR(I)
      IF (NBRS.EQ.2500.AND.NSRS.EQ.2500) GO TO 17
      NN=NCOUNT(K) $M=NN/ITN $NN=M/ITN $NSR=M-NN*ITN $M=NN/ITN $NBR=M
   17 IF(ABS(SS(K)).LT.ALIM.OR.NBR.GT.NBRS.OR.NSR.GT.NSRS) GO TO 20
      ZR=ZZ(K)
      IP=(ZMAX-ZR)/SZ+1.5
      IF(IP.GT.115) IP=115
      IF(IP.LE.0) GO TO 20
      IF(LINE(IP).EQ.IBLNK.OR.LINE(IP).EQ.IS.OR.LINE(IP).EQ.IHB) GOTO 19
      DO 16 J=1,8
      IF(LINE(IP).NE.INUM(J)) GO TO 16
```

,4A 06/04/73

```
      LINE(IP)=INUM(J+1)
      GO TO 20
   16 CONTINUE
      LINE(IP)=INUM(1)
      GO TO 20
   19 LINE(IP)=ISYM(I)
   20 CONTINUE
      WRITE (LTHP,901) RKM,LINE
    1 FORMAT (1H1,10A8)
  900 FORMAT(27HOPLOT OF RAY PATHS     SCALE,F8.2,2X,10HM/POSITION/
     1   10HORANGE(KM),3X,114(1HX),1HS)
  901 FORMAT(F11.3,2X,115A1)
      RETURN
      END
```

```
'S    RAYPLOT                                                    06/04/73       EC      0

                                              IDENT      RAYPLOT
   PROGRAM LENGTH                   00605
   ENTRY POINTS       RAYPLOT       00145
   BLOCK NAMES
                      INFO          00024
                      RAYS          13561
                      TMPSTR        00266
                      ABC           00026
                      TRIANG        02261
                      TLE           00012
   EXTERNAL SYMBOLS
                      THEND,
                      01110100
                      OBCDICT,
                      STH,
                      SLO,
                      ONSINGL,
```

```
1,4A
                                                              06/04/73
      SUBROUTINE RAYZDIST (NP)
      COMMON /RAYS/ NRAY,TGAM(1000),ZZ(1000),SS(1000),TIME(1000),
     1   NCOUNT(1000),PHASE(1000)
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,
     1   ISCP,IT1,IT2,IT3,IPEK,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT
      COMMON /TMPSTR/ DUC(182)
      COMMON /TLE/STITLE (10)
      DIMENSION LINE(71)
      DIMENSION ISYM(25),IR(25)
      COMMON /PIDEF/ PI,DTR,TWOPI
      EQUIVALENCE (LINE,DDC)
      COMMON/ABC/PUNCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1
      DATA (IENT=0),(IFT2=0),(IBH=0)
      DATA (ISYM=1HA,1HC,1HD,1HE,1HF,1HG,1HH,1HI,1HJ,1HK,1HL,1HM,1HN,1HO
     1   ,1HP,1HQ,1HR,1HT,1HU,1HV,1HW,1HX,1HY,1HZ,1H*)
      IF (IFT1.EQ.IFT2) GO TO 7
      IBH=0
      IFT2=IFT1
    7 IF (IFT1.EQ.0.OR.IBH.EQ.1) GO TO 6
      IENT=0
      IBH=1
    6 IF (IENT.EQ.1 ) GO TO 3
      LTRD=37
      ANP=FLOAT(NRAY)/FLOAT(NP)
      DO 4 I=1,NP
      A=ANP*(FLOAT(I)-.5)+1.
      IR(I)=A
      IF(IR(I).GT.NRAY) IR(I)=NRAY
    4 CONTINUE
      IENT=1
    3 WRITE (LTRD,2),STITLE
      INC=1
    1 CALL CHANNEL(1.,1000.,ZS,ZB)
      DO 5 I=1,71
    5 LINE(I)=1HX
      RK=RMAX/1000.
      SCALE=ZB/71.0
      WRITE(LTRD,900) RK,ZB,SCALE,LINE
      DO 8 I=1,71
    8 LINE(I)=1H
      DO 40 I=1,NRAY
      S=SS(I)
      IF (NBRS.EQ.2500.AND.NSRS.EQ.2500) GO TO 35
      N=NCOUNT(I)
      M=N/ITN
      N=M/ITN
      NSR=M-N*ITN
      M=N/ITN
      NBR=M
   35 IF(S.GT.ALIM.AND.NBR.LE.NBRS.AND.NSR.LE.NSRS) GO TO 12
      IF (I.EQ. IR(INC))10,15
   10 WRITE (LTRD,1901),ISYM(INC),I
      INC=INC+1
      GO TO 40
   15 WRITE(LTRD,901) I
  900 FORMAT(26HORAY DEPTH DISTRIBUTION AT,F10.4,4H KM,,10X,*BOTTOM DEPT
```

```
i,4A                                                                  06/04/73
      1H=*,F10.3,*  M*,10X,*SCALE=*,F10.3,* M/PØSITIØN*,//,29HØLD  NRAY
      2NBR  NTU  NSR  NTØ,3X,5HDEPTH,5X,5HTHETA,6X,4HTIME,1X,6HLØSSES,1X,
      371A1)
 901   FØRMAT(4X,I4,10X,11HTERMINATED,)
 1901 FØRMAT (2X,A1,1X,I4,10X,11HTERMINATED,)
       GØ TØ 40
 12    DB=10.*ALØG10(S)
       T=TIME(I)
       Z=ZZ(I)
       N=NCØUNT(I)
       M=N/ITN
       NTØ=N-M*ITN
       N=M/ITN
       NSR=M-N*ITN
       M=N/ITN
       NTU=N-M*ITN
       NBR=M
       LINE(1)=1HE
       LINE(71)=1HS
       CALL CHANNEL(Z,TGAM(I),ZTØ,ZTL)
       IZP=70.*(1.-ZTL/ZB)+1.5
       IF (IZP.GT.71.ØR.IZP.LT.1) GØ TØ 45
       LINE(IZP)=1H*
   45 IZM=70.*(1.-ZTØ/ZB)+1.5
       IF (IZM.GT.71.ØR.IZM.LT.1) GØ TØ 55
       LINE(IZM)=1H*
   55 IZR=70.*(1.-Z/ZB)+1.5
       IF (IZR.GT.71.ØR.IZR.LT.1) GØ TØ 60
       LINE(IZR)=1H*
   60 TH=DTR*ATAN(TGAM(I))
       IF (I.EQ. IR(INC))20,25
   20 WRITE (LTRD,902) ISYM(INC), I,NBR,NTU,NSR,NTØ,Z,TH,T,DB,LINE
       INC=INC+1
       GØ TØ 30
 902   FØRMAT(2X,A1,1X,5I5, F8.2,F10.5,F10.3,F7.1,1X,71A1)
   25 WRITE (LTRD,1902) I,NBR,NTU,NSR,NTØ,Z,TH,T,DB,LINE
 1902 FØRMAT(4X,5I5, F8.2,F10.5,F10.3,F7.1,1X,71A1)
   30 IF (IZP.LE.71.AND.IZP.GE.1) LINE(IZP)=1H
       IF (IZM.LE.71.AND.IZM.GE.1) LINE(IZM)=1H
       IF (IZR.LE.71.AND.IZR.GE.1) LINE(IZR)=1H
 40    CØNTINUE
    2 FØRMAT (1H1,10A8,/)
       RETURN
       END
```

```
)S  RAYZDIST                                                    06/04/73        ED      0

                                              IDENT        RAYZDIST
    PROGRAM LENGTH                  01'54
    ENTRY POINTS       RAYZDIST     00234
    BLOCK NAMES
                       RAYS         13561
                       INFO         00024
                       TMPSTR       00266
                       TLE          00012
                       PIDEF        00003
                       ABC          00026
    EXTERNAL SYMBOLS
                       G1G1010U
                       THEND,
                       CBGDICT,
                       CHANNEL
                       ALOG10
                       ATANF
                       STH,
                       SLE,
                       GNSINGL,
```

,4A 06/04/73

```
      SUBROUTINE BYEBYE                                    BYBY   1
      DIMENSION LEAVE(1)                                   BYBY   2
      J=1                                                  BYBY   3
      LEAVE(J)=6300000003000000B                           BYBY   4
      END                                                  BYBY   5
```

```
S     BYEBYE                                                  06/04/73        ED      0
                                            IDENT       BYEBYE
   PROGRAM LENGTH                   00017
   ENTRY POINTS      BYEBYE         00004
   EXTERNAL SYMBOLS
                     Q8QDICT,
```

```
IDS  RECOVERY
                                                        08/02/72        ED      0          PAGE NO.     1
                                    IDENT      RECOVERY
     PROGRAM LENGTH          00125
     ENTRY POINTS    DUMP    00000                                                                 00001
                     RESTART 00057
                           ASTATUS   MACRO      P1
                           ST        STATUS     ((P1))                                             00002
                                     NOJP       Q+47+ST                                            00003
                                     NOJP       Q+46+ST                                            00004
                                     ENDM                                                          00005
                                                                                                   00006


                                                TITLE -- DUMP AND RESTART FACILITY
                                                IDENT NAME -- Q4-NRL-RECOVERY                      00008
                                                IDENT NUMBER -- Q4001R00                           00009
                                                LANGUAGE -- COMPASS 5.3                            00010
                                                COMPUTER -- CDC 3800                               00011
                                                CONTRIBUTOR -- ANNA BYRD MAYS, CODE 7817.1         00012
                                                          DOUGLAS P. SHANNON, CODE 7817.3          00013
                                                          RESEARCH COMPUTATION CENTER              00014
                                                          MATH. AND INFO. SCIENCES DIVISION        00015
                                                DATE -- JUNE 1970                                  00016
                                                PURPOSE -- ALLOWS PROGRAMS WITH A LONG RUN-TIME TO 00017
                                                        HAVE A RESTART CAPABILITY                  00018
                                                                                                   00019


                                     ENTRY      DUMP,RESTART
          00017   MT1       EQU        15        ALWAYS INPUT TAPE, FIRST OUTPUT TAPE              00021
          00004   TRIES     EQU        5-1       PARITY RE-TRY COUNTER                             00022
          50000   LOWCORE   EQU        50000B    OCTAL NUMBER ON DEMAND CARD                       00023
          00052   PARITY    EQU        42        PARITY STATUS BIT                                 00024
          00000   UNLOAD    EQU                  1 IF UNLOAD TAPE AFTER USE, LAW SMITH             00025
         P00000   FWA       EQU        *                                                           00026
                                                                                                   00027
```

```
OS  RECOVERY
                                                      08/02/72        ED      0          PAGE NO.     2
 00000   63  0  00000  DUMP    UNJP      **
         00  0  77777
 00001   77  2  04000          USTA      (*)SAVEAQ        SAVE REGISTERS TO DUMP ON TAPE
         20  0  P00110
 00002   00  7  40053          RAT       Q,A
         20  0  P00112         STA       SAVEQ
 00003   56  1  P00113         SIU       SAVE12,1
         57  2  P00113         SIL       SAVE12,2
 00004   56  3  P00114         SIU       SAVE34,3
         57  4  P00114         SIL       SAVE34,4
 00005   56  5  P00115         SIU       SAVE56,5
         57  6  P00115         SIL       SAVE56,6
 00006   50  1  00017          ENI       MT1,1
         50  0  00000
 00007                 MODE    MODE      ((0,1),*,BIN,LO)     MODE TAPE 200 BPI
 00012   50  6  00004          ENI       TRIES,6          SET RE-TRY COUNTER
         50  0  00000
 00013                 REW,1   REWIND    ((0,1),*)
 00016                         WRITE     ((0,1),=CWA,*)
 00021                         ASTATUS   ((0,1))
 00025   63  0  30052          ZMJP      Q,PARITY,CONT,1    JUMP IF NO PARITY ERROR
         64  0  P00050
 00026                         REWIND    ((0,1),*)
 [illegible]                   READ      ((0,1),RSKIPCW,*)    MAKE SURE OF PARITY ERROR
 [illegible]                   ASTATUS   ((0,1))
 [illegible]  63  0  30052     ZMJP      Q,PARITY,CONT,1      JUMP IF NO PARITY ERROR
         64  0  P00050
 00041   55  6  P00013         IJP       REW,1,6
         51  1  00001          INI       1,1
 00042                         RELEASE   ((-1,1),*)
                                                       BAD TAPE --- TRY ANOTHER UNIT
 00044   62  0  00022          RGJP,NE   R1,MT1+3,MODE    JUMP IF NOT OVER TAPE UNIT LIMIT
         30  1  P00007
 00045   12  1  P00102         LDA       ERROR-MT1-1,1    ABORT MESSAGE
         20  0  P00047         STA       *+1,1
 00046                         ABORT     **               KILL JOB
                               IFZ       UNLOADMT,2
 [illegible]  62  0  00017  CONT,1  RGJP,NE  R1,MT1,*-3   JUMP IF NOT FIRST TAPE
         30  1  P00045
 00051                         REWIND    ((0,1),*)        PERFORM FREE REWIND
                               IFN       UNLOADMT
 00054   52  1  P00113         LIU       SAVE12,1         RELOAD USED INDEX REG.
         53  6  P00115         LIL       SAVE56,6
 00055   77  2  00000          LLDA      SAVEAQ           RESTORE A AND Q
         12  0  P00110
 00056   75  0  P00000         UJP       DUMP             EXIT
         50  0  00000
```

```
40S  RECOVERY                                                    08/02/72        Ed      0           PAGE NO,       3
        00057   00  0  00000  RESTART  UCT        0
                00  0  00000                                                                                      00078
        00060   77  1  04000           END        *
                               *                               REGISTERS NEED NOT BE SAVED                        00079
                50  6  00006           ENI        TRIES,6      SET RE-TRY COUNTER                                 00080
        00061                          MODE       ([illegible],LO,BIN) SET MODE TO 200 BPI                        00081
        00064                 REW,2    REWIND     *T1,*                                                           00082
        00067                          READ       MT1,RC=A,*   REINCARNATE CORE                                   00083
        00072                          ASTATUS    MT1                                                             00084
        00076   63  0  30052           ZRJP       Q,PARITY,CONT,2                                                 00085
                64  0 P00102                                                                                      00086
        00077   55  6 P00064           IJP        REW,2,6
                                       ABORT      BAD READ     KILL JOB IF TAPE UNREADABLE                        00087
        00102   12  0 P00112  CONT,2   LDA        SAVED        REVITALIZE MACHINE REGISTERS                       00088
                00  7  40555           RAT        A,D                                                             00089
        00103   77  2  00000           DLDA       SAVEAQ                                                          00090
                12  0 P00110                                                                                      00091
        00104   52  1 P00113           LIU        SAVE12,1
                53  2 P00113           LIL        SAVE12,2                                                        00092
        00105   52  3 P00114           LIU        SAVE34,3                                                        00093
                53  4 P00114           LIL        SAVE34,4                                                        00094
        00106   52  5 P00115           LIU        SAVE56,5                                                        00095
                53  6 P00115           LIL        SAVE56,6                                                        00096
                               *       IFN        UNLOAD=T,1                                                      00097
        00107   75  0 P00057           UJP        RESTART                                                         00098
                50  0  00000                                                                                      00101
```

```
5  RECOVERY
                                                        08/02/72      ED      0        PAGE NO.     6
  00110                    SAVEAU   BSS     2
  00112                    SAVEU    BSS     1
  00113   00  0  00000     SAVE12   OCT     0
          00  0  00000
  00114   00  0  00000     SAVE34   OCT     0
          00  0  00000
  00115   00  0  00000     SA,E56   OCT     0
          00  0  00000

  00116   50  0  77777     *C*A     IOT*,C   (1)00000,77777H        ALL OF BANK ONE
          00  1  00000
                                             BANK ZERO FROM LOWER BOUND TO RECOVERY - 1
  00117   50  0 P50000              IOT*,C   77776H-LO*CORE,F*A-77776H+LO*CORE-1
          00  0  27776
  00120   13  0  00006              IOT*     (3)SAVEAU,A            SPACE FOR INDEZ REGISTERS
          00  0 P00110
                P00116     *C*A     EQU      *C*A
  00121   20  0  77777     *SKIPC*  IJSH     **,**
          00  0  77777
  00122   22  2  12*66     ERROR    BCD      1,BACK* 15
          51  6  00105
  00123   22  2  12*66              BCD      1,BACK* 16
          51  6  00106
  00124   22  2  12*66              BCD      1,BACK* 17
          51  6  00107
                                    IFN      UNLOAD*T,1
                                    END
```

.5A 04/05/72

```
      PROGRAM TRIPLT
C     THIS VERSION IS COMPATIABLE WITH 4-5-72 VERSION OF TRIMAIN
C        DISK VERSION OF TRIPLT
C        IF INFO WILL FIT IN CORE DISK IS NOT OPENED
C        THIS DETERMINED BY NRMAX AND THE NUMBER OF RAYS TO PLOT
C
      COMMON /INFO/ ID,NR,RMAX,ZMAX,RSCALE,AL,RR(2000),ZBOT(2000),IKNM
      DIMENSION TITLE(10),BUF(254),NRPLOT(512),ZR(1000),TR(1000),SS(1000
     1),NCOUNT(1000)
      COMMON /1/ ZSTOR(16384)
      COMMON /2/ TSTOR(16384)
900   FORMAT(10A8)
901   FORMAT(28H1CALCOMP PLOT FROM RAY TAPE ,10A8)
 902  FORMAT (2F8.3,I4,6I5,F10.3)
903   FORMAT(8H0LENGTH=,F10.2,3X,10HMAX DEPTH=,F12.1,3X,14HNO. OF RECORD
     1S,I10,5X,*IKNM=*,I3,5X,*IFMC=*,I3,5X,*NFSK=*,I3,5X,*ITTR=*,I3,/,
     21X,*DB LIMIT=*,F8.3,5X,*MAXIMUM NUMBER OF SURFACE REFLECTIONS=*,
     3I5,5X,*MAXIMUM NUMBER OF BOTTOM REFLECTIONS=*,I5)
904   FORMAT(20I4)
905   FORMAT(5H0NRAY,20I5)
906   FORMAT(11H0NO OF RAYS,I6,3X,15HLENGTH OF BLOCK,I6,3X,12HNO OF BLOC
     1KS,I6)
9039  FORMAT(24H0PARITY ERROR IN RECORD  ,I6)
      IDF9=0 $ ICO=0 $READ 4,ITNO $REWIND 1
    4 FORMAT (I2)
      CALL PLOTS(BUF,254,10)
    2 READ 902, AL,ZMAX,NRMAX,IKNM,IFMC,NFSK,ITTR,NSR1,NBR1,ALIM1
      IF (EOF,60)2,7
    7 ICO=ICO+1
      DO 3 J=1,NFSK
    3 CALL SKIPFILE (1)
      READ (1),TITLE,ALIM,NBRS,NSRS,ITNSIF(ITTR,LT,0)READ 900,TITLE
      IF (ALIM1.NE.0.0.AND.ALIM1.GT.ALIM) ALIM=POWRF(10.0,(-ALIM1/10.0))
      IF (ALIM1.EQ.0.0) ALIM1=-10.0*ALOG10(ALIM) $ PRINT 901,TITLE
      IF (NSR1.NE.0.AND.NSR1.LT.NSRS) NSRS=NSR1
      IF (NBR1.NE.0.AND.NBR1.LT.NBRS) NBRS=NBR1
      PRINT 903,AL,ZMAX,NRMAX,IKNM,IFMC,NFSK,ITTR,ALIM1,NSRS,NBRS
      IF(AL.LE.0..OR.AL.GT.120.) STOP $ IF (ZMAX.LE.0.) STOP $ IL=1
      IF(NRMAX.LE.0.OR.NRMAX.GT.2000) STOP
5     IH=IL+19
      IF(IH.GT.511) STOP
      READ 904,(NRPLOT(I),I=IL,IH)
      PRINT 905,(NRPLOT(I),I=IL,IH)
      IF(EOF,60) 10,15
10    IH=IL-1
      GO TO 25
15    IF(NRPLOT(IH).EQ.0) GO TO 20
      IL=IL+20
      GO TO 5
20    IH=IH-1
      IF(NRPLOT(IH).NE.0) GO TO 25
      IF(IH.GT.0) GO TO 20
25    NTOPLT=IH
      IF(IH.LE.0) STOP
      LBLK=32*(512/NTOPLT)
      NBLK=(NRMAX-1)/LBLK+1
```

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```
      PRINT 906,NTOPLT,LBLK,MBLK
      NDISK=MBLK*LBLK*NTOPLT*2
      IF(NDISK.GT.2**20) STOP
      IF(MBLK.EQ.1.OR.IDFO.EQ.1) GO TO 30
      IDFO=1
      CALL DKOPEN(2,3HRAN,0)
C        PLOT TITLE AND Z-AXIS
30    CALL SYMBOL(1.,0.,.14,TITLE,90.,80)
      CALL SYMBOL(2.8,9.93,.14,1HC,0.,1)
      Z=0.
      DO 31 I=1,10
      CALL PLOT(3.,11.-I,3)
      CALL PLOT(3.,10.-I,2)
      CALL PLOT(3.05,10.-I,2)
      CALL PLOT(2.95,10.-I,2)
      Z=Z+ZMAX/10.
      CALL NUMBER(2.32,9.93-I,.14,Z,0.,4HF5.0)
      IF (I.EQ.5.AND.IFMC.GE.0) CALL SYMBOL (2.,4.5,.14,9HDEPTH (M),90.,
     19)
      IF (I.EQ.5.AND.IFMC.LT.0) CALL SYMBOL (2.,4.5,.14,10HDEPTH (FT),
     190.,10)
31    CONTINUE
      IF (IFMC.LT.0) ZMAX= ZMAX*0.3048
      NR=NRMAX
      M=1
      IREC=0
35    DO 50 IR=1,LBLK
      IREC=IREC+1 $  IFEF=0
      READ(1) NRAY,RR(IREC),ZOUT(IREC),(TR(I),I=1,NRAY),(ZR(I),I=1,NRAY)
     1,(SS(I),I=1,NRAY),(NCOUNT(I),I=1,NRAY)
      IF(EOF,1) 36,38
36    IFEF=1
      IF (NRMAX.LT.IREC-1) GO TO 52
      NRMAX=IREC-1
      NR=NRMAX
      GO TO 52
38    IF(IOCHECK,1) 39,40
39    PRINT 9039,IREC
40    DO 45 I=1,NTOPLT $ K=NRPLOT(I) $J=LBLK*(I-1)+IR $ ZSTOR(J)=ZR(K)
      IF (NSRS.EQ.2500.AND.NBRS.EQ.2500) GO TO 41
      NN=NCOUNT (K)$MM=NN/ITN$NN=MM/ITN$NSR=MM-NN*ITN $MM=NN/ITN$NBR=MM
41    IF (SS(K).LE.ALIM.OR.NSR.GE.NSRS.OR.NBR.GE.NBRS) ZSTOR(J)=-ZR(K)
      IF (ZR(K).LT.0.0) ZSTOR(J)=ZR(K)
45    TSTOR(J)=-TR(K)
50    CONTINUE
52    IF(MBLK.EQ.1) GO TO 60 $ IDEL=MBLK*LBLK
      MDISK=(M-1)*LBLK
      DO 55 I=1,NTOPLT
      CALL DKLOCATE(MDISK)
      J=(I-1)*LBLK+1
      K=J+LBLK-1
      CALL DKWRITE(ZSTOR(J),ZSTOR(K))
      MDISK=MDISK+IDEL
      CALL DKLOCATE(MDISK)
      CALL DKWRITE(TSTOR(J),TSTOR(K))
55    MDISK=MDISK+IDEL
```

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```
 60     IF(M.EQ.MBLK.OR.IEFF.EQ.1) GO TO 65
        M=M+1
        GO TO 35
     65 NREC=32*((NRMAX-1)/32+1)
        RMAX=RR(NR)
        RSCALE=AL/RMAX
        CALL PLOTOPT
        IF(MBLK.EQ.1) GO TO 80
        ID=1
        MDISK=0
        DO 70 I=1,NTOPLT
        CALL DKLOCATE(MDISK)
        CALL DKREAD(ZSTOR(1),ZSTOR(NREC))
        MDISK=MDISK+IDEL
        CALL DKLOCATE(MDISK)
        CALL DKREAD(TSTOR(1),TSTOR(NREC))
        MDISK=MDISK+IDEL
        CALL RAYPLOT(ZSTOR,TSTOR)
 70     ID=-ID
        GO TO 90
 80     ID=1
        DO 85 I=1,NTOPLT
        L=(I-1)*LBLK+1
        CALL RAYPLOT(ZSTOR(L),TSTOR(L))
 85     ID=-ID
 90     CALL PLOT(AL+10.,0.,-3)
        IF (IEFF.EQ.1) GO TO 91   $ IREC=0
     92 IREC=IREC+1
        READ(1) NRAY,RR(IREC),ZBOT(IREC),(TR(I),I=1,NRAY),(ZR(I),I=1,NRAY)
       1,(SS(I),I=1,NRAY),(NCOUNT(I),I=1,NRAY)
        IF (EOF,1) 91,92
     91 IF (ICO.LT.ITNC) GO TO 2
        CALL STOPPLOT
        STOP
        END
```

UNCLASSIFIED

```
5    TRIPLT                                                     04/05/72        ED      0
                                          IDENT      TRIPLT
  PROGRAM LENGTH                 12771
  ENTRY POINTS      TRIPLT       11432
  BLOCK NAMES
                    INFO         07647
                    1            40000
                    2            40000
  EXTERNAL SYMBOLS
                    Q8QENTRY
                    THEND,
                    Q8QSTOPS
                    Q2Q07000
                    Q1Q03100
                    Q8QDICT,
                    PLOTS
                    SKIPFILE
                    DKOPEN
                    SYMBOL
                    PLOT
                    NUMBER
                    DKLOCATE
                    DKWRITE
                    PLOTBOT
                    DKREAD
                    PAYPLOT
                    STEPPLOT
                    ALOG10
                    POWRF
                    Q8QIFEOF
                    Q8QIFIOC
                    REW.
                    TSH.
                    TSO.
                    STH.
                    SLO.
                    SLI.
                    QNSINGL,
```

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```
      SUBROUTINE PLOTBOT
      COMMON /INFO/ ID,NR,RMAX,ZMAX,RSCALE,AL,RR(2000),ZBOT(2000),IKNM
      NTM=AMIN1(AL+1.,40.5)
      RT=1.
      RMAN=RMAX
      IF (IKNM.LT.0) RMAN=RMAX/1.852
   56 NT=RMAN/RT
      IF(NT.LE.NTM) GO TO 57
      RT=2.*RT
      NT=RMAN/RT
      IF(NT.LE.NTM) GO TO 57
      RT=2.5*RT
      NT=RMAN/RT
      IF(NT.LE.NTM) GO TO 57
      RT=2.*RT
      GO TO 56
C        PLOT SURFACE AXIS
   57 CALL PLOT(3.,10.,3)
      X=3.
      RSCALE1=RSCALE
      IF (IKNM.LT.0) RSCALE1=1.852*RSCALE
      DX=RT*RSCALE1
      R=0.
      IF=0
   58 CALL PLOT(X,10.,2)
      CALL PLOT(X,9.95,2)
      RK=R/1000.
      CALL NUMBER(X-.24,10.05,1.4E-1,RK,0.,4HF4.0)
      IF(R.LT.RMAN/2.) GO TO 59
      IF(IF.EQ.1) GO TO 59
      IF(IKNM.LT.0)CALL SYMBOL(X-.30,10.25,.14,10HRANGE (NM),0.,10)
      IF(IKNM.GE.0)CALL SYMBOL(X-.30,10.25,.14,10HRANGE (KM),0.,10)
      IF=1
   59 CALL PLOT(X,10.,3)
      IF(R.GE.RMAN) GO TO 60
      X=X+DX
      R=R+RT
      GO TO 58
C        PLOT BOTTOM CONTOUR
   60 DO 63 I=1,NR
      K=NR+1-I
      Y=10.*(1.-ZBOT(K)/ZMAX)
      X=RR(K)*RSCALE+3.
      IP=2
      IF(I.EQ.1) IP=3
      IF(Y.GE.0.) GO TO 63
      IP=3
      Y=0.
   63 CALL PLOT(X,Y,IP)
      RETURN
      END
```

```
5   PLOTBOT                                                        04/05/72        ED     0
                                        IDENT      PLOTBOT
PROGRAM LENGTH                  00305
ENTRY POINTS       PLOTBOT      00010
BLOCK NAMES
                   INFO         07647
EXTERNAL SYMBOLS
                   C1010100
                   SBODICT,
                   PLOT
                   NUMBER
                   SYMBOL
                   MINIF
```

```
5A                                                                  04/05/72
      SUBROUTINE RAYPLOT(ZSTOR,TSTOR)                                    TPLT 199
      DIMENSION ZSTOR(2000),TSTOR(2000)                                  TPLT 200
      DIMENSION Z(25),R(25)                                              TPLT 201
      COMMON /INFO/ ID,NR,RMAX,ZMAX,RSCALE,AL,RR(2000),ZBOT(2000),IKNM   TPLT 202
      NID=1  $ IBH=L $ IPR=0 $ IHT=0 $IRI=0  $ IST=0  $ IJ1=0            TPLT 203
      IF(ID.LT.0) NID=NR $ IF (NID.NE.1) IPR=1                           TPLT 204
      ZO=ABSF(ZSTOR(NID))    $  IF (ZSTOR(1).LT.0.0) RETURN              TPLT 205
      TO=TSTOR(NID)                                                      TPLT 206
      RO=RR(NID)                                                         TPLT 207
      ZBO=ZBOT(NID)                                                      TPLT 208
      X=RO*RSCALE  $ IF (ZO.GT.ZBO) ZO=ZBO                               TPLT 209
      Y=10.*(1.-ZO/ZMAX)                                                 TPLT 210
      IF(Y.LT.0.) Y=0.                                                   TPLT 211
      CALL PLOT(X+3.,Y,3)                                                TPLT 212
      DO 99 LL=2,NR                                                      TPLT 213
      IF(ID.GT.0) GO TO 73                                               TPLT 214
      L=NR-LL+1                                                          TPLT 215
      GO TO 74                                                           TPLT 216
73    L=LL                                                               TPLT 217
74    ZN=ABSF(ZSTOR(L))$ TN=TSTOR(L) $RN=RR(L) $ZBN=ZBOT(L)$DR=RN-RO     TPLT 218
      IF(ZN.GT.ZBN) ZN=ZBN $ IF (ZSTOR(L).LT.0.0.AND.IPR.EQ.1) 91,93     TPLT 219
   93 IF (NID.NE.1.AND.IBH.EQ.0) 94,95                                   TPLT 220
   94 X=RO*RSCALE $Y=10.*(1.-ZO/ZMAX)$IF (Y.LT.0.) Y=0.0                 TPLT 221
      CALL PLOT (X+3.,Y,3) $ IBH=1$IPR=0$IRI=1$IF(ZSTOR(L+1).GE.0.)IST=1TPLT 222
   95 ZNB=ZN-DR*TN                                                       TPLT 223
      ZON=ZO+DR*TO                                                       TPLT 224
      IF(ZNO.GE.0.) GO TO 75                                             TPLT 225
      IF(ZON.GE.0.) GO TO 75                                             TPLT 226
      ZO=-ZO                                                             TPLT 227
      ZON=-ZON                                                           TPLT 228
      TO=-TO                                                             TPLT 229
75    TB=(ZON-ZOB)/DR                                                    TPLT 230
      IF(ZNB.LE.ZOB) GO TO 78                                            TPLT 231
      IF(ZON.LE.ZBN) GO TO 78                                            TPLT 232
      IF(TB.EQ.0.) GO TO 76                                              TPLT 233
      DZ=ZBO-ZO                                                          TPLT 234
      ZO=ZO+2.*DZ/(1.+TB**2)                                             TPLT 235
      RO=RO-2.*DZ/(TB+1./TB)                                             TPLT 236
      TO=(TO-TB)/(1.+TO*TB)                                              TPLT 237
      TO=(TB-TO)/(1.+TO*TB)                                              TPLT 238
      GO TO 77                                                           TPLT 239
76    ZO=2.*ZBO-ZO                                                       TPLT 240
      TO=-TO                                                             TPLT 241
77    DR=RN-RO                                                           TPLT 242
      ZON=ZO+DR*TO                                                       TPLT 243
      ZNO=ZN-DR*TN                                                       TPLT 244
78    DX=ABS(DR*RSCALE)                                                  TPLT 245
      N=DX/.02+2.                                                        TPLT 246
C        INTERPOLATION TO FIFTIETHS WILL BE DONE                         TPLT 247
      IF(N.GT.25) N=25                                                   TPLT 248
      II=1                                                               TPLT 249
      DF=1./(N-1)                                                        TPLT 250
      F=0.                                                               TPLT 251
C        SPLINE FIT BY CONTINUED LINEAR INTERPLOLATION                   TPLT 252
      DZ=ZN-ZO                                                           TPLT 253
      DZP=ZON-ZO                                                         TPLT 254
```

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```
      DZN=ZN-ZN0
79    Z1=Z0+F*DZ
      Z2=Z0+F*DZ0
      Z3=ZN0+F*DZN
      G=1.-F
      Z4=G*Z2+F*Z1
      Z5=G*Z1+F*Z3
      Z(II)=G*Z4+F*Z5
      R(II)=R0+F*DR
      II=II+1
      F=F+DF
      IF(II,LE.N) GO TO 79
      DO 89 II=1,N
      IN=0
      IF(Z(II).LT.0.) IN=1
      IF(Z(II).GT,ZBN+(R(II)-RN)*TB) IN=-1
      IF(II,EQ.1) GO TO 82
      IF(IN,EQ.IO) GO TO 82
      IF(IN,NE.1.AND.IO,NE.1) GO TO 80
      RHIT=.5*(R(II)+R(II-1)+(R(II)-R(II-1))*(Z(II)+Z(II-1))/(Z(II-1)-Z(
     1II)))
      X=RHIT*RSCALE$IP=3$IF (IBT,EQ,1,OR,NID,EQ,1.OR.IST,EQ.1)IP=2$IBT=1
      CALL PLOT(X+3.,10.,IP)$ IF (ZSTOR(L).GE.0.0) GO  TO 82 $ IPR=1
      GO TO 91
80    D=(Z(II)-Z(II-1))/(R(II)-R(II-1))-TB
      RHIT=(Z(II-1)-ZBN-(R(II-1)-RN)*TB)/D+R(II-1)
      F=(RHIT-R(II-1))/(R(II)-R(II-1))
      IF(F.GT.1.) GO TO 82
      IF(F.LT.0.) GO TO 82
      X=RHIT*RSCALE$IP=3$IF(IBT.EQ.1,OR.NID,EQ.1,OR.IST,EQ,1)IP=2
      IBT=1
      Y=10.*(1.-(ZBN+(RHIT-RN)*TB)/ZMAX)$IF(ZSTOR(L).LT,0,0) IPR=1
      IF(Y.GT.0.) GO TO 81
      Y=0.
      IP=3
81    CALL PLOT(X+3.,Y,IP)
82    IF(Z(II).GT,0.) GO TO 83
      Y=10.*(1.+Z(II)/ZMAX)
      X=R(II)*RSCALE$IF  (Z(II).EQ,0,0,AND.IPI.EQ.1) IJT=1
      IF  (Z(II),EQ.0.0.AND.ZSTOR(L).LT.0.0) IPR=1  $ GO TO 85
83    IF(Z(II),GT,ZBN+(R(II)-RN)*TB) GO TO 84
      Y=10.*(1.-Z(II)/ZMAX)$IF(Z(II),EQ.ZBN+(R(II)-RN)*TB,AND.ZSTOR(L).L
     1T.0.0) IPR=1
      X=R(II)*RSCALE$IF(Z(II).EQ,ZBN+(R(II)-RN)*TB,AND,IPI,EQ.1)IJT=1
      GO TO 86
84    DZ=Z(II)-(ZBN+(R(II)-RN)*TB)
      ZP=Z(II)-2.*DZ/(1.+TB**2)    $ RP=R(II)
      IF(TB,NE.0.) RP=RP+2.*DZ/(TB+1./TB) $Y=10.*(1.-ZP/ZMAX)
      IF(ZP,EQ.ZBN+(RP-RN)*TB.AND,ZSTOR(L).LT.0.)IPR=1
      IF(ZP,EQ.ZBN+(RP-RN)*TB.AND,IHI.EQ.1) IJT=1 $X=RP*RSCALE
      IF  (IBT.EQ.1.AND,NID.NE.1.OR,IST.EQ,1) GO TO 86
      IF  (NID.NE.1) GO TO 187
      IF  (IPR.EQ.1.OR,ZSTOR(L).GE.0.0) GO TO 86
187   IF  (II.EQ,N) GO TO 186
      DZS=Z(II+1)-(ZBN+(R(II+1)-RN)*TB)
      ZPS=Z(II+1)-2.*DZS/(1.+TB**2)
```

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```
      IF (ZP.GE.ZPS.AND.NID.EQ.1.OR.DZS.LE.0.0.AND.NID.EQ.1) IPR=1
      IF (ZP.GE.ZPS.AND.NID.NE.1.OR.DZS.LE.0.0.AND.NID.NE.1) IJT=1
      GO TO 86
  186 IF (IPR.EQ.0.AND.ZSTOH(L).LT.0.0) IPR=1
      IF (IBT.EQ.0.AND.ZSTOH(L+1).LT.0.0.AND.NID.NE.1) IJT=1
 86   IP=2
      IF(Y.LT.10..AND.Y.GT.0.) GO TO 87
      IP=3
      Y=AMIN1(10.,AMAX1(Y,0.))
 87   IF(X.LT.AL+1..AND.X.GE.-.01) GO TO 88
      IP=3
      X=AMIN1(AL+1.,AMAX1(X,0.))
 88   IF (IBT.EQ.0.AND.IRI.EQ.1.AND.IST.EQ.0)IP=3 $ CALL PLOT(X+3.,Y,IP)
      IO=IN $ IF(IJT.EQ.1) IBT=1 $ IF (IPR.EQ.1) GO TO 91
 89   CONTINUE
   91 ZO3=ZON  $  ZO=ZN
      TO=TN
 90   RO=RN
      RETURN
      END
```

```
5   RAYPLOT                                                      04/05/72      ED     0
                                          IDENT      RAYPLOT
    PROGRAM LENGTH                   01377
    ENTRY POINTS       RAYPLOT       00065
    BLOCK NAMES
                       INFO          07647
    EXTERNAL SYMBOLS
                       C1210100
                       GOGDICT,
                       PLOT
                       MIN1F
                       MAX1F
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Appendix B

COMPARISON OF CALCULATED AND EXPERIMENTAL RESULTS

A comparison was made between the calculated results from TRIMAIN and some experimental data which was furnished by Cdr. P.R. Tatro of the Maury Center for Ocean Science. The input parameters for TRIMAIN were: a frequency of 100 hertz and no volume attenuation, a fan of rays between ± 60° in 1° steps, a bottom loss of MGS class IV for the entire track, type II intensity calculations, a source depth of 152.4 meters and a receiver depth of 762.0 meters. Figs. B1a, B1b, and B1c are print plots of input sound-speed profiles, Fig. B2 is a Calcomp plot of profiles and the bottom track, Fig. B3a is a list of calculated intensity values, Fig. B3b is a list of experimental intensity values, Fig. B4 is a Calcomp plot of selected rays which were traced (one ray every 15°), and Fig. B5 is a Calcomp comparison of experimental and calculated intensity values. Good agreement exists between the two sets of values.

INPUT PROFILE AT RANGE 0.000 KM FIRST PROFILE

DEPTH (M)	VELOCITY
0,0000	1532,1033
31,0001	1532,6200
40,0001	1532,7701
50,0002	1532,9369
55,0002	1533,0202
61,0003	1533,1204
70,0004	1533,2704
75,0005	1533,3536
80,0005	1532,6920
85,0006	1531,5214
91,0007	1529,8340
122,0012	1522,5254
182,0026	1514,9776
243,0047	1509,1096
365,0105	1499,3879
400,0125	1496,7253
600,0292	1485,4393
800,0502	1481,7435
1000,0784	1482,0351
1500,1744	1486,2632
2000,3136	1491,7024
2500,4901	1499,2837
3000,7058	1508,2274
3500,9607	1516,4107
4001,2546	1525,2095
5001,9608	1543,2634
8005,0213	1599,1036

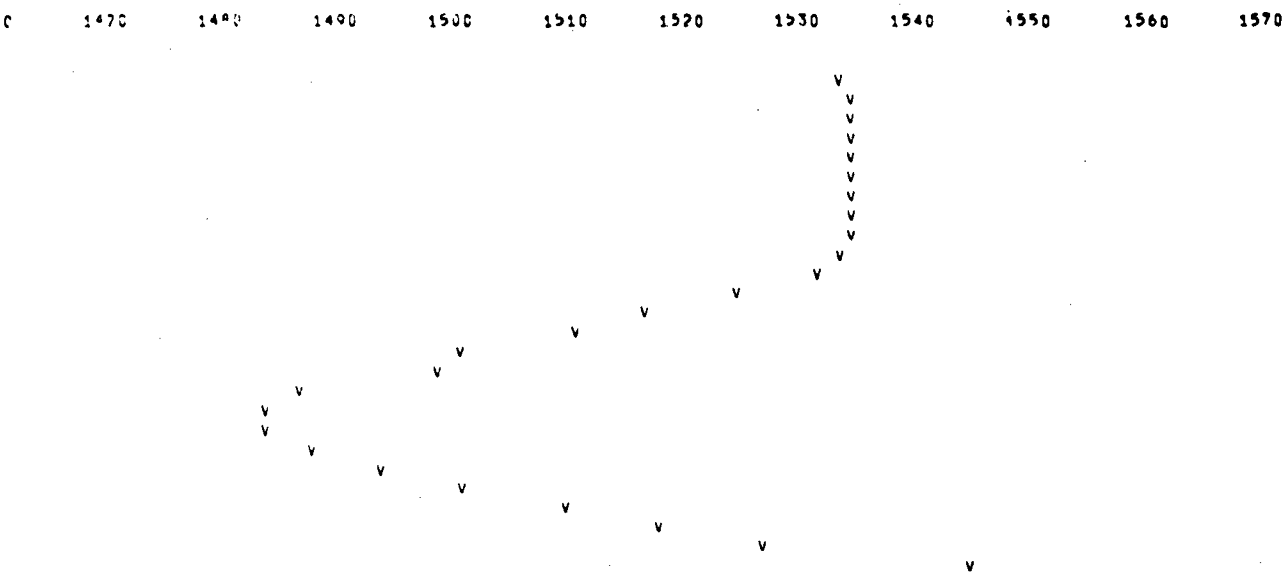

Fig. B1a — Input profile at 0 km

INPUT PROFILE AT RANGE 111,216 KM SECOND PROFILE

DEPTH (M)	VELOCITY
0,0000	1530,9714
31,0001	1531,4855
40,0001	1531,6357
50,0002	1531,7055
55,0002	1531,8085
61,0003	1531,9493
70,0004	1532,1390
75,0005	1532,2224
80,0005	1532,3256
85,0006	1531,6244
91,0007	1530,4432
122,0012	1522,7559
182,0025	1513,1761
243,0047	1506,0516
365,0105	1496,4157
400,0125	1493,4455
600,0247	1483,6410
800,0502	1481,3164
1000,0734	1481,7763
1500,1744	1486,3125
2000,3136	1491,7460
2500,4971	1499,4756
3000,7053	1506,2274
3500,9607	1516,5411
4001,2945	1525,3392
5001,9600	1543,2453
6005,0214	1599,1336

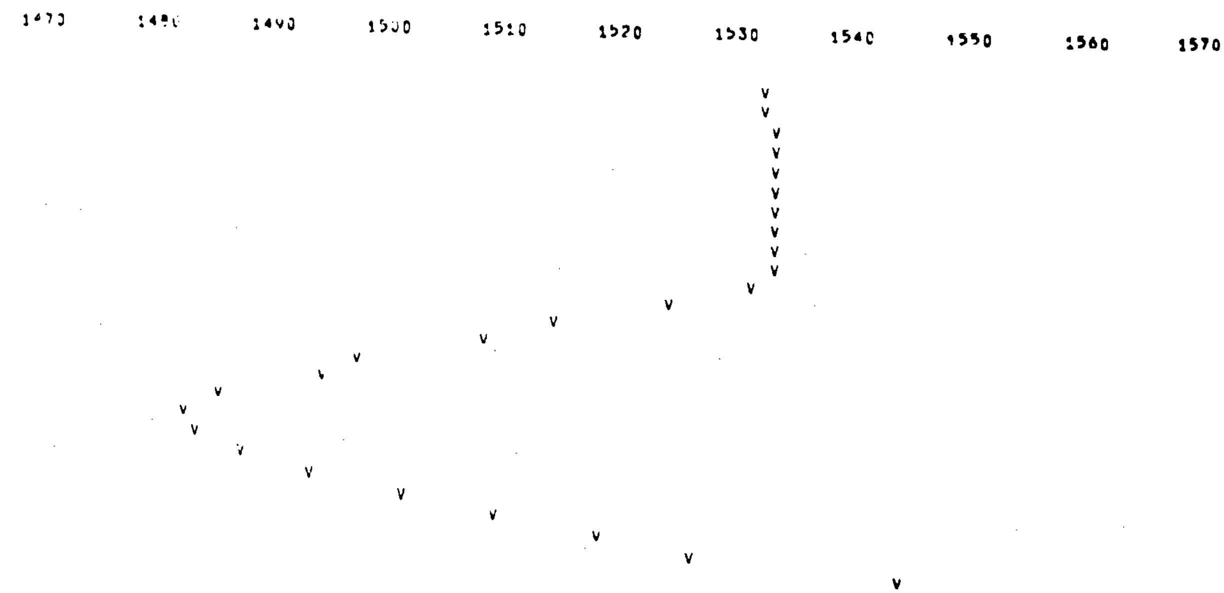

Fig. B1b — Input profile at 111.216 km

INPUT PROFILE AT RANGE 3??,941 KM THIRD PROFILE

DEPTH (M)	VELOCITY	1470	1480	1490	1500	1510	1520	1530	1540	1550	1560	1570
0,0000	1527,[illegible]											
31,0001	1528,3[illegible]											
40,0001	1528,4[illegible]											
50,0002	1528,54[illegible]											
55,0002	1528,7[illegible]											
61,0003	1528,[illegible]											
70,0004	1528,[illegible]											
75,0005	1527,[illegible]											
80,0005	1525,[illegible]											
85,0005	1524,[illegible]											
91,0007	1522,[illegible]											
122,0012	1516,[illegible]											
1?2,0026	1508,[illegible]											
243,0047	1503,[illegible]											
365,0105	1494,2045											
400,0125	1495,1990											
600,0292	1484,1191											
800,0502	1480,7347											
1000,0734	1481,4444											
1500,1754	1485,0277											
2000,3176	1491,7324											
2500,4911	1499,[illegible]											
3000,7052	1504,1054											
3500,9617	1515,4117											
4001,2540	1525,2231											
5001,9600	1543,3061											
8035,0213	1554,1034											

Fig. E1c — Input Profile at 329.941 km

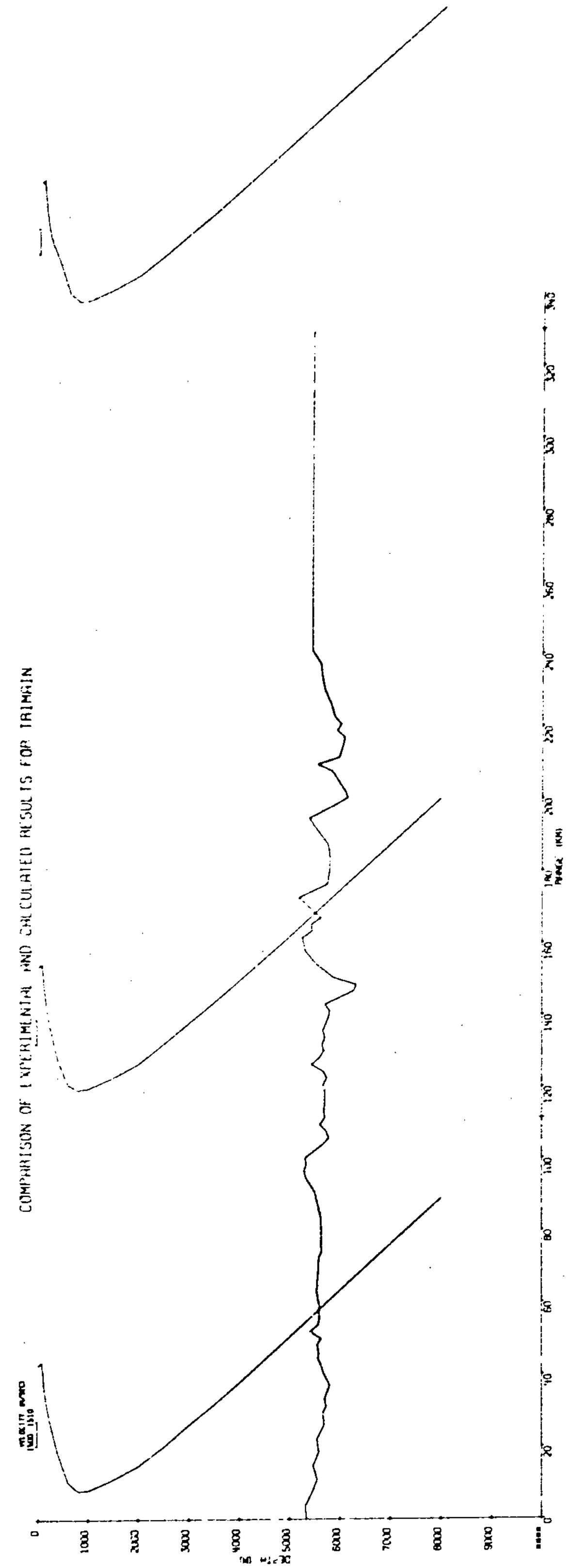

Fig. B2 — Profiles and Bottom Track

CALCULATED RESULTS

RANGE	LOSSES								
		60,000	82,800	126,000	91,300	192,000	98,700	258,000	105,800
		61,000	83,800	127,000	92,300	193,000	100,300	259,000	106,100
		62,000	84,900	128,000	94,000	194,000	102,400	260,000	105,800
		63,000	85,400	129,000	95,400	195,000	103,900	261,000	104,900
		64,000	86,100	130,000	96,900	196,000	106,200	262,000	103,300
		65,000	86,700	131,000	97,000	197,000	107,800	263,000	101,300
		66,000	87,200	132,000	96,800	198,000	108,100	264,000	98,900
1,000	58,800	67,000	89,000	133,000	98,300	199,000	106,500	265,000	96,500
2,000	63,400	68,000	90,900	134,000	100,200	200,000	105,300	266,000	94,200
3,000	66,800	69,000	92,000	135,000	101,500	201,000	106,900	267,000	94,000
4,000	68,500	70,000	92,700	136,000	101,600	202,000	105,800	268,000	94,100
5,000	69,700	71,000	92,400	137,000	102,400	203,000	102,900	269,000	94,300
6,000	78,400	72,000	92,800	138,000	103,600	204,000	102,600	270,000	94,200
7,000	83,200	73,000	92,800	139,000	105,600	205,000	101,800	271,000	94,200
8,000	85,800	74,000	92,900	140,000	107,800	206,000	101,800	272,000	93,700
9,000	83,000	75,000	94,000	141,000	107,900	207,000	100,300	273,000	93,400
10,000	83,400	76,000	93,500	142,000	105,700	208,000	98,000	274,000	92,800
11,000	87,100	77,000	92,300	143,000	108,600	209,000	97,200	275,000	92,400
12,000	87,000	78,000	92,300	144,000	110,600	210,000	96,000	276,000	92,600
13,000	87,400	79,000	93,800	145,000	112,400	211,000	94,500	277,000	92,900
14,000	87,200	80,000	95,300	146,000	110,700	212,000	93,000	278,000	93,100
15,000	87,800	81,000	95,000	147,000	107,400	213,000	92,700	279,000	93,800
16,000	87,500	82,000	94,600	148,000	108,100	214,000	92,800	280,000	94,100
17,000	87,400	83,000	96,000	149,000	106,000	215,000	92,800	281,000	94,000
18,000	87,700	84,000	94,200	150,000	104,100	216,000	92,800	282,000	94,500
19,000	87,400	85,000	98,000	151,000	101,400	217,000	92,500	283,000	95,000
20,000	86,700	86,000	100,800	152,000	98,800	218,000	92,400	284,000	95,800
21,000	86,100	87,000	103,000	153,000	97,600	219,000	92,100	285,000	96,500
22,000	86,200	88,000	103,800	154,000	97,400	220,000	91,500	286,000	97,000
23,000	85,100	89,000	102,800	155,000	96,300	221,000	91,200	287,000	98,100
24,000	86,200	90,000	100,300	156,000	94,600	222,000	91,300	288,000	99,700
25,000	84,700	91,000	101,400	157,000	92,600	223,000	91,800	289,000	100,100
26,000	88,600	92,000	104,500	158,000	90,800	224,000	92,000	290,000	100,600
27,000	90,500	93,000	106,700	159,000	90,700	225,000	92,400	291,000	100,600
28,000	90,900	94,000	107,500	160,000	90,800	226,000	92,900	292,000	100,300
29,000	90,800	95,000	104,900	161,000	90,800	227,000	93,700	293,000	99,500
30,000	90,400	96,000	105,500	162,000	90,600	228,000	94,400	294,000	98,100
31,000	90,700	97,000	103,200	163,000	90,600	229,000	95,200	295,000	96,400
32,000	90,000	98,000	100,500	164,000	90,300	230,000	95,500	296,000	95,700
33,000	89,300	99,000	98,000	165,000	90,000	231,000	96,100	297,000	96,000
34,000	88,100	100,000	95,900	166,000	89,300	232,000	96,000	298,000	95,800
35,000	87,100	101,000	93,900	167,000	89,100	233,000	96,400	299,000	96,600
36,000	87,000	102,000	91,900	168,000	89,500	234,000	96,400	300,000	96,700
37,000	87,200	103,000	90,300	169,000	89,800	235,000	96,200	301,000	96,100
38,000	87,600	104,000	88,500	170,000	90,400	236,000	95,900	302,000	95,500
39,000	87,600	105,000	87,900	171,000	90,900	237,000	95,700	303,000	95,100
40,000	87,900	106,000	87,900	172,000	91,700	238,000	95,100	304,000	95,300
41,000	87,900	107,000	87,800	173,000	92,500	239,000	95,700	305,000	94,800
42,000	88,500	108,000	87,700	174,000	92,500	240,000	95,500	306,000	96,000
43,000	89,500	109,000	87,800	175,000	92,700	241,000	95,700	307,000	96,900
44,000	89,900	110,000	87,600	176,000	92,700	242,000	94,500	308,000	97,400
45,000	90,100	111,000	87,300	177,000	93,100	243,000	93,800	309,000	97,700
46,000	89,200	112,000	87,100	178,000	93,300	244,000	94,000	310,000	98,100
47,000	89,300	113,000	86,900	179,000	93,500	245,000	94,000	311,000	97,700
48,000	86,700	114,000	87,100	180,000	93,700	246,000	94,500	312,000	99,600
49,000	85,200	115,000	87,100	181,000	93,500	247,000	95,100	313,000	101,500
50,000	83,400	116,000	87,200	182,000	93,200	248,000	95,600	314,000	102,600
51,000	83,300	117,000	87,800	183,000	92,800	249,000	96,800	315,000	102,800
52,000	83,400	118,000	88,500	184,000	93,300	250,000	97,000	316,000	102,200
53,000	83,700	119,000	88,800	185,000	93,300	251,000	97,900	317,000	101,100
54,000	83,900	120,000	89,800	186,000	93,200	252,000	98,700	318,000	99,500
55,000	84,100	121,000	90,300	187,000	93,500	253,000	100,700	319,000	97,600
56,000	84,000	122,000	90,700	188,000	95,000	254,000	102,700	320,000	95,600
57,000	83,600	123,000	91,000	189,000	96,100	255,000	104,100	321,000	95,200
58,000	82,700	124,000	91,100	190,000	97,900	256,000	105,000	322,000	95,200
59,000	82,200	125,000	91,200	191,000	98,900	257,000	105,900	323,000	95,300

Fig. B3a — Calculated intensity values

EXPERIMENTAL RESULTS

RANGE	LOSSES				
		98.527	92.750	210.879	95.370
		99.898	96.120	212.512	94.500
		102.641	95.500	216.256	95.500
		104.013	95.870	217.627	95.750
		105.385	96.620	218.999	97.620
		106.756	88.870	220.370	97.620
		108.128	91.880	221.742	98.620
2.515	87.630	109.499	97.500	223.114	96.620
3.886	82.250	110.871	93.620	224.485	91.750
5.258	82.120	112.243	92.000	225.857	96.500
6.629	83.130	113.614	91.250	227.228	98.500
8.001	80.630	114.986	91.120	230.200	100.120
9.373	81.680	116.357	89.500	231.572	96.120
10.744	83.370	117.729	97.120	232.943	94.870
12.116	86.000	119.210	95.000	234.315	97.000
13.487	85.370	120.582	92.870	235.687	96.620
14.859	82.620	121.954	98.870	237.058	97.750
16.231	86.500	123.325	93.370	238.430	102.250
19.460	86.750	124.697	94.260	239.801	108.370
21.731	84.870	126.068	106.120	241.173	104.500
22.463	87.750	127.440	108.870	242.545	97.380
23.774	88.250	128.812	111.120	243.916	97.750
25.146	87.000	130.183	113.120	246.888	103.250
26.518	88.000	131.555	112.620	249.631	104.750
27.889	89.500	132.502	114.370	251.003	104.250
29.261	91.120	136.246	110.750	252.374	103.370
30.632	88.870	137.617	110.500	253.746	101.620
32.004	88.250	138.989	109.620	255.118	102.000
33.376	87.750	140.360	112.250	256.489	102.250
36.576	86.620	141.732	111.500	257.861	101.250
37.948	88.370	143.104	112.120	259.232	99.120
39.319	91.880	144.475	111.750	260.604	97.370
40.691	90.750	145.847	111.500	262.890	97.000
42.062	91.500	147.218	110.370	264.262	98.370
43.434	92.250	149.276	107.500	265.633	98.500
46.177	92.500	150.647	105.750	267.005	99.250
47.549	91.750	152.019	101.870	268.376	99.500
48.920	87.620	153.391	99.750	269.748	99.380
53.721	91.120	154.762	96.120	271.120	98.130
55.093	90.000	157.505	93.370	272.491	97.120
56.464	92.000	158.877	96.000	273.863	97.000
57.836	93.500	160.249	93.130	275.234	99.370
62.746	88.750	161.620	93.250	276.606	100.250
64.118	94.380	162.992	93.500	283.117	96.750
65.489	88.620	166.378	95.120	284.489	96.120
66.870	96.000	168.250	96.120	285.860	99.380
68.233	94.120	170.293	93.250	287.231	99.500
69.723	95.370	172.364	92.500	288.612	98.620
71.095	97.370	173.736	92.620	289.975	101.870
72.466	97.370	175.108	94.120	291.346	103.500
75.209	95.370	176.479	97.870	292.718	101.750
76.581	98.370	177.851	93.500	294.089	99.500
77.953	95.120	179.222	95.120	295.461	97.750
79.324	96.880	180.594	97.380	298.783	102.120
80.696	98.000	183.794	98.130	300.152	106.120
82.067	97.870	185.166	93.130	301.523	102.870
83.439	98.130	186.538	98.500	302.895	98.250
86.182	98.000	198.535	103.500	304.267	96.250
87.554	96.880	199.906	102.620	305.638	99.870
88.925	96.500	201.278	102.620	307.010	100.620
90.297	98.130	202.649	101.620		
91.669	98.500	204.021	102.500		
93.040	99.500	205.393	98.370		
94.412	98.620	206.764	96.880		
95.783	93.370	208.136	95.870		
97.155	98.750	209.507	95.500		

Fig. B3b — Experimental intensity values

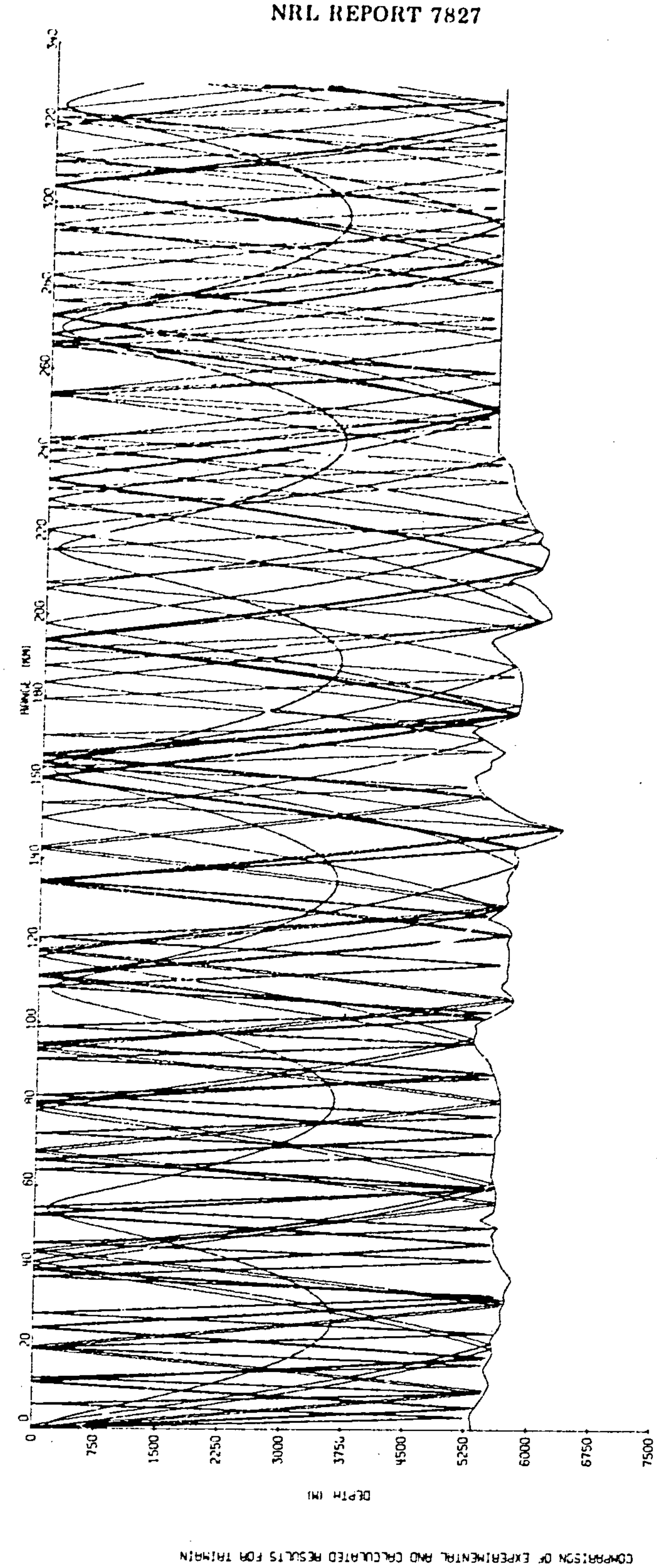

Fig. B4 — Selected rays which were traced (one ray every 15°)

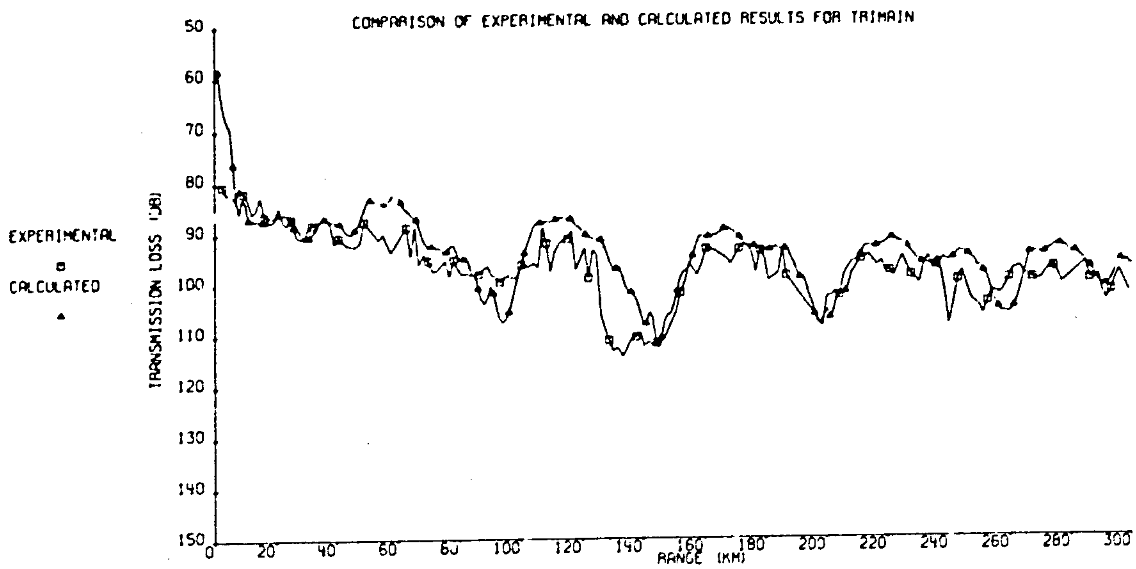

Fig. B5 — Comparison of experimental and calculated intensity values