HORIZONTAL-GRADIENT ACOUSTICAL RAY-TRACE PROGRAM TRIMAIN

B. G. Roberts, Jr.

Naval Research Laboratory
Washington, D. C.

16 December 1974

ECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NRL Report 7827	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER AD A-006254
4. TITLE *(and Subtitle)* Horizontal Gradient Acoustical Ray Trace Program TRIMAIN		5. TYPE OF REPORT & PERIOD COVERED Interim report on a continuing NRL Problem
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) B.G. Roberts		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Research Laboratory Washington, D.C. 20375		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NRL Problem S01-36
11. CONTROLLING OFFICE NAME AND ADDRESS Department of the Navy Arlington, Va. 22217		12. REPORT DATE December 16, 1974
		13. NUMBER OF PAGES 135
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Sonar	Fortran	Wave equation	Deep ocean
Ray tracing	CDC 3800	Sound speed	Propagation
Transmission loss	Acoustics	Eikonal equation	Wave theory
Refraction	Ray acoustics	Geometrical acoustics	Normal mode theory
Digital computers	Underwater sound	Long-range underwater sound propagation	

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

DD FORM 1 JAN 73 1473

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

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

INTRODUCTION 1

BASIC EQUATIONS 2

TRIMAIN INPUT 3

CONTROL CARDS FOR TRIMAIN 12

SUBROUTINES 14

Subroutine INITRAYS 14
Subroutine BRLTRD 14
Subroutine NEWPROF 16
Subroutine CONNECT 19
Subroutine WORDSIZE 20
Subroutine ADVANCE 20
Subroutine PROFPLOT 23
Subroutine RAYZDIST 24
Subroutine CHANNEL 29
Subroutine VELCALC 29
Subroutine RAYPLOT 29
Subroutine PROFPLIT 29
Subroutine ITNPRINT 31
Subroutine IVSRPLOT 35
Subroutine INTENSTY 35
Subroutine RECOVERY 35
Subroutine RETRY 35
Subroutine CLOSEIOP 35
Subroutine BYEBYE 37

DIFFERENT INTENSITIES IN TRIMAIN 37

EIGENRAY OUTPUT OPTION 39

THE LLOYD'S MIRROR OPTION FOR RECEIVERS 39

ADDITIONAL INSTRUCTIONS FOR THE RESTART OPTION 41

CAUTIONS TO THE USER 42

PROGRAM TRIPLT 43

REFERENCES 47

APPENDIX A — Listing of the Program 48

APPENDIX B — Comparison of Calculated and Experimental Results . 124

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:

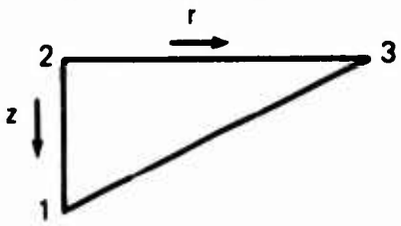
$$n(\vec{r}) = \frac{1}{c(\vec{r})}, \tag{1}$$

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

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

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:

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

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

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

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)

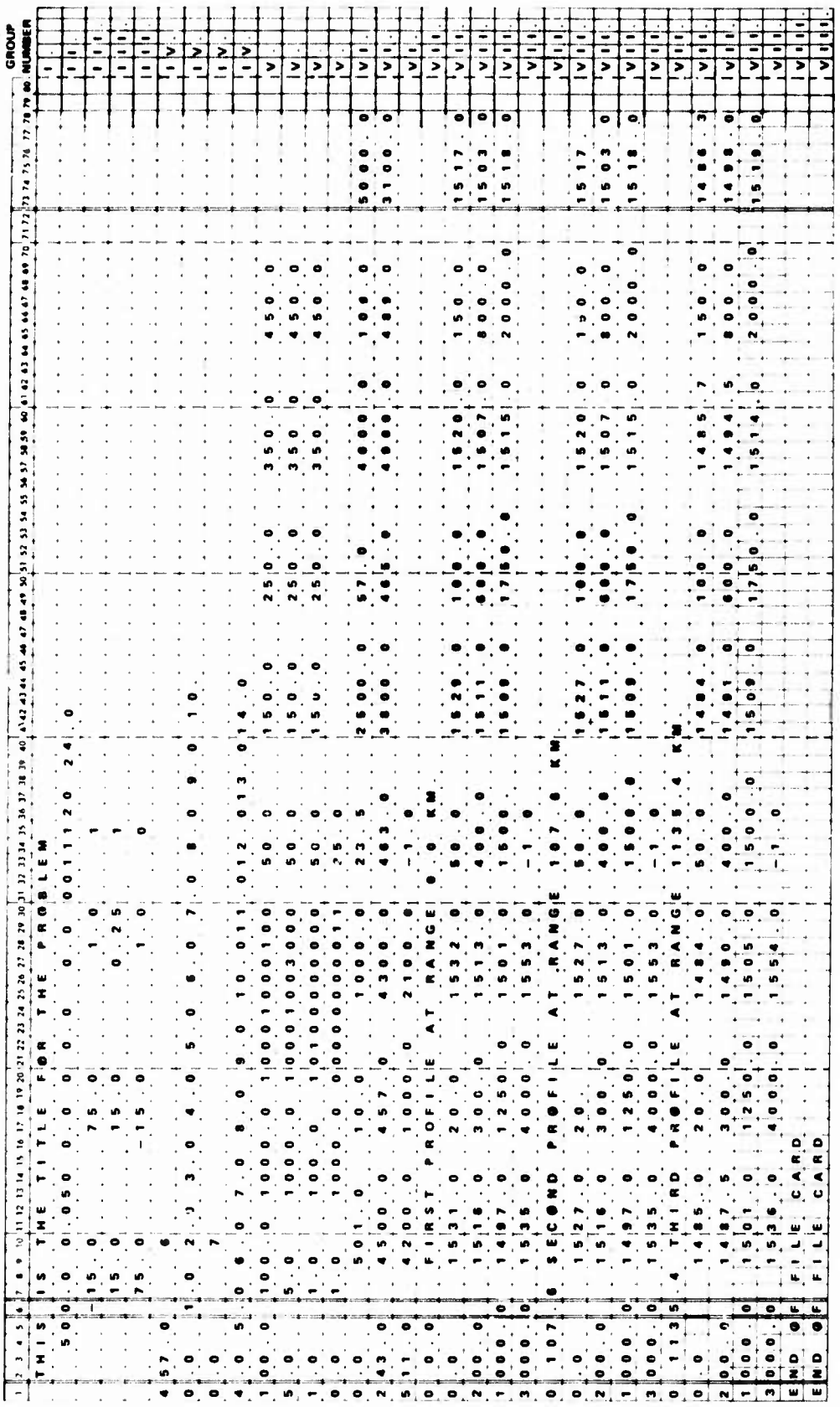


Fig. 1 — Sample data deck of the program TRIMAIN

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 $\neq$ 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, $1 \leq N \leq 25$. 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),81S0162,014BGR,10
DEMAND,50C006
COMMENT,THIS JOB PRODUCES DELAYED PRINTOUTS
EQUIP,1=MT,MI,W0,(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,MI,RO,(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), LOPP
LOAD,20
RUN,10,10C00
```

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

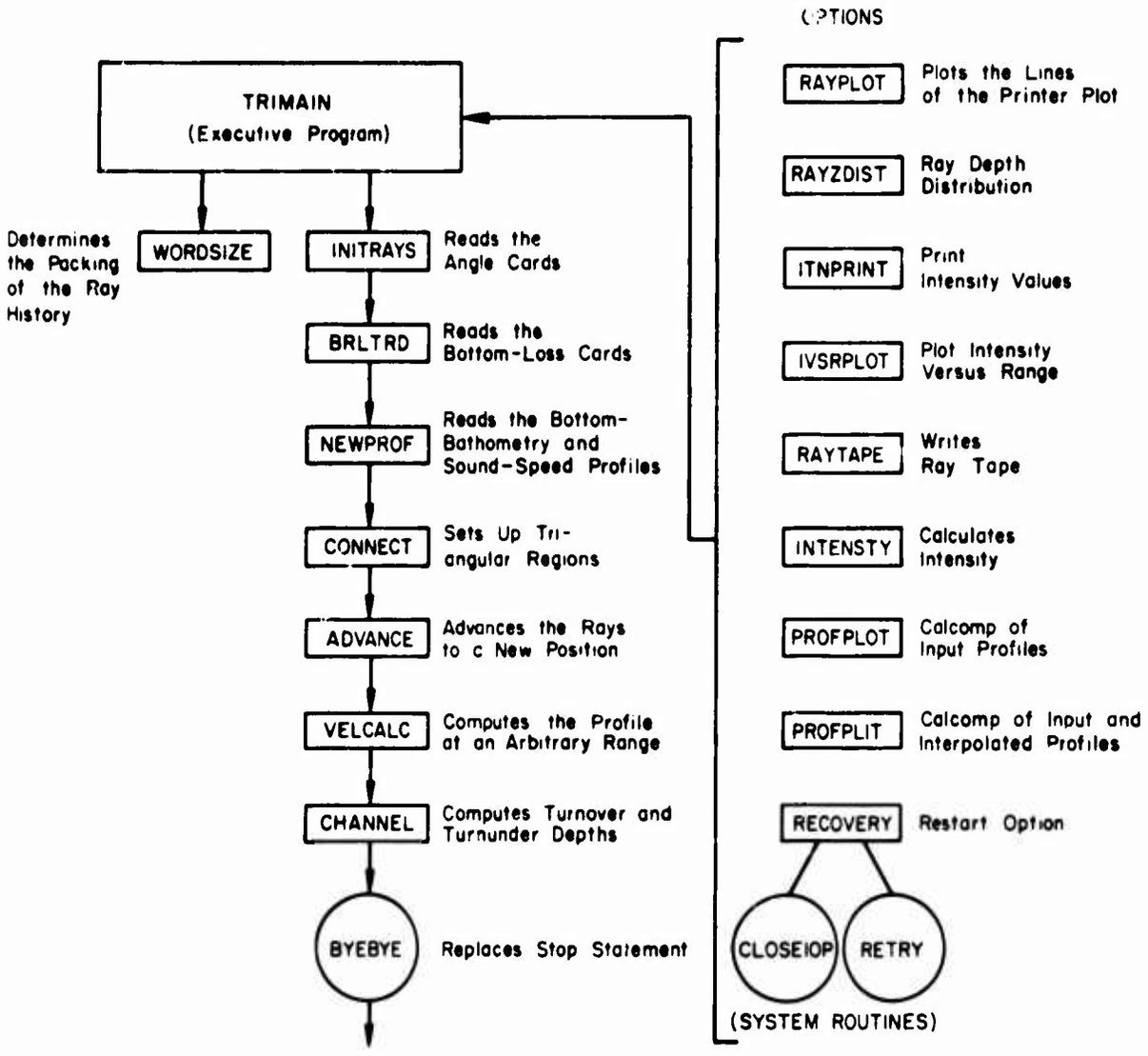


Fig. 3 — Function of each subroutine of the program TRIMAIN

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 I.E30 (i.e., 10^{30} km ≫ 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 $R2$ (range to the current profile), $N2$ (number of points in the current profile), $Z2$ (depth array), and $V2$ (sound-speed array) to $R1$ (range to the previous profile), $N1$ (number of points in the previous profile), $Z1$ (depth array for the previous profile), and $V1$ (sound-speed array for the previous profile) and set new values for $R2$, $N2$, $Z2$, and $V2$. It returns the maximum bottom depth in ZMAX. The printed output of NEWPROF is illustrated in Figs. 4a and 4b.

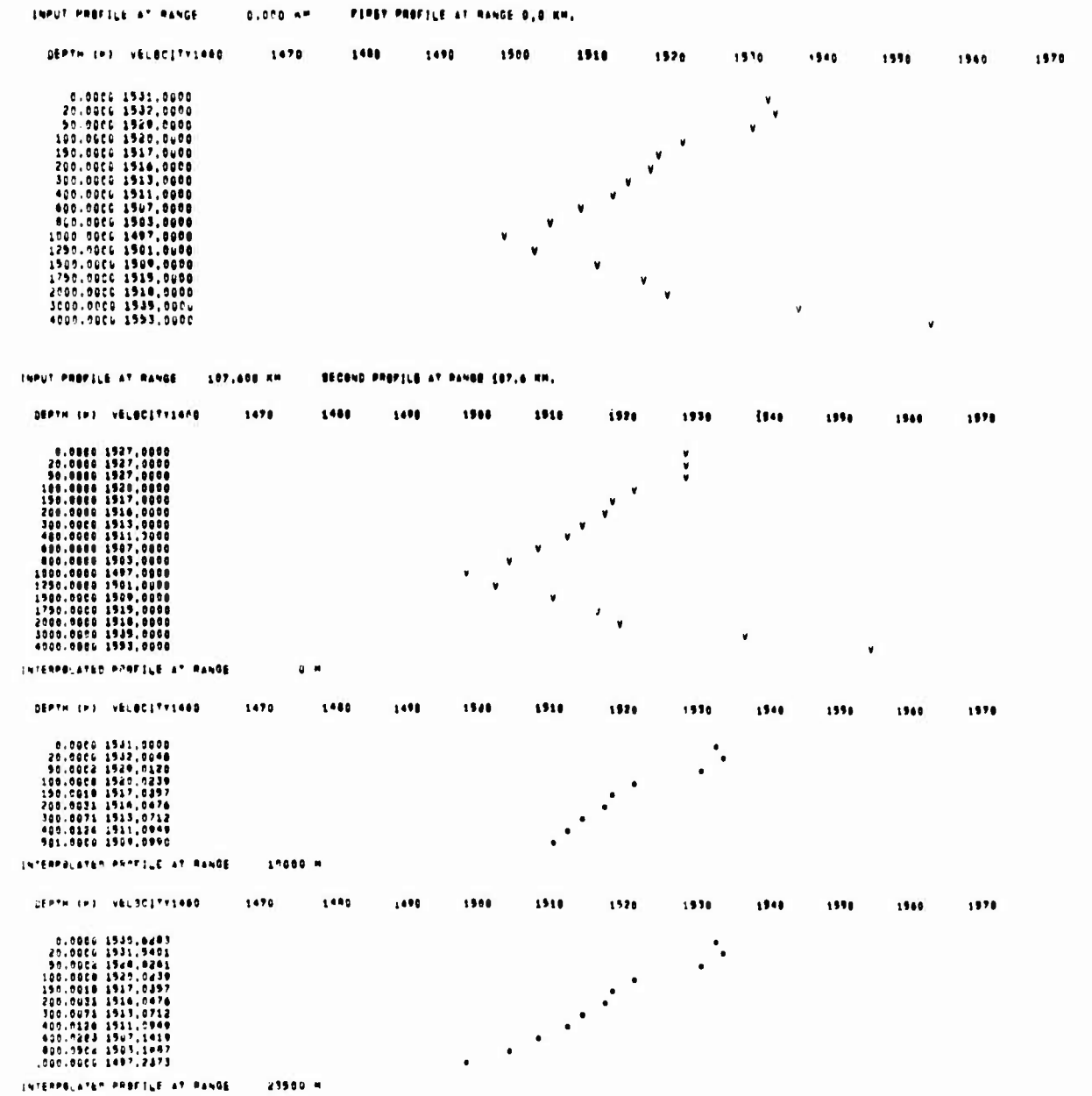


Fig. 4a — Output of NEWPROF. The first two input profiles are those of the sample case given in Fig. 1.

```
   DEPTH (F)  VELOCITY1460      1470      1480      1490      1500      1510      1520      1530      1540      1550      1560      1570

     0.0000 1540,1204
    20.0000 1538,9138
    50.0002 1528,9792
   100.0000 1528,0439
   150.0010 1517,0397
   200.0021 1516,0476
   300.0071 1513,0712
   400.0120 1511,0949
   600.0203 1507,1419
   800.0502 1503,1887
  1000.0703 1497,2358
  1250.1220 1501,2945
  1500.1760 1509,3593
  1750.2403 1515,4101
  2000.3139 1518,4705
  2900.0006 1547,0909

 INTERPOLATED PROFILE AT RANGE    97000 M

   DEPTH (F)  VELOCITY1460      1470      1480      1490      1500      1510      1520      1530      1540      1550      1560      1570

     0.0000 1528,0010
    20.0000 1528,3961
    50.0002 1527,9525
   100.0000 1528,0239
   150.0010 1517,0397
   200.0021 1516,0476
   300.0071 1513,0712
   400.0120 1511,0949
   600.0203 1507,1419
   800.0502 1503,1887
  1000.0703 1497,2358
  1250.1220 1501,2945
  1500.1760 1509,3593
  1750.2403 1515,4101
  2000.3139 1518,4705
  3000.7003 1535,7220
  4000.0000 1593,9521

 INTERPOLATED PROFILE AT RANGE   511000 M

   DEPTH (F)  VELOCITY1440      1470      1480      1490      1500      1510      1520      1530      1540      1550      1560

     0.0000 1519,9195
    20.0000 1519,1277
    50.0002 1517,1348
   100.0000 1506,5613
   150.0010 1504,9860
   200.0021 1504,8013
   300.0071 1504,0636
   400.0120 1503,2446
   600.0203 1502,2293
   800.0502 1501,2260
  1000.0703 1498,8092
  1250.1220 1502,0848
  1500.1760 1509,3593
  1750.2403 1515,0435
  2000.3139 1518,8091
  3000.7003 1536,1159
  4001.2956 1594,3677
  4200.0000 1597,9933

 INTERPOLATED PROFILE AT RANGE  1000000 M

   DEPTH (F)  VELOCITY1460      1470      1480      1490      1500      1510      1520      1530      1540      1550      1560

     0.0000 1490,9330
    20.0000 1489,6694
    50.0002 1488,6764
   100.0000 1490,2420
   150.0010 1490,3794
   200.0021 1491,3613
   300.0071 1493,1003
   400.0120 1493,7285
   600.0203 1496,2876
   800.0502 1498,8469
  1000.0703 1500,7086
  1250.1220 1504,7802
  1500.1760 1509,3593
  1750.2403 1514,5476
  2000.3139 1519,3451
  2100.0000 1521,0636

 INTERPOLATED PROFILE AT RANGE  1100000 M

   DEPTH (F)  VELOCITY1460      1470      1480      1490      1500      1510      1520      1530      1540      1550      1560

     0.0000 1486,4466
    20.0000 1485,4857
    50.0002 1485,4927
   100.0000 1486,9047
   150.0010 1487,3924
   200.0021 1488,5283
   300.0071 1490,8624
   400.0120 1491,7825
   600.0203 1495,0713
   800.0502 1498,3603
  1000.0703 1501,0978
  1250.1220 1504,1375
  1500.1760 1509,3593
  1750.2403 1514,4903
  2000.3139 1519,4424
  2100.0000 1521,1009
```

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.

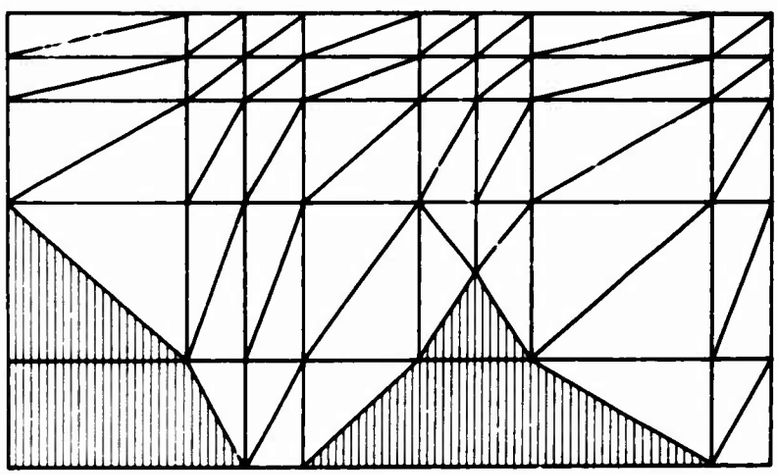


Fig. 5 — Typical network of triangular regions

Subroutine WORDSIZE

Subroutine WORDSIZE calculates some machine-dependent quantities. Four numbers are packed into array NCOUNT by using *ITN*, which is *ITN* = $\sqrt[4]{1/4\ \text{JBIG.}}$, 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).

} 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

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

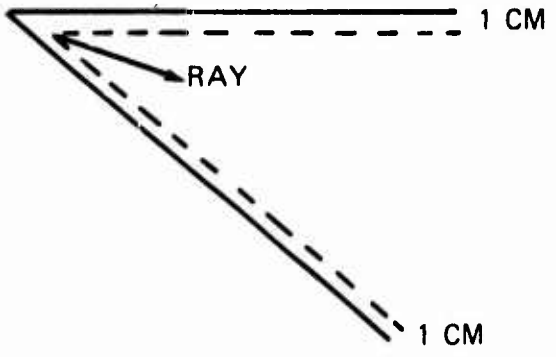
When α = 0, special linear path statements are used (ADVA0055 through ADVA0065 and ADAV0171 through ADVA0174). After statement 40 (ADVA0085), the next position is selected.

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.

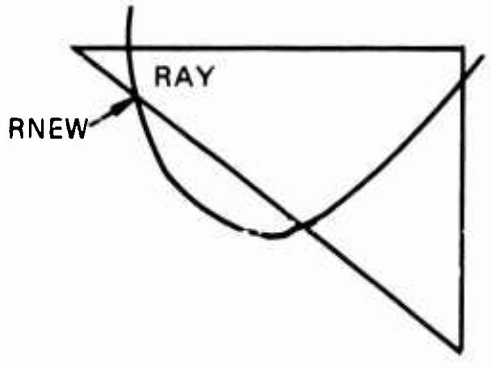
There are four possibilities, in RPNEW, ZPNEW, ZNEW, and RNEW arrays. In general, the rule is

RNEW = min(RNEW(k)) such that 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 $ST = 0$, $BV \to \infty$; 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.

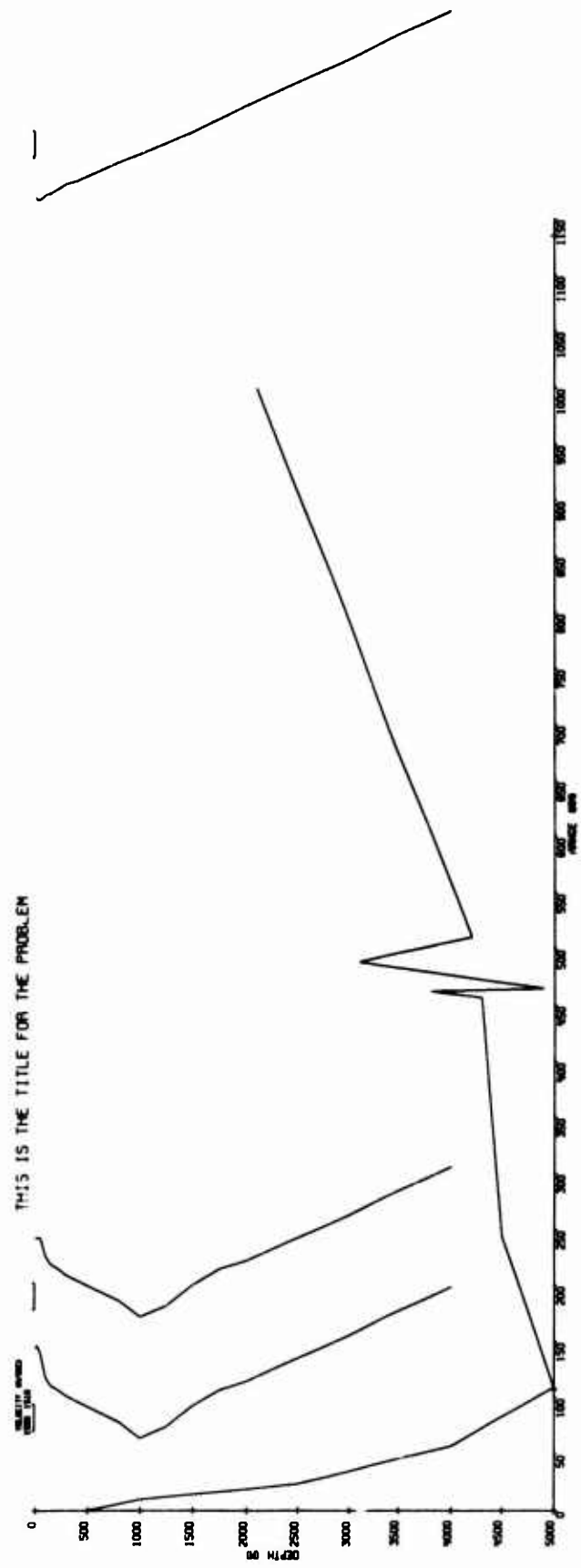


Fig. 6 — Colcomp plot of input profiles and the bottom track

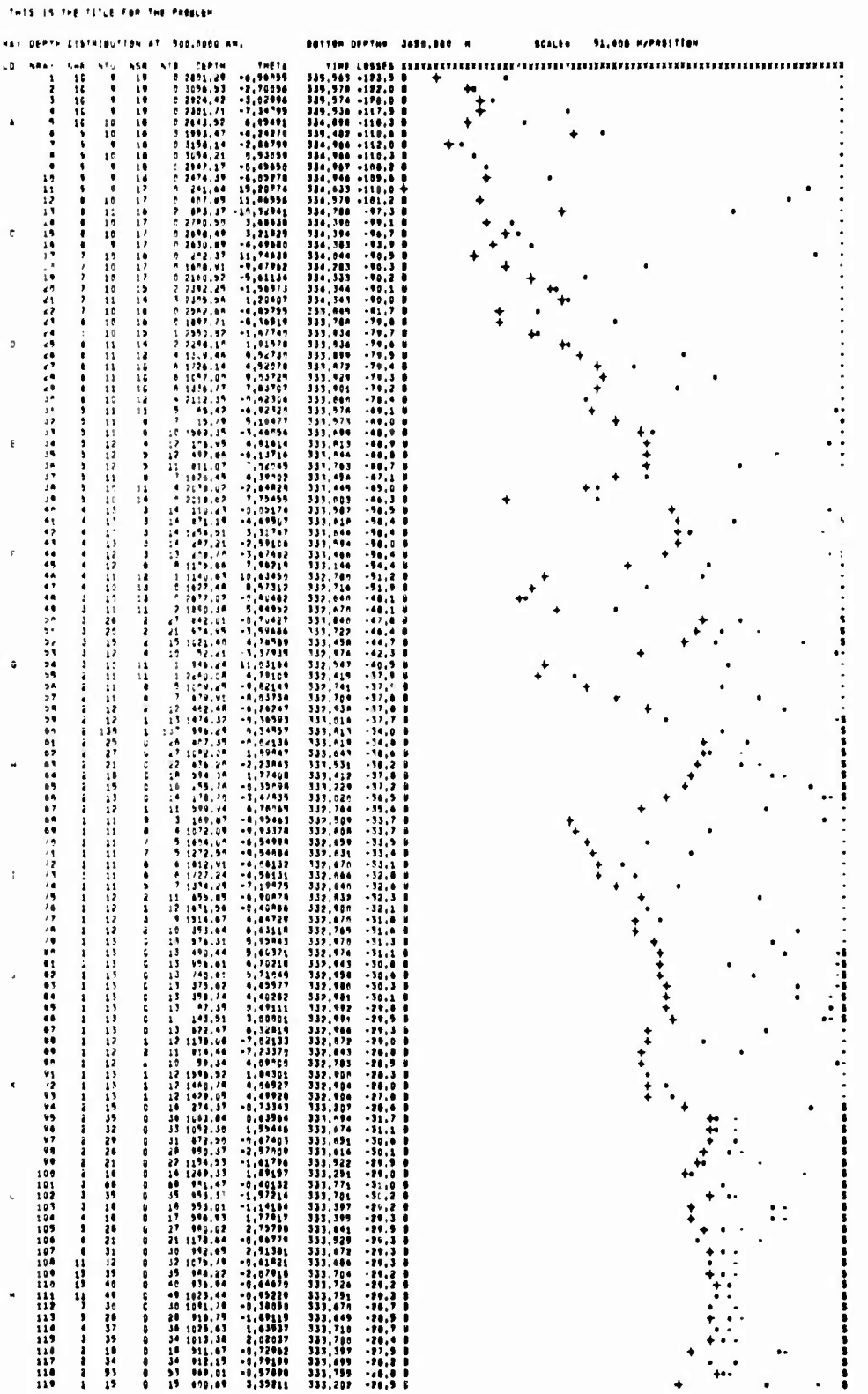


Fig. 7 — Example of the output from RAYZDIST (first of four pages)

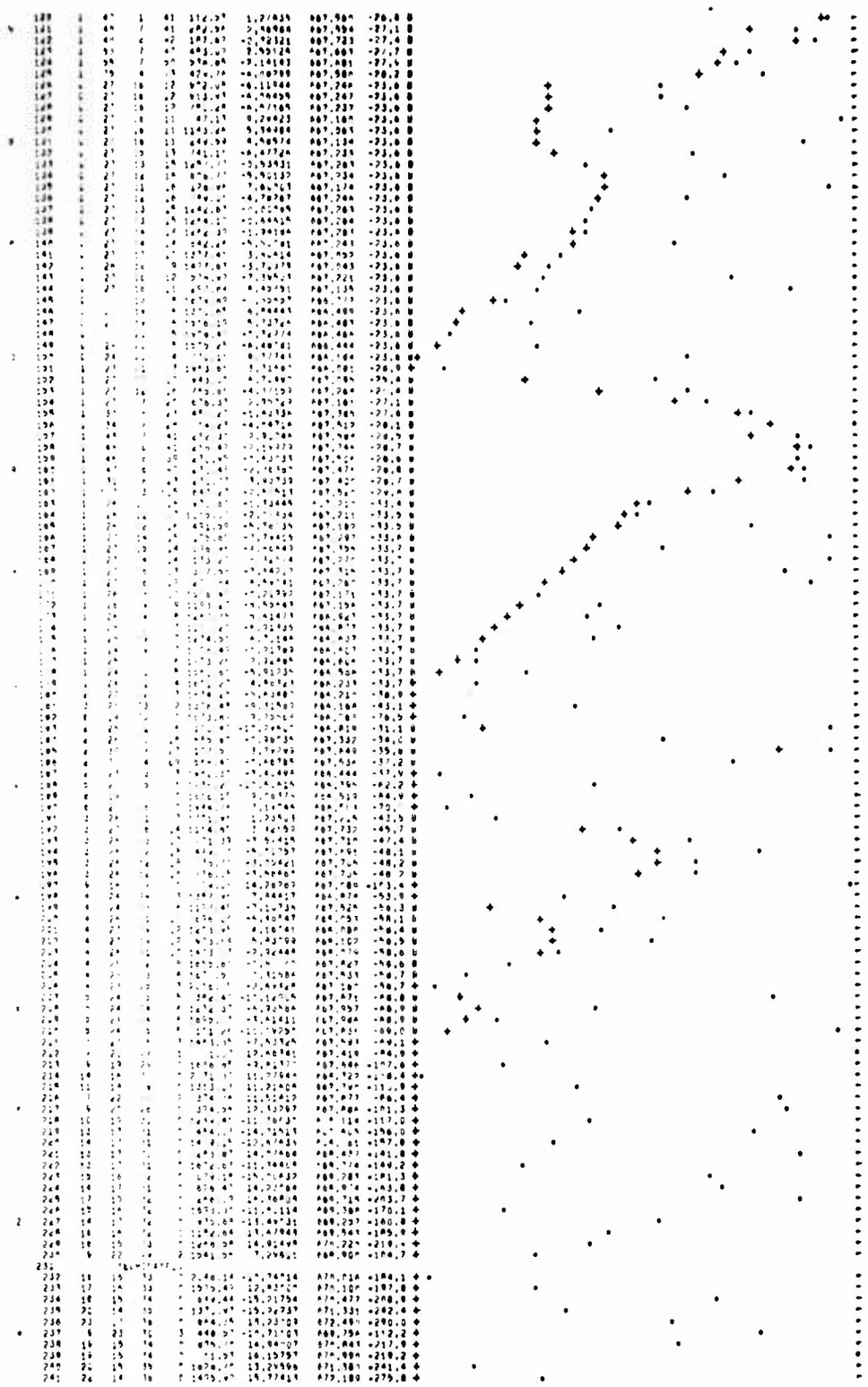


Fig. 7 (Continued) — Example of the output from RAYZDIST (second of four pages)

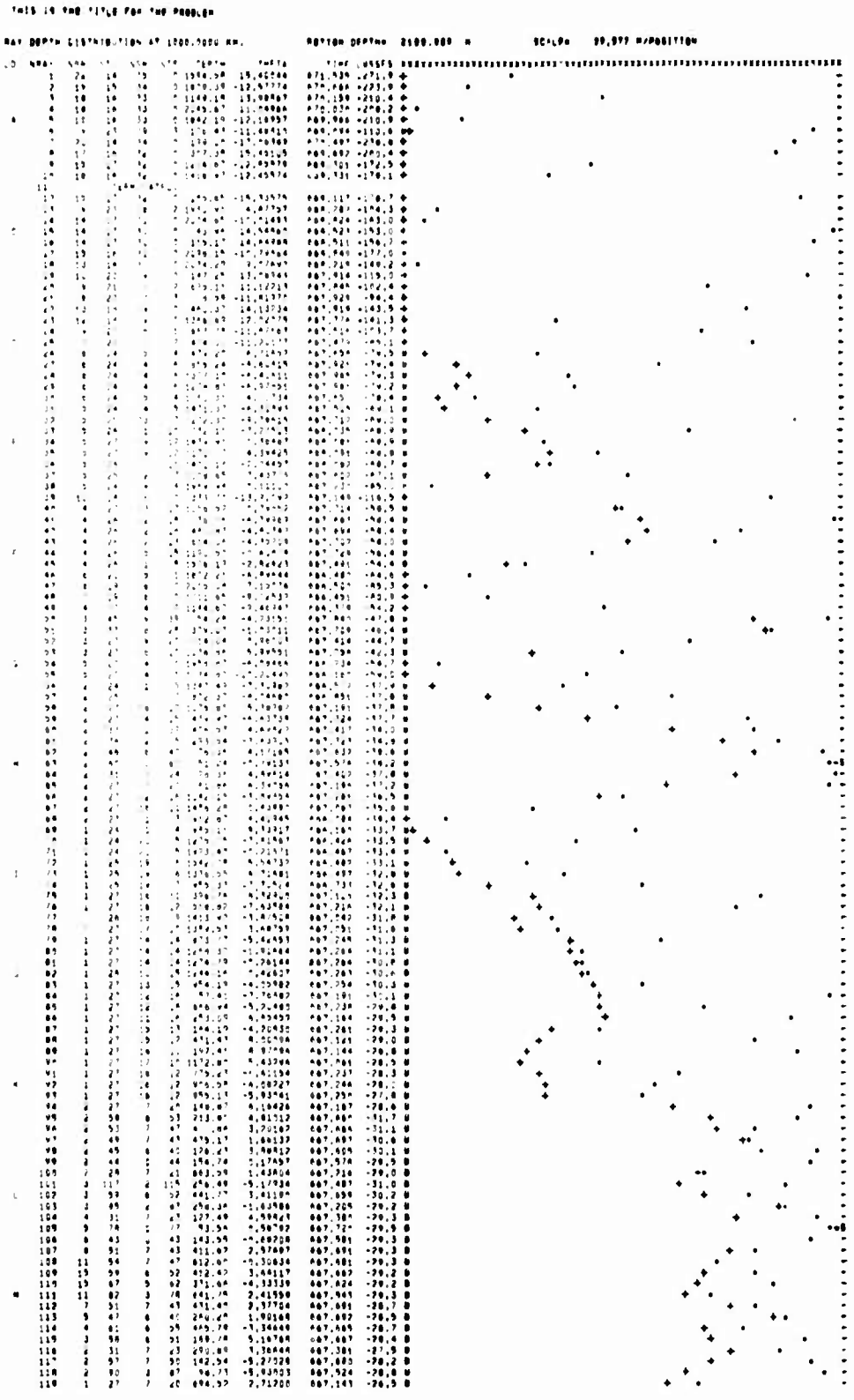


Fig. 7 (Continued) — Example of the output from RAYZDIST (third of four pages)

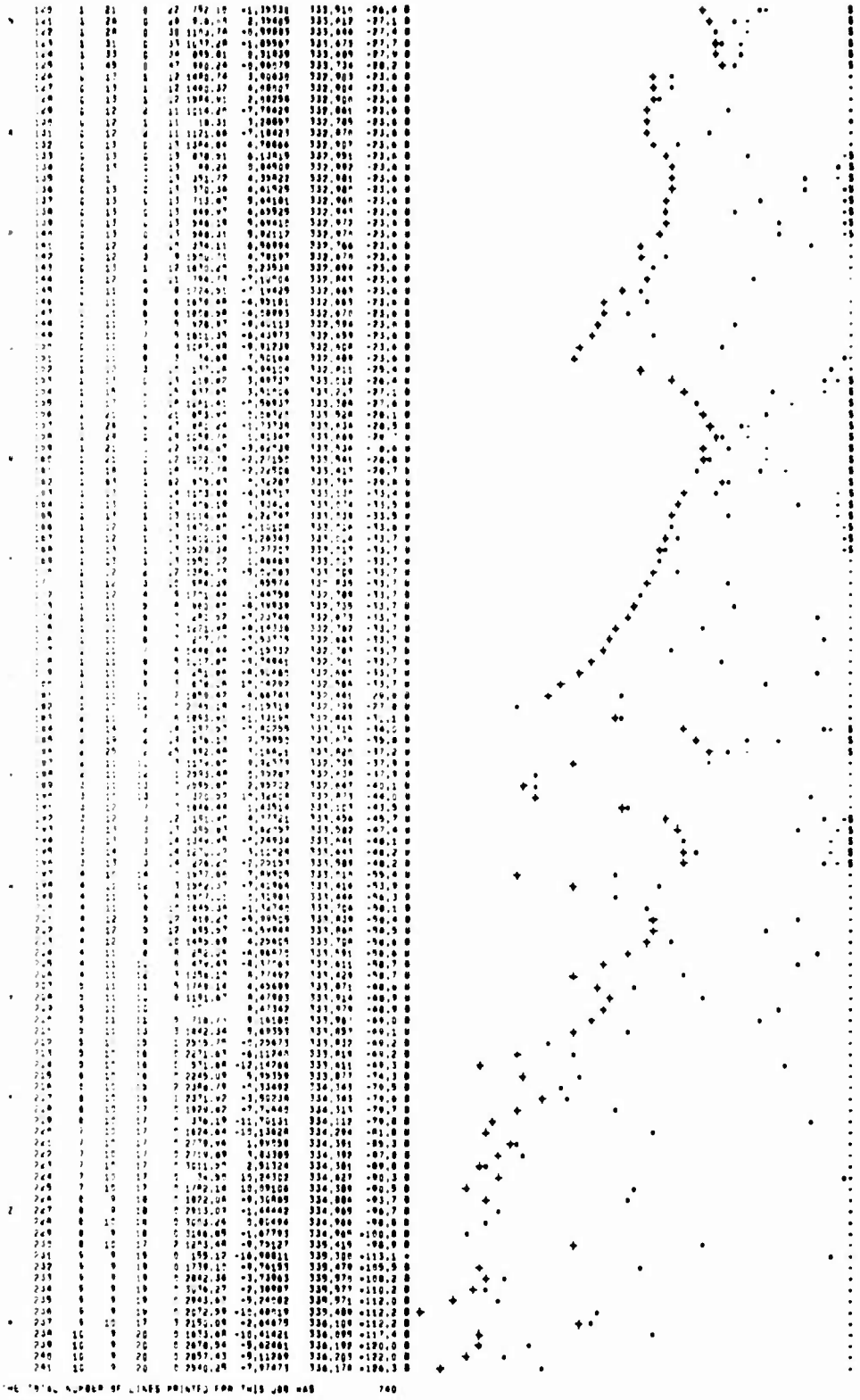


Fig. 7 (Continued) — Example of the output from RAYZDIST (fourth of four pages)

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 turn-under depth). The entry RCALC then calculates

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

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.

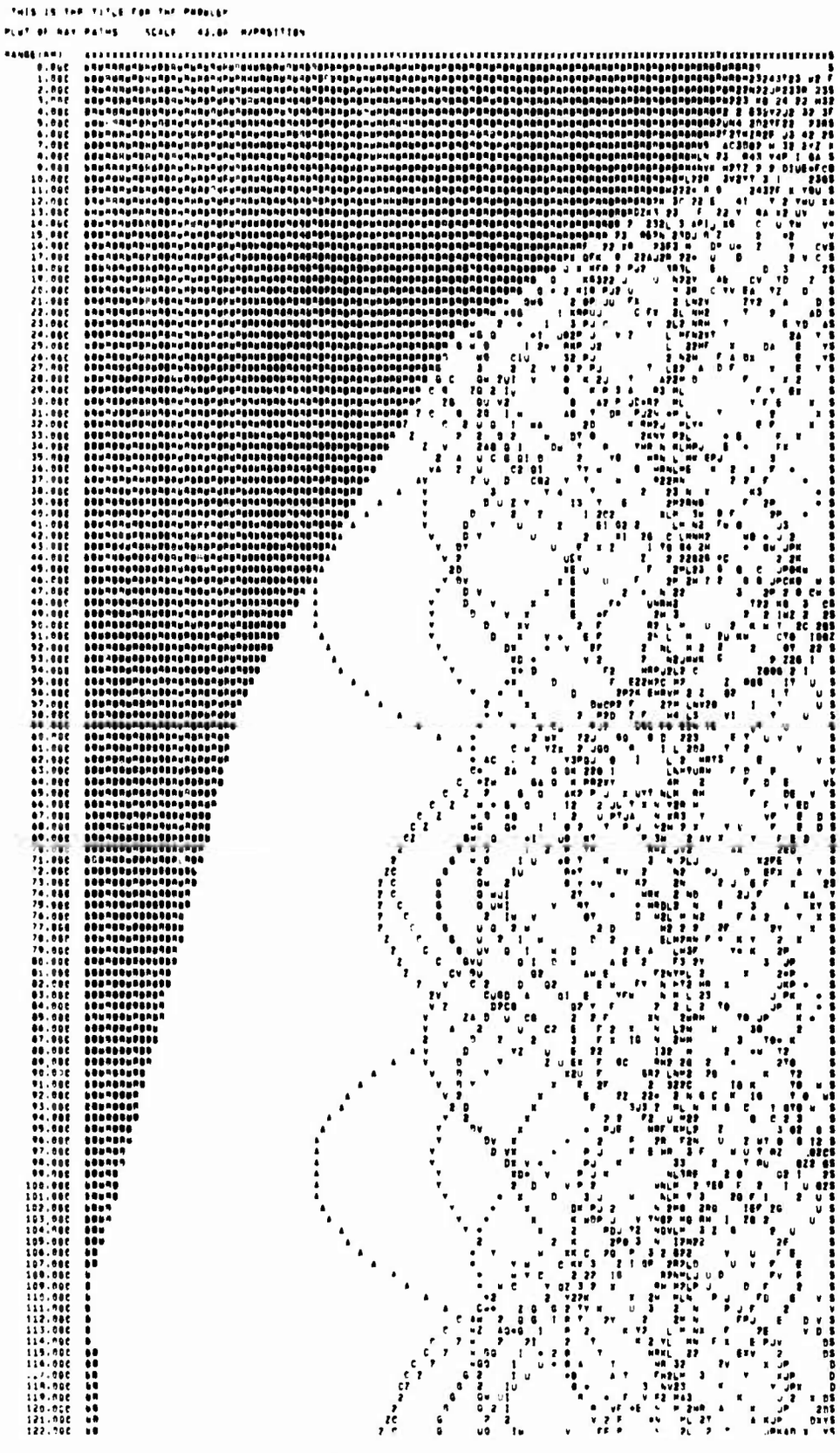
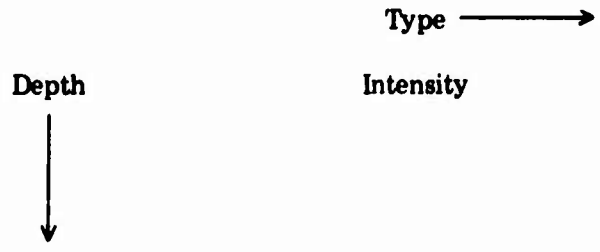


Fig. 8 — Ray plot

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



is printed.

THIS IS THE TITLE FOR THE PROBLEM

RECEIVED INTENSITY VS RANGE AT DEPTHS

R(KM)	TYPE	90.000	190.000	290.000	390.000	490.000
1.000	R	-97.4	-97.5	-97.5	-97.6	-97.8
2.000	R	-82.3	-82.8	-82.7	-82.7	-82.4
3.000	R	-69.0	-66.1	-66.4	-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	-71.6	-70.8
6.000	R	-69.3	-71.5	-70.6	-70.8	-70.5
6.000	R	-70.4	-69.1	-68.4	-72.8	-72.4
7.000	R	-77.4	-80.1	-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	-76.2	-79.3	-75.9
10.000	3	-80.1	-77.8	-77.3	-76.6	-74.1
10.000	R	-82.9	-85.1	-78.6	-77.1	-74.0
11.000	R	-85.4	-87.4	-87.7	-80.1	-78.2
12.000	R	-91.6	-83.8	-87.7	-88.8	-81.2
13.000	R	-93.1	-85.9	-84.4	-84.0	-87.3
14.000	R	-94.9	-86.9	-87.6	-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	-94.5	-87.3	-90.3	-89.5
17.000	R	-114.7	-96.8	-96.8	-90.0	-90.5
18.000	R	-119.7	-113.7	-90.7	-89.1	-91.6
19.000	R	-113.8	-114.4	-93.3	-90.7	-89.8
20.000	3	-99.5	-88.7	-84.1	-82.3	-82.9
20.000	R	-116.4	-115.9	-114.8	-94.5	-90.9
21.000	R	-129.6	-117.5	-121.3	-122.4	-88.7
22.000	R	-138.8	-120.1	-120.3	-122.3	-122.9
23.000	R	-143.0	-119.4	-121.5	-121.6	-123.9
24.000	R	-145.4	-127.8	-121.5	-123.0	-123.0
25.000	3	-98.2	-87.8	-84.5	-70.3	-84.1
25.000	R	-143.0	-132.7	-120.8	-123.2	-123.3
26.000	R	-142.7	-130.9	-121.2	-122.9	-125.2
27.000	R	-147.1	-132.7	-120.8	-123.7	-98.9
28.000	R	-149.5	-143.8	-118.6	-124.0	-99.4
29.000	R	-147.1	-141.6	-109.8	-123.3	-99.6
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	-150.8	-134.7	-118.5	-123.0	-121.9
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	-85.2	-85.6
35.000	R	-146.6	-139.9	-123.5	-114.5	-92.9
36.000	R	-144.0	-145.7	-121.4	-117.9	-94.8
37.000	R	-145.6	-135.5	-127.5	-118.5	-86.3
38.000	R	-143.6	-121.4	-120.6	-118.5	-88.6
39.000	R	-144.0	-124.3	-124.1	-118.8	-89.1
40.000	3	-101.6	-89.9	-86.6	-85.8	-86.2
40.000	R	-143.1	-124.8	-101.4	-80.0	-86.3
41.000	R	-104.0	-104.3	-88.9	-78.3	-88.4
42.000	R	-102.3	-101.7	-81.3	-79.5	-87.8
43.000	R	-94.3	-94.7	-81.5	-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	-98.3	-99.4	-79.2	-81.3	-83.5
47.000	R	-99.1	-98.9	-83.1	-89.0	-79.8
48.000	R	-99.6	-99.8	-83.3	-81.6	-78.9
49.000	R	-100.1	-100.2	-81.6	-87.7	-84.1
50.000	3	-102.9	-90.9	-87.6	-86.8	-87.1
50.000	R	-100.2	-86.5	-78.8	-89.5	-89.2
51.000	R	-99.7	-85.7	-..5.3	-88.9	-89.6
52.000	R	-101.3	-74.0	-84.3	-86.7	-88.1
53.000	R	-101.2	-79.2	-82.6	-84.4	-87.5
54.000	R	-100.9	-85.0	-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	-94.2
59.000	R	-99.4	-93.8	-94.2	-100.9	-96.5
60.000	3	-103.9	-91.7	-88.3	-83.1	-87.9
60.000	R	-110.0	-93.6	-87.1	-87.6	-93.6
61.000	R	-110.1	-94.0	-87.9	-88.3	-88.9
62.000	R	-116.4	-110.1	-101.5	-100.5	-98.8
63.000	R	-107.1	-107.8	-100.7	-101.1	-101.1
64.000	R	-106.7	-108.5	-97.0	-102.0	-102.8
65.000	3	-104.3	-92.0	-88.7	-87.9	-88.3
65.000	R	-115.1	-108.9	-104.9	-99.1	-102.7
66.000	R	-128.9	-114.5	-113.7	-100.2	-100.0
67.000	R	-140.4	-124.1	-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	-138.9	-127.4	-129.0	-120.2
71.000	R	-138.9	-130.2	-129.5	-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	-143.8	-130.0	-123.7	-87.4
75.000	3	-105.3	-92.7	-89.3	-88.9	-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	-144.8	-138.8	-130.2	-91.6
78.000	R	-156.8	-134.4	-130.8	-84.4	-92.9
79.000	R	-156.9	-141.0	-130.0	-82.7	-87.7
80.000	3	-105.6	-93.8	-89.6	-88.4	-89.2
80.000	R	-300.0	-143.2	-128.6	-89.9	-87.5
81.000	R	-300.0	-300.0	-90.9	-83.5	-87.4
82.000	R	-300.0	-140.5	-94.1	-86.2	-89.5
83.000	R	-171.1	-124.6	-88.6	-87.5	-89.3
84.000	R	-111.1	-111.1	-88.5	-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	1	-109.7	-93.2	-89.0	-88.1	-88.4
89.000	R	-113.1	-113.1	-89.4	-88.4	-83.3
86.000	R	-101.9	-102.8	-89.9	-93.0	-87.8
87.000	R	-103.4	-103.9	-87.8	-91.9	-88.7
88.000	R	-104.9	-104.9	-88.1	-87.8	-88.6
89.000	R	-105.2	-105.2	-94.7	-87.1	-91.3
90.000	3	-106.1	-93.4	-90.1	-89.3	-89.7
90.000	R	-105.8	-105.8	-87.2	-88.8	-89.2
91.000	R	-105.9	-103.7	-88.1	-88.8	-88.1
92.000	R	-106.1	-99.7	-91.2	-90.4	-83.8
93.000	R	-106.2	-106.2	-89.8	-79.8	-88.2
94.000	R	-106.1	-106.2	-84.2	-88.7	-95.5
95.000	3	-106.5	-93.7	-90.3	-89.6	-89.9
95.000	R	-106.8	-81.4	-87.2	-90.6	-92.0
96.000	R	-105.6	-91.0	-88.4	-92.6	-91.7
97.000	R	-86.2	-68.9	-89.7	-91.3	-92.5
98.000	R	-103.8	-65.3	-90.1	-90.2	-91.7
99.000	R	-103.4	-92.6	-87.9	-90.4	-90.8
100.000	3	-106.8	-93.9	-90.6	-89.8	-90.1
100.000	3	-106.8	-93.9	-90.6	-89.8	-90.1
100.000	R	-112.5	-97.9	-90.4	-89.8	-85.5
105.000	3	-107.0	-94.2	-90.8	-90.0	-90.3
110.000	3	-105.4	-91.9	-91.1	-88.4	-90.6
115.000	3	-106.2	-93.3	-91.9	-88.9	-90.8
120.000	3	-106.6	-93.4	-91.8	-89.3	-91.0
125.000	3	-107.2	-93.7	-92.0	-89.7	-91.2
130.000	3	-107.6	-91	-92.2	-90.5	-91.4
135.000	3	-99.5	-91..	-92.1	-90.5	-91.7
140.000	3	-99.8	-91.8	-91.8	-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	-92.9	-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	-100.3	-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	-90.8	-92.1	-93.4
195.000	3	-101.9	-92.1	-91.5	-92.3	-93.5
200.000	3	-97.6	-92.7	-91.8	-92.5	-93.7
205.000	3	-97.8	-92.7	-91.8	-92.5	-93.7
209.000	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	-78.3	-93.9	-91.9	-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	-93.9	-94.4	-95.1
265.000	3	-99.2	-92.8	-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	-100.6	-95.3	-93.8	-95.2	-95.7
300.000	3	-100.4	-93.8	-94.0	-95.3	-95.8
305.000	3	-100.4	-93.9	-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	-95.3	-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	-95.4	-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	-94.9	-95.8	-96.3	-96.2
370.000	3	-101.6	-94.7	-95.9	-96.4	-96.3
375.000	3	-101.8	-94.9	-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	-95.3	-96.3	-96.8	-96.1
400.000	3	-99.7	-95.5	-96.4	-96.9	-96.5
400.000	3	-99.7	-95.5	-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	-97.6	-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)

905.000	3	-96.7	-97.6	-97.5	-97.8	-97.8
910.000	3	-97.0	-97.7	-97.5	-97.8	-97.9
915.000	3	-97.2	-97.9	-97.3	-97.9	-98.0
920.000	3	-97.4	-97.9	-97.5	-97.9	-97.8
925.000	3	-97.2	-98.0	-97.7	-98.0	-97.8
930.000	3	-97.6	-97.8	-97.9	-98.1	-97.9
935.000	3	-96.8	-97.4	-98.0	-98.2	-97.6
940.000	3	-96.8	-97.7	-98.0	-98.2	-97.7
945.000	3	-97.1	-97.8	-97.9	-98.3	-97.7
950.000	3	-97.2	-97.8	-98.0	-98.3	-97.9
955.000	3	-97.3	-97.9	-98.1	-97.8	-98.0
960.000	3	-96.9	-97.8	-97.2	-98.2	-98.1
965.000	3	-96.6	-97.0	-98.3	-98.3	-98.2
970.000	3	-96.7	-97.1	-98.4	-98.1	-98.3
975.000	3	-96.9	-97.2	-98.5	-97.5	-98.3
980.000	3	-96.4	-97.2	-98.5	-97.9	-98.3
985.000	3	-96.5	-97.3	-98.5	-98.1	-98.4
990.000	3	-96.5	-97.5	-98.6	-98.2	-97.2
995.000	3	-96.4	-97.5	-98.5	-98.1	-98.1
000.000	3	-96.6	-97.4	-98.4	-98.3	-97.8
005.000	3	-96.6	-97.4	-98.4	-98.3	-97.8
010.000	3	-97.0	-97.5	-98.5	-98.3	-97.5
015.000	3	-97.2	-97.6	-98.6	-98.4	-97.9
020.000	3	-97.5	-97.3	-98.3	-98.5	-98.1
025.000	3	-97.6	-97.5	-98.5	-98.3	-98.2
030.000	3	-97.7	-97.4	-98.5	-97.9	-98.2
035.000	3	-97.8	-97.5	-98.6	-98.1	-98.3
040.000	3	-97.9	-97.5	-98.7	-97.5	-98.4
045.000	3	-98.1	-97.4	-98.7	-98.0	-98.5
050.000	3	-98.0	-97.4	-98.8	-98.2	-98.5
055.000	3	-98.3	-97.7	-98.8	-98.4	-98.6
060.000	3	-98.3	-97.6	-98.8	-98.4	-98.6
065.000	3	-98.5	-97.8	-98.8	-98.4	-98.6
070.000	3	-98.6	-97.7	-98.8	-98.4	-98.6
075.000	3	-98.7	-97.3	-98.5	-98.5	-98.7
080.000	3	-98.8	-97.9	-98.4	-98.6	-98.7
085.000	3	-98.9	-97.9	-98.4	-98.6	-98.7
090.000	3	-97.6	-97.9	-98.4	-98.6	-98.7
095.000	3	-98.5	-97.8	-98.3	-98.6	-98.8
100.000	3	-98.5	-97.7	-98.4	-98.3	-98.9
105.000	3	-98.7	-97.7	-98.4	-98.6	-98.9
110.000	3	-98.7	-97.7	-98.4	-98.6	-98.9
115.000	3	-98.7	-97.7	-98.4	-98.6	-98.9
120.000	3	-98.8	-97.7	-98.3	-98.6	-98.9
125.000	3	-98.8	-97.7	-98.3	-98.6	-98.9
130.000	3	-98.4	-97.7	-98.3	-98.6	-98.9
135.000	3	-98.4	-97.7	-98.3	-98.6	-98.9
140.000	3	-97.9	-97.7	-98.2	-98.8	-97.9
145.000	3	-98.2	-97.8	-98.1	-98.7	-97.9
150.000	3	-98.4	-97.7	-98.0	-98.7	-97.9
155.000	3	-98.4	-97.7	-97.8	-98.6	-97.9
160.000	3	-98.5	-97.7	-97.6	-98.6	-97.9
165.000	3	-98.6	-97.8	-97.3	-98.5	-97.8
170.000	3	-98.7	-97.7	-97.9	-98.6	-97.8
175.000	3	-98.8	-97.8	-97.8	-98.6	-97.9
180.000	3	-98.8	-97.8	-99.0	-98.5	-98.1
185.000	3	-98.9	-97.8	-99.0	-98.5	-98.1
190.000	3	-98.7	-97.8	-99.0	-98.5	-98.1
195.000	3	-98.9	-97.8	-99.0	-98.3	-98.3
200.000	3	-98.9	-97.8	-99.0	-98.2	-98.5
205.000	3	-98.9	-97.8	-98.9	-98.1	-98.7
210.000	3	-99.0	-97.8	-98.9	-98.1	-98.7
215.000	3	-99.1	-97.8	-98.9	-98.1	-98.7
220.000	3	-98.4	-97.8	-98.8	-98.0	-98.6
225.000	3	-98.3	-97.8	-98.8	-97.7	-98.6
230.000	3	-98.4	-97.8	-98.8	-97.4	-98.8
235.000	3	-97.6	-97.7	-98.8	-97.2	-98.7
240.000	3	-97.6	-97.7	-98.8	-97.2	-98.7
245.000	3	-97.6	-97.8	-98.8	-97.1	-98.7
250.000	3	-97.7	-97.8	-98.8	-97.8	-98.6
255.000	3	-98.1	-97.8	-98.8	-97.4	-98.6
260.000	3	-98.2	-97.8	-98.8	-97.3	-98.5
265.000	3	-98.3	-97.8	-98.7	-97.2	-98.2
270.000	3	-98.3	-97.8	-98.8	-97.2	-98.6
275.000	3	-98.3	-97.8	-98.8	-97.2	-98.7
280.000	3	-98.4	-97.8	-98.8	-97.3	-98.9
285.000	3	-98.5	-97.8	-98.8	-97.4	-98.9
290.000	3	-98.6	-97.8	-98.8	-97.4	-98.9
295.000	3	-98.4	-97.8	-98.8	-97.4	-98.9
300.000	3	-97.9	-97.8	-98.5	-97.9	-98.8
305.000	3	-97.9	-97.8	-98.5	-97.9	-98.8
310.000	3	-97.9	-97.8	-98.4	-97.9	-98.8
315.000	3	-98.1	-97.8	-98.4	-97.9	-98.7
320.000	3	-98.1	-97.8	-98.3	-98.8	-98.7
325.000	3	-98.1	-97.8	-98.3	-98.8	-98.7
330.000	3	-98.1	-97.8	-98.3	-98.8	-98.6
335.000	3	-98.2	-97.8	-98.4	-98.8	-98.7
340.000	3	-98.2	-97.8	-98.4	-98.8	-98.7
345.000	3	-98.2	-97.8	-98.4	-98.8	-98.7
350.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
355.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
360.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
365.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
370.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
375.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
380.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
385.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
390.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
395.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
400.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
405.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
410.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
415.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
420.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
425.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
430.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
435.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
440.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
445.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
450.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
455.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
460.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
465.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
470.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
475.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
480.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
485.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
490.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
495.000	3	-98.3	-97.8	-98.4	-98.8	-98.7
500.000	3	-98.3	-97.8	-98.4	-98.8	-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.

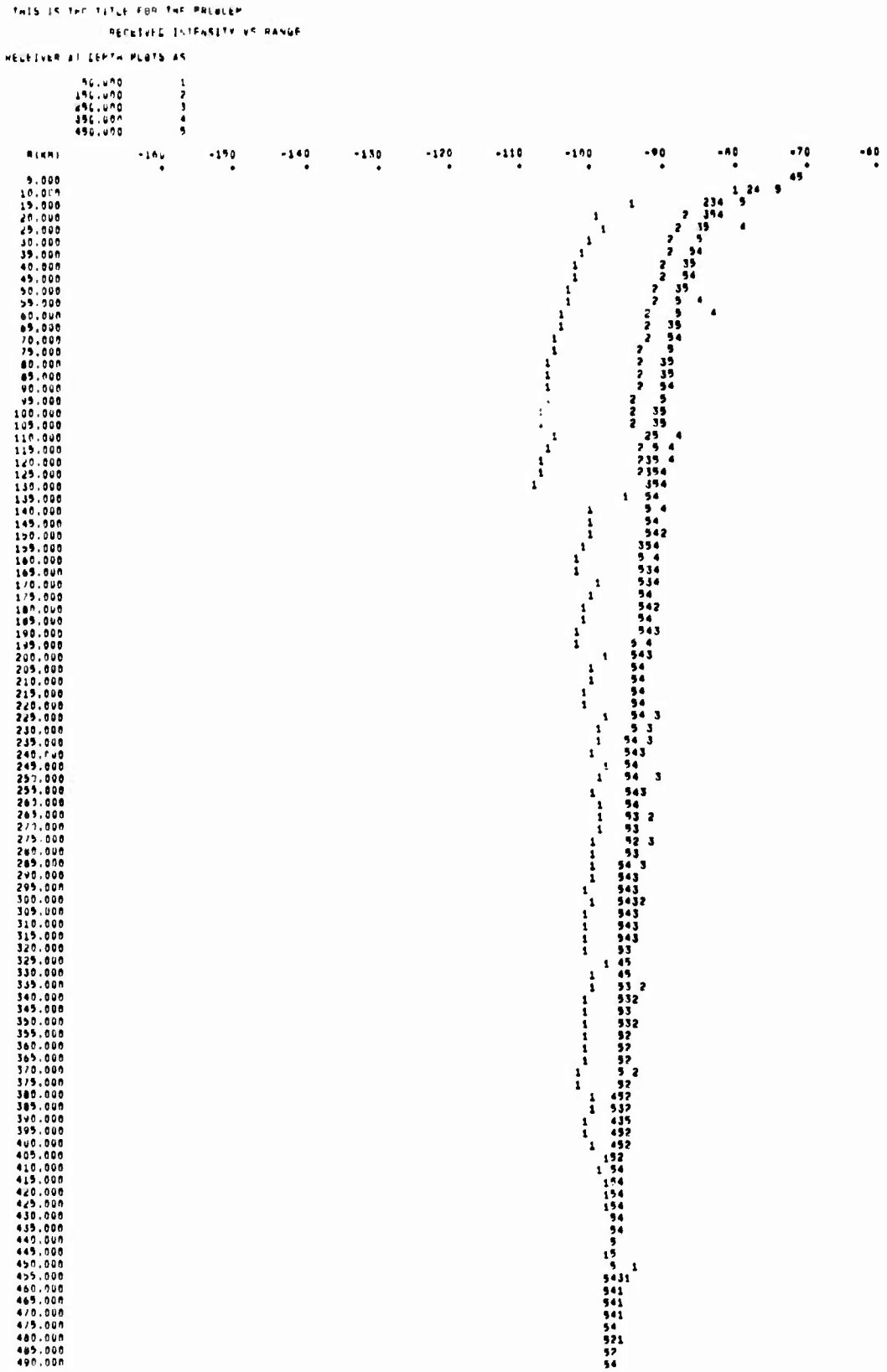


Fig. 10 — Example of the output from IVSRPLOT

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

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

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. $DZM = ZB/\sqrt{NRAY}$, 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.

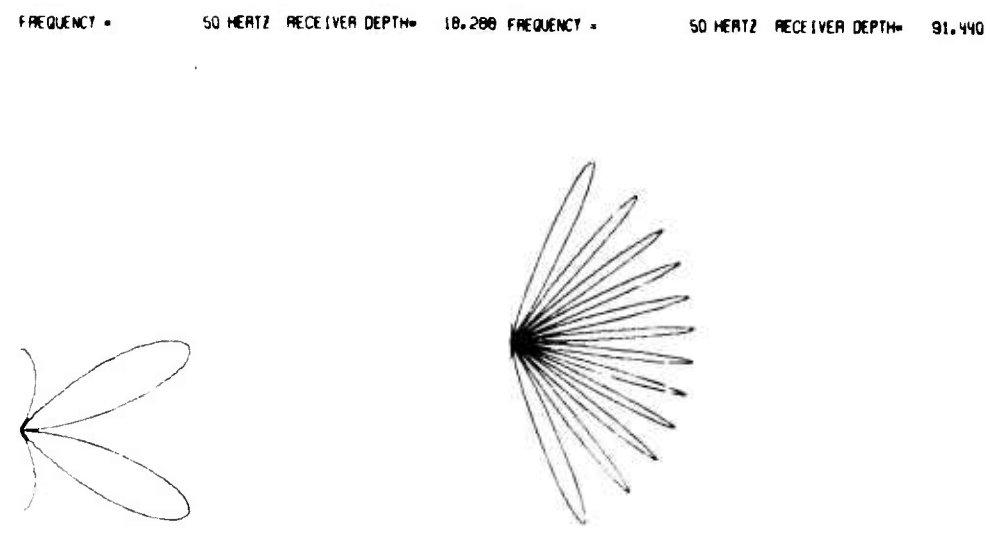
EIGENRAY SET TEST CASE FOR INTENSITY

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	8.9143	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.



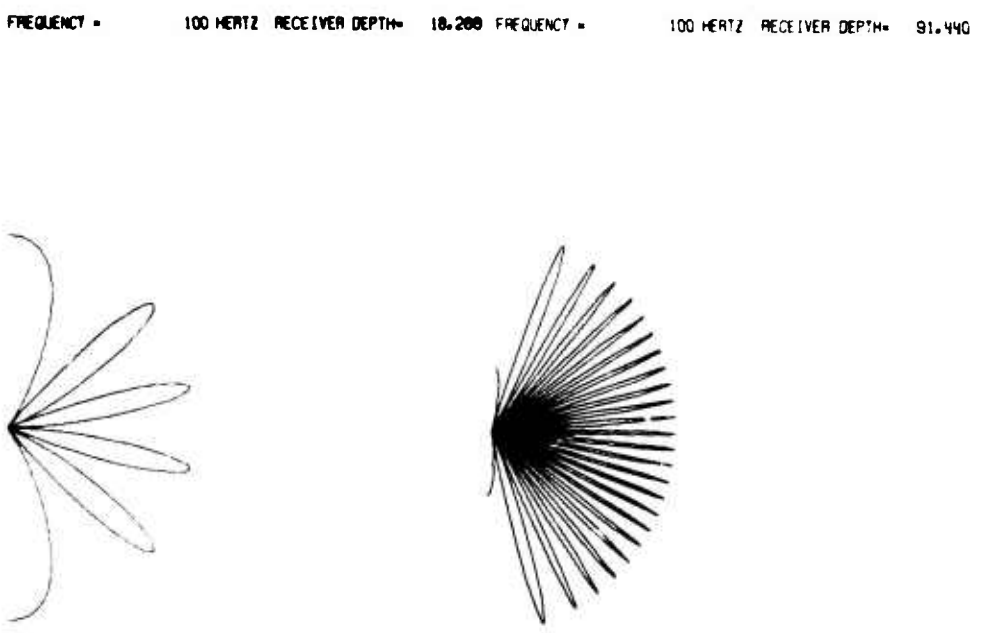


Fig. 12 — Examples of Lloyd's mirror beam patterns for receivers

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 EQUIP, 1 = *MT*, density, *RO*, 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:

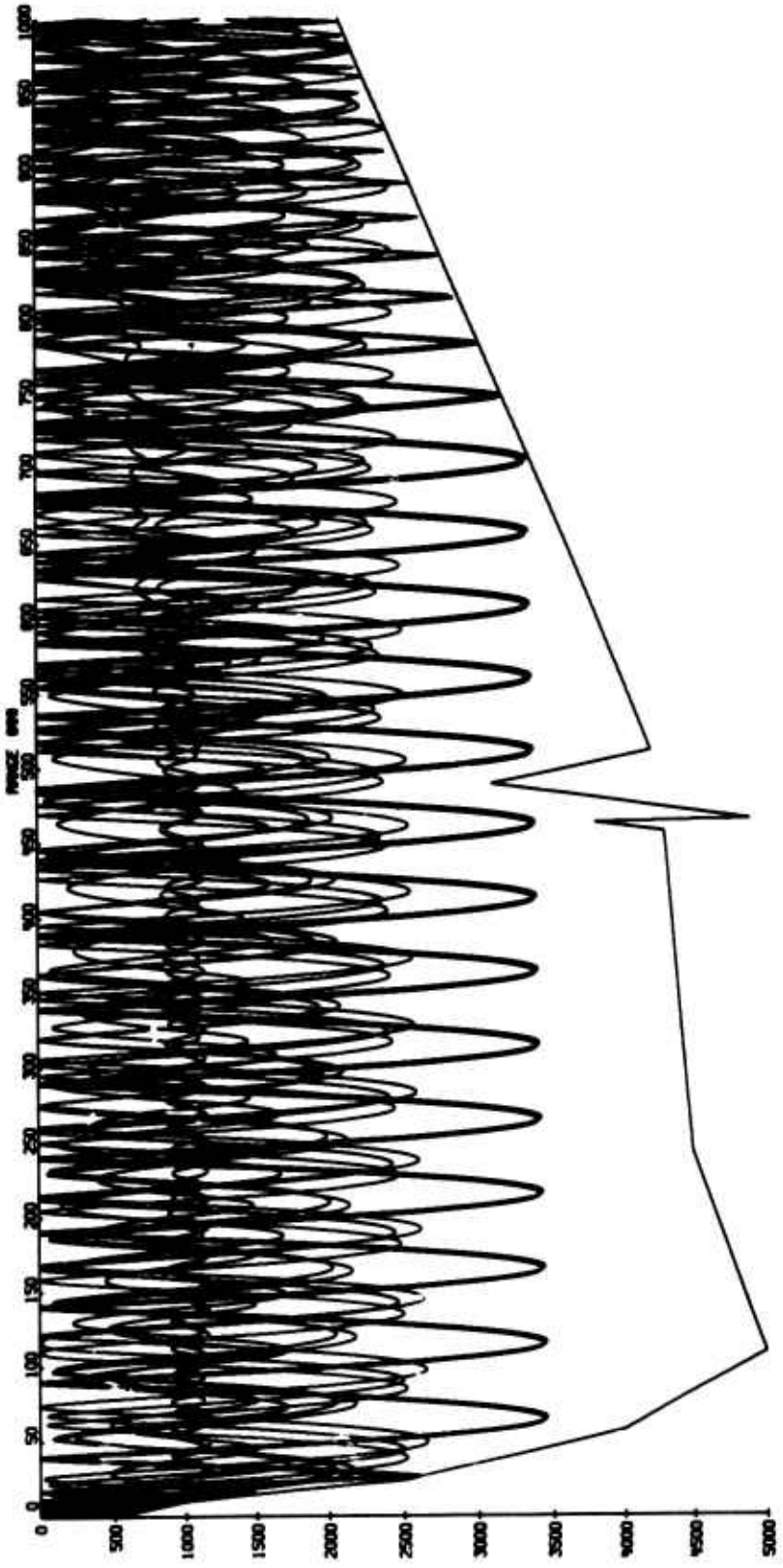


Fig. 13 — Example of a Calcomp plot

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 ≥ 0)	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

1. E.B. Wright, "Acoustic Transmission Loss by Single-Profile Raytracing (Program RTRACE)", NRL Report (7815), 1974.

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

```
.4A                                                          07/25/73

      PROGRAM TRIMAIN                                                    TRIM   1
      DIMENSION JUNK(10), R1(10),DR(10),R2(10),STRCD(26,10),JNRC(10),INTTRIM   2
     1   (10),IT(6,10),IRT(10),IRD(10),ISCPEQ(6) ,Z(2,50),V(2,50),TI(9) TRIM   3
      EQUIVALENCE (ISCP,ISCPEQ)                                          TRIM   4
      COMMON /MIRRORS/ FSRL,RRLT(200),BPST(200)                          TRIM   5
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,      TRIM   6
     1   ISCP,IT1,IT2,IT3,IPER,IFTIME,LTRT,LTER,LTRP,LPIN,IATT           TRIM   7
      COMMON /PROFIL/ RONE,N1,Z1(50),V1(50),RTWO,N2,Z2(50),V2(50),IBOTC,TRIM   8
     1IPFL                                                              TRIM   9
      COMMON /LOLOMESS/ LNRC,RCD(100),DINT(400)                          TRIM  10
      COMMON /PRO/ IPROP,IKNM,PLTL,RM,IPCO,IFPR                          TRIM  11
      DATA (LTRT=1),(LTER=41),(LTRP=42),(LPIN=60)                        TRIM  12
      COMMON /PATTERN/ SD,ITRP,DATD,SORLEV                               TRIM  13
      COMMON /PIDEF/ PI,DTR,TWOPI                                        TRIM  14
      COMMON/LIMITS/R1,DR,R2                                             TRIM  15
      COMMON /TLE/ ITITLE (10)                                           TRIM  16
      COMMON/ABC/PUNCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1               TRIM  17
      COMMON /IFC/ IFE,IA,IB,IP,ID,IS,LA                                 TRIM  18
      COMMON /RANST/ RTWOM,IREC,IFSK,SDS                                 TRIM  19
      PI=4.*ATAN(1.) $IFT=0 $IFT1=0 $ IPCO=0 $TWOPI=PI+PI$DTR=180./PI    TRIM   0
    1 READ 900,ITITLE$ IOPT=ITITLE(1) $ WRITE (19) ITITLE                TRIM  21
      REWIND 19                                                          TRIM  22
      IF (EOF, 60) 155, 2                                                TRIM  23
    2 IF (IOPT.EQ.8HRESTART )GO TO 104    $ GO TO 122                  TRIM  24
  900 FORMAT(10A8)                                                       TRIM  25
  155 IF (IFE.EQ.1) GO TO 152 $ IFE=1 $ GO TO 1                          TRIM  26
  122 PRINT 901,ITITLE $ RSTART=0.0  $RMAX=0.0   $  NTPLT=0             TRIM  27
  901 FORMAT(*1HORIZONTAL GRADIENT RAY TRACE *,10A8)                     TRIM  28
      READ 902,SD,FKHZ,IATT,SORLEV,ITRP,DATD,SLDB,IABOT,ISCP,NRECUR,     TRIM  29
     1IBOTC,IPFL,IPROP,IKNM,PLTL,NBRS,NSRS,ALIM,IA,IB,IP,ID,IS,LA,IOPT  TRIM  30
      AL1=ALIM     $  SDS=SD                                             TRIM  31
      FSRL=10.**(-.1*SLDB) $IF(ALIM,NE,0.0)ALIM=POWRF(10.0,(-ALIM/10.0)) TRIM  32
  902 FORMAT(F8.3,F5.3,I1,F5.2,I1,2F5.2,7I1,F8.3,2I5,F10.3,6I1,1X,A8)    TRIM  33
      OMEGA =2000.*PI*FKHZ $IF (ALIM,EQ,0.0)ALIM=1.0E-30 $ S2=FKHZ**2    TRIM  34
      PRINT 903,SD,SORLEV,FKHZ,ITRP,DATD,NBRS,NSRS,AL1,IA,IB,IP,ID,IS,LATRIM  35
     1,IOPT                                                              TRIM  36
  903 FORMAT(*0SOURCE DEPTH*,F8.2,* LEVEL*,F6.1,* FREQ(KHZ)*,F6.3,*  BEATRIM  37
     1MPATTERN *,I2,3X,*ANGLE=*,F5.1,5X,*NBRS=*,I5,5X,*NSRS=*,I5,5X,*DB TRIM  38
     2LIMIT=*,F10.3,/,5X,*IA=*,I1,5X,*IB=*,I1,5X,*IP=*,I1,5X,*ID=*,I1,  TRIM  39
     35X,*IS=*,I1,5X,*LA=*,I1,5X,*IOPT=*,A8)                             TRIM  40
      IF (NRECUR,GT.0,AND,IBOTC,GT.0)SD=SD*(1.+.5*SD/6371221.3)          TRIM  41
      ATT=0.0003025*S2  +44.*S2/(4100.+S2)                               TRIM  42
      IF(IATT.EQ.0) ATT=0.   $ IF (NBRS,EQ,0) NBRS=2500  $ IVSR=0        TRIM  43
      PRINT 904,ATT,SLDB  $ IF (NSRS,EQ,0) NSRS=2500                     TRIM  44
  904 FORMAT(*0VOLUME ATTENUATION*,F10.6,* DB/KM,  SURFACE LOSS*,F7.2,   TRIM  45
     1   * DB,*)                                                         TRIM  46
      CALL INITRAYS $ DO 985 J=1,10 $R1(J)=0.0 $DR(J)=0.0                TRIM  47
  985 R2(J)=0.0 $IF(IABOT,NE,0) GO TO 15    $  RR=ISCP                   TRIM  48
      CALL BRLTRD(RB) $IF (LA,EQ,1,OR,IB,EQ,1,OR,IB,EQ,3) REWIND 9       TRIM  49
      IF (LA,EQ,1,OR,IB,GE,2) REWIND 8   $ GO TO 18                      TRIM  50
   15 PRINT 905                                                          TRIM  51
      RB=1.E30                                                           TRIM  52
  905 FORMAT(*0BOTTOM ABSORBS ALL INCIDENT SOUND ENERGY*)                TRIM  53
   18 N=1 $IF (IP,EQ,0,AND,LA,EQ,0,OR,LA,EQ,1) LPC=60 $IF(IP,EQ,1)LPC=4 TRIM  54
   20 IF(LPC,EQ,60)READ(LPC,906)R1(N),DR(N),R2(N),IC,(IT(I,N),I=1,6),JVSTRIM  55
     1R,IRD(N),IRP,  IRT(N),IPRAY,(STRCD(I,N),I=1,6)                     TRIM  56
```

```
.4A                                                                07/25/73

      IF(LPC.EQ. 4)READ(LPC)    R1(N),DR(N),R2(N),IC,(IT(I,N),I=1,6),JVSTRIM  57
     1R,IRD(N),IRP,   IRT(N),IPRAY,(STRCD(I,N),I=1,6)                 TRIM  58
      IF(LA.EQ.1)WRITE(  4)    R1(N),DR(N),R2(N),IC,(IT(I,N),I=1,6),JVSRTRIM  59
     1,IRD(N),IRP,    IRT(N),IPRAY,(STRCD(I,N),I=1,6)                 TRIM  60
 906  FORMAT(3F8.2,I2,11I1,1X,6F8.4)                                   TRIM  61
      INT(N)=0                                                         TRIM  62
      DO 22 I=1,5                                                      TRIM  63
 22   INT(N)=INT(N)+IABS(IT(I,N))                                      TRIM  64
      IF (IT(5,N).GT.0) IPER=IT(5,N)                                   TRIM  65
      IF(INT(N).EQ.0) GO TO 30                                         TRIM  66
      PRINT 907,R1(N),DR(N),R2(N),(IT(I,N),I=1,6)                      TRIM  67
      IF(DR(N).LT.0.) DR(N)=-1.*DR(N)/R1(N)                            TRIM  68
      IH=6                                                             TRIM  69
 23   IF(STRCD(IH,N).GT.0.) GO TO 25                                   TRIM  70
 24   IH=IH+1                                                          TRIM  71
      IF(STRCD(IH,N).GT.0.) GO TO 26                                   TRIM  72
      IF(IH.LE.1) 26,24                                                TRIM  73
 25   IL=IH+1                                                          TRIM  74
      IH=IH+10                                                         TRIM  75
      IF(LPC.EQ.60)READ (LPC,908)(STRCD(I,N),I=IL,IH)                  TRIM  76
      IF(LPC.EQ. 4)READ (LPC)     (STRCD(I,N),I=IL,IH)                 TRIM  77
      IF(LA.EQ.1)WRITE (  4)     (STRCD(I,N),I=IL,IH)                  TRIM  78
C         THE SWITCH ITIM IS NOW LLMR, THE LLOYDS MIRROR SWITCH FOR ALL TRIM  79
C       RECEIVERS ON A GIVEN RANGE FAN CARD                            TRIM  80
 907  FORMAT(*0OUTPUT RANGES*,3F8.2,5H ISCP,I2,4H IT1,I2,4H IT2,I2,4H **TRIM  81
     13,I2,5H IPER,I2,5H LLMR,I2)                                      TRIM  82
 908  FORMAT(10F8.2)                                                   TRIM  83
      GO TO 23                                                         TRIM  84
 26   JNRC(N)=IH                                                       TRIM  85
      PRINT 909,(STRCD(I,N),I=1,IH)                                    TRIM  86
      IF (NRECUR.LE.0) GO TO 29                                        TRIM  87
      DO 31 I=1,IH                                                     TRIM  88
   31 STRCD (I,N)=STRCD(I,N)*(1.+.5*STRCD(I,N)/6371221.3)              TRIM  89
 909  FORMAT(*0RCD*,10F9.2)                                            TRIM  90
   29 IF(JVSR.EQ.0) GO TO 27                                          TRIM  91
      PRINT 910,JVSR                                                   TRIM  92
 910  FORMAT(*0INTENSITY VERSUS RANGE PLOT WILL BE MADE FOR TYPE*,I3)  TRIM  93
      IF(IVSR.NE.0) PRINT 911                                          TRIM  94
 911  FORMAT(5H ***,*CAUTION*,. ONLY THE LAST I VS R PLOT WILL BE MADE*)TRIM  95
      IVSR=JVSR                                                        TRIM  96
      NVSR=N                                                           TRIM  97
 27   IF(IRP.EQ.0) GO TO 28                                            TRIM  98
      NTPLT=15                                                         TRIM  99
      ZMAX=0.                                                          TRIM 100
      DRPLT=1.                                                         TRIM 101
      RLPLT=1.E6                                                       TRIM 102
      PRINT 915                                                        TRIM 103
 28   IF(IRD(N).NE.0) PRINT 912                                        TRIM 104
      IF(IRT(N).NE.0) PRINT 913                                        TRIM 105
  915 FORMAT (*0RAY PLOT WILL BE MADE*)                                TRIM 106
 912  FORMAT(*0RAY DEPTH DISTRIBUTION WILL BE MADE*)                   TRIM 107
 913  FORMAT(*0RAY TAPE WILL BE MADE*)                                 TRIM 108
      GO TO 40                                                         TRIM 109
 30   IF(IRP.EQ.0) GO TO 33                                            TRIM 110
      NTPLT=STRCD(1,N)*.1                                              TRIM 111
      IF(NTPLT.LT.1) NTPLT=15                                          TRIM 112
```

```
4A                                                              07/25/73

      ZMAX=STRCD(2,N)                                                    TRIM 113
      DRPLT=DR(N)                                                        TRIM 114
      RLST=R2(N)                                                         TRIM 115
      RLPLT=RLST                                                         TRIM 116
      PRINT 915                                                          TRIM 117
      PRINT 914,R1(N),DR(N),R2(N)                                        TRIM 118
33    IF(IRD(N)+IRT(N).EQ.0) GO TO 35                                    TRIM 119
      PRINT 914,R1(N),DR(N),R2(N)                                        TRIM 120
914   FORMAT(*0OUTPUT RANGES*,3F10.4)                                    TRIM 121
      IF(IRD(N).NE.0) PRINT 912                                          TRIM 122
      IF(IRT(N).NE.0) PRINT 913                                          TRIM 123
      GO TO 40                                                           TRIM 124
35    N=N-1                                                              TRIM 125
40    IF(IC.EQ.0) GO TO 45                                               TRIM 126
      N=N+1                                                              TRIM 127
      IF (N.GT.10)41,20                                                  TRIM 128
41    PRINT 42                                                           TRIM 129
42    FORMAT (1H0,*NUMBER OF OUTPUT CONTROL CARDS EXCEEDS 10, PROGRAM    TRIM 130
     1ABORTED*)                                                          TRIM 131
      CALL BYEBYE                                                        TRIM 132
45    NR=N   $ IF (LA.EQ.1.OR.IP.EQ.1) REWIND 4                          TRIM 133
      JRT=0                                                              TRIM 134
      RMAX1=0.                                                           TRIM 135
      D=1.0  $  D1=DRPLT  $  DELTM=0.0   $ ICA=0  $DELTA=0.0             TRIM 136
      DO 47 I=1,NR                                                       TRIM 137
      IF (DR(I).LT.D) D=DR(I)      $ IF (DR(I).LT.D1) D1=DR(I)           TRIM 138
      IF(R2(I).GT.RLST) RLST=R2(I)                                       TRIM 139
      IF(IT(2,I).EQ.0) GO TO 47                                          TRIM 140
      IF(R2(I).GT.RMAX1) RMAX1=R2(I)                                     TRIM 141
47    JRT=JRT+IRT(I)                                                     TRIM 142
      D=D/2.0                                                            TRIM 143
      CALL INIT                                                          TRIM 144
      CALL NEWPROF(ZM)                                                   TRIM 145
      CALL NEWPROF                                                       TRIM 146
      CALL CONNECT                                                       TRIM 147
      IF(ZMAX.EQ.0.) ZMAX=ZM                                             TRIM 148
      RPLT=1.E6                                                          TRIM 149
      IF(NTPLT.EQ.0) GO TO 49                                            TRIM 150
      RPLT=DRPLT                                                         TRIM 151
      CALL RAYPLOT(NTPLT,ZMAX)                                           TRIM 152
49    IF(JRT.EQ.0) GO TO 51                                              TRIM 153
      CALL RAYTAPE                                                       TRIM 154
51    NOLD=-10                                                           TRIM 155
      J=0                                                                TRIM 156
      NINT=1                                                             TRIM 157
C        IF ALL THE INTENSITY CALCULATIONS HAVE THE SAME RCDS            TRIM 158
C        A TABULAR FORMAT WILL BE USED                                   TRIM 159
      DO 55 I=1,NR                                                       TRIM 160
      IF(INT(I).EQ.0) GO TO 55                                           TRIM 161
      IF(J.EQ.0) J=I                                                     TRIM 162
      IF(J.EQ.I) GO TO 55                                                TRIM 163
      IF(JNRC(I).NE.JNRC(J)) GO TO 54                                    TRIM 164
      K=JNRC(I)                                                          TRIM 165
      DO 53 L=1,K                                                        TRIM 166
      IF(ABS(STRCD(L,I)-STRCD(L,J)).GT..1) GO TO 54                      TRIM 167
53    CONTINUE                                                           TRIM 168
```

```
.4A                                                                    07/25/73

      GO TO 55                                                                  TRIM 169
54    NINT=2                                                                    TRIM 170
      GO TO 95                                                                  TRIM 171
55    CONTINUE                                                                  TRIM 172
95    RMAX=0.                                                                   TRIM 173
100   RN=1.E6                                                                   TRIM 174
      DO 103 I=1,NR                                                             TRIM 175
      IF(R1(I).LT.RN) RN=R1(I)                                                  TRIM 176
103   CONTINUE                                                                  TRIM 177
      RSTART=RMAX                                                               TRIM 178
      RMAX=AMIN1(.001*RTWO,RPLT,RN)*1000.                                       TRIM 179
      RT=.001*(RMAX+1.)                                                         TRIM 180
      IF(RT.GT.RLST+D)    GO TO 140                                             TRIM 181
      IF (IOPT.NE.6HDUMP    ) GO TO 104                                         TRIM 182
      TILTP=TILT                                                                TRIM 183
      TILT=TIMELEFT(1)                                                          TRIM 184
      DELT=TILTP-TILT                                                           TRIM 185
      IF (DELT.LT.0.0) GO TO 108                                                TRIM 186
      ICA=ICA+1                                                                 TRIM 187
      FICA=ICA                                                                  TRIM 188
      DELTA=DELTA+DELT                                                          TRIM 189
      DELTM=DELTA/FICA                                                          TRIM 190
108   RER=(RLST-(RSTART/1000.0))/D1                                             TRIM 191
      TOTIME=RER*DELTM*2.0                                                      TRIM 192
      TOTIMM=TOTIME/60.0                                                        TRIM 193
      IF (TILT.LE.90.0+DELTM.AND.TOTIME.GE.30.0+DELTM) 107,104                  TRIM 194
107   IF (JRT.NE.0) BACKSPACE 1    $  CALL DUMP                                 TRIM 195
      PRINT 105,TILT,TOTIMM                                                     TRIM 196
105   FORMAT(1HO,*PROGRAM ABORTED, INSUFFICIENT RUN TIME,  TIME REMAININTRIM 197
     1G=*,F10.3,* SECONDS*,5X,*ESTIMATED TIME TO FINISH RUN=*,F10.3,    TRIM 198
     2* MINUTES*)                                                               TRIM 199
      PRINT 101,RTWOM                                                           TRIM 200
101   FORMAT (1HO,*REMOVE DATA DECK THROUGH PROFILE AT RANGE=*,F10.3,* KMTRIM 201
     1 BEFORE RESTARTING CASE*,/)                                               TRIM 202
      IF (IFE.EQ.1) PRINT 106                                                   TRIM 203
      IF (IS.EQ.1.AND.IFE.EQ.0) PRINT 112                                       TRIM 204
112   FORMAT (1HO,*INSERT BLANK CARD AFTER RESTART CARD, FOLLOWED BY A CTRIM 205
     1ARD WITH WORD START IN COLUMS 1-6, FOLLOWED BY REMAINING DATA*,/) TRIM 206
106   FORMAT (1HO,*INSERT END OF FILE CARD AFTER RESTART CARD BEFORE RESTRIM 207
     1TARTING CASE*,/)                                                          TRIM 208
      IF (IFE.EQ.1) GO TO 111                                                   TRIM 209
109   READ 900,JUNK                                                             TRIM 210
      IF (EOF,60)111,109                                                        TRIM 211
111   CALL BYEBYE                                                               TRIM 212
104   IF (IOPT.NE.6HRESTART ) GO TO 102                                         TRIM 213
      IF (IOPT.EQ.6HRESTART ) CALL RESTART  $  CALL CLOSEIOP                    TRIM 214
      PRINT 90,ITITLE       $  DO 113 J=1,10                                    TRIM 215
113   JUNK(J)=ITITLE(J)  $ READ (19) ITITLE                                     TRIM 216
      REWIND 19                                                                 TRIM 217
      IF (ITITLE(1).EQ.6HRESTART ,AND.IS.EQ.1.AND.IFE.EQ.0) CALL RETRY  TRIM 218
      IOPT1=ITITLE(2)                                                           TRIM 219
      IF (IOPT1.EQ.6H         ) IOPT=IOPT1   $ DO 114 J=1,10                    TRIM 220
114   ITITLE(J)=JUNK(J) $ IF (JRT.EQ.0) GO TO 102  $ DO 121 J=1,IFSK    TRIM 221
121   CALL SKIPFILE (1)    $ DO 123 J=1,IREC                                    TRIM 222
123   READ (1)                                                                  TRIM 223
102   CALL ADVANCE $IF(RMAX+1.LT.RTWO) GO TO 110      $  CALL NEWPROF   TRIM 224
```

```
4A                                                              07/25/73

      CALL CONNECT                                                      TRIM 225
  110 IF(RT,LT,RPLT) GO TO 115     $  CALL RAYPLOT                      TRIM 226
      RPLT=RPLT+DRPLT                                                   TRIM 227
      IF(RPLT.GT.RLPLT+.1) RPLT=1.E6                                    TRIM 228
  115 IF(RT.LT.RN) GO TO 135                                            TRIM 229
      DO 130 I=1,NR                                                     TRIM 230
      IF(R1(I).GT.RT) GO TO 130                                         TRIM 231
      IF(INT(I).EQ.0) GO TO 125                                         TRIM 232
      IF(I.EQ.NOLD) GO TO 120                                           TRIM 233
      LNRC=JNRC(I)                                                      TRIM 234
      DO 117 J=1,LNRC                                                   TRIM 235
  117 RCD(J)=STRCD(J,I)                                                 TRIM 236
      DO 119 J=1,6                                                      TRIM 237
  119 ISCPEQ(J)=IT(J,I)                                                 TRIM 238
  120 CALL INTENSTY                                                     TRIM 239
      CALL ITNPRINT(NINT)                                               TRIM 240
      IF(I.EQ.NVSR) CALL IVSRPLOT(IVSR)                                 TRIM 241
      NOLD=I                                                            TRIM 242
  125 IF(IRD(I).NE.0) CALL RAYZDIST (NTPLT)                             TRIM 243
      IF(IRT(I).NE.0) CALL RAYTAPE                                      TRIM 244
      IF(DR(I).LT.0.) GO TO 126                                         TRIM 245
      R1(I)=R1(I)+DR(I)                                                 TRIM 246
      GO TO 127                                                         TRIM 247
  126 R1(I)=R1(I)+DR(I)                                                 TRIM 248
  127 IF(R1(I).GT.R2(I)+.001) R1(I)=1.E6                                TRIM 249
  130 CONTINUE                                                          TRIM 250
  135 IF(RT.GT.RB) CALL NWBRLT(RB)                                      TRIM 251
      GO TO 100                                                         TRIM 252
  140 IF(JRT.EQ.0) GO TO 150                                            TRIM 253
      ENDFILE LTRT                                                      TRIM 254
      ENDFILE LTRT                                                      TRIM 255
      BACKSPACE LTRT                                                    TRIM 256
  150 IF (INCR.GT.1.AND.INCR.LE.16) 151,153                             TRIM 257
  151 INCRC=INCR-1                                                      TRIM 258
      WRITE (36,919) (PLNCHDR(II),II=1,INCRC)                           TRIM 259
  919 FORMAT (16F5.1)                                                   TRIM 260
  153 IF (IFE.EQ.1) GO TO 158                                           TRIM 261
      IF (LA.EQ.1.OR.IS.EQ.1) GO TO 160                                 TRIM 262
  157 READ 900,JUNK                                                     TRIM 263
      IF (EOF,60) 158,157                                               TRIM 264
  160 IF (LA.EQ.1.OR.IS.EQ.0.AND.LA.EQ.0) LPM=60                        TRIM 265
      IF (IS.EQ.1) LPM=6                                                TRIM 266
  170 IF(LPM.EQ.60)READ (LPM,1903) NCUR,RB,TI                           TRIM 267
      IF(LPM.EQ. 6)READ (LPM)      NCUR,RB,TI                           TRIM 268
      IF(EOF,LPM ) 177,178                                              TRIM 269
  177 IF (LA.EQ.1) ENDFILE 6                                            TRIM 270
      REWIND 6                                                          TRIM 271
      GO TO 158                                                         TRIM 272
  178 IL=1  $ IF (LA.EQ.1) WRITE (6)     NCUR,RB,TI                     TRIM 273
  179 IH=IL+4                                                           TRIM 274
      IF(LPM.EQ.60)READ(LPM,1900)(Z(2,I),V(2,I),I=IL,IH)                TRIM 275
      IF(LPM.EQ. 6)READ(LPM)     (Z(2,I),V(2,I),I=IL,IH)                TRIM 276
      IF(LA.EQ.1)WRITE ( 6)      (Z  (2,I),V  (2,I),I=IL,IH)            TRIM 277
      IF(V  (2,IH).LE.0.) GO TO 176                                     TRIM 278
      IL=IL+5                                                           TRIM 279
      GO TO 179                                                         TRIM 280
```

```
.4A                                                                    07/25/73

 1503 FORMAT(I1,F7.3,9A8)                                                    TRIM 281
 1600 FORMAT(10F8.4)                                                         TRIM 282
  158 IFPR1=IFPR  $ IF (IFPR.NE.1) IFPR=1  $ IF (IPFL.EQ.0) GO TO 159        TRIM 283
      IF (IFPR1.EQ.0.AND.IPFL.EQ.1) CALL PROFPLOT (2.0,5.1)                  TRIM 284
      IF (IPFL.EQ.2.AND.IFPR1.EQ.0) CALL PROFPLIT (2.0,5.1)                  TRIM 285
  159 IFS=1  $  IFT1 =IFT1+1  $  IF (IS.EQ.0) GO TO 1                        TRIM 286
  161 READ 900,JUNK  $ IF (EOF,60) 1,161                                     TRIM 287
 1502 IF (IPCO.NE.0) CALL STOPPLOT                                           TRIM 288
      CALL BYEBYE                                                            TRIM 289
      END                                                                    TRIM 290
```

```
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
                        PIDEF           00003
                        LIMITS          00036
                        TLE             00012
                        ABC             00026
                        IFC             00037
                        RANST           00004
        EXTERNAL SYMBOLS
                        COCENTRY
                        THEND.
                        02007111
                        01010100
                        COCDICT.
                        INITRAYS
                        BRLTRD
                        BYEBYE
                        INIT
                        NEWPROF
                        CONNECT
                        RAYPLOT
                        RAYTAPE
                        TIMELEFT
                        DUMP
                        RESTART
                        CLOSEIOP
                        RETRY
                        SKIPFILE
                        ADVANCE
                        INTENSTY
                        ITNPRINT
                        IVSRPLOT
                        RAYZDIST
                        NWBRLT
                        PROFPLOT
                        PROFPLIT
                        STOPPLOT
                        POWRF
                        MINIF
                        ATANF
                        COCIFEOF
                        EFT.
                        BSP.
                        REW.
                        TSW.
                        TSB.
                        STW.
                        STB.


                        SLC.
                        SLI.
                        ONSINGL.
```

```
; CLOSEIOP                                              07/12/73     ED 00000     PAGE NO.   1
                                          IDENT     CLOSEIOP                               CIOP  1
 PROGRAM LENGTH                00012
 ENTRY POINTS      CLOSEIOP    00004
 .XTERNAL SYMBOLS
                   IOP.
                                          ENTRY     CLOSEIOP                               CIOP  2
                                          EXT       IOP.                                   CIOP  3
   00000                        SAVEAQ    BSS       2                                      CIOP  4
   00002    50  1  77777        SAVE12    ENI       **,1                                   CIOP  5
            50  0  00000
   00003    77  2  00000                  DLDA      SAVEAQ                                 CIOP  6
            12  0 P00000
   00004    00  0  00000        CLOSEIOP  OCT       0                                      CIOP  7
            00  0  00000
   00005    77  2  04000                  DSTA      (*)SAVEAQ                              CIOP  8
            20  0 P00000
   00006    56  1 P00002                  SIU       SAVE12+1                               CIOP  9
            50  1  00017                  ENI       15,1                                   CIOP 10
   00007    04  1  00063    *             ENQ       35,1                                   CIOP 11
            50  0  00000
   00010    63  0  00031    *             63        31B                                    CIOP 12
            03  0 X77777                  03        (B)IOP.                                CIOP 13
   00011    55  1 P00007                  IJP       *-2,1                                  CIOP 14
            75  0 P00002                  UJP       SAVE12                                 CIOP 15
                                          END                                              CIOP 16
```

```
.5,4A                                                                06/04/73

      SUBROUTINE RETRY                                                    RETY   1
      DIMENSION TITLE (9),ZIL(2,50),VIL(2,50)                             RETY   2
   15 READ 1,IC                                                           RETY   3
    1 FORMAT (A8)                                                         RETY   4
      IF (EOF,60) 15,14                                                   RETY   5
   14 IF (IC.EQ.8HSTART   ) GO TO 75                                      RETY   6
      GO TO 15                                                            RETY   7
   75 LPN=60                                                              RETY   8
   76 IF(LPN.EQ.60)READ (LPN ,903) NCUR,RB,TITLE                          RETY   9
      IF(EOF,LPN ) 77,78                                                  RETY  10
   77 ENDFILE 6                                                           RETY  11
      REWIND 6                                                            RETY  12
      GO TO 82                                                            RETY  13
   78 IL=1  $                  WRITE (6)      NCUR,RB,TITLE               RETY  14
   79 IH=IL+4                                                             RETY  15
      IF(LPN.EQ.60)READ (LPN ,900) (ZIL(2,I),VIL(2,I),I=IL,IH)            RETY  16
      WRITE (  6)      (ZIL(2,I),VIL(2,I),I=IL,IH)                        RETY  17
      IF(VIL(2,IH),LE,0.) GO TO 78                                        RETY  18
      IL=IL+5                                                             RETY  19
      GO TO 79                                                            RETY  20
  900 FORMAT(10F8.4)                                                      RETY  21
  903 FORMAT (I1,F7.3,9A8)                                                RETY  22
   82 RETURN                                                              RETY  23
      END                                                                 RETY  24
```

```
IDS     RETRY
                                                                06/04/73        FC      0
                                      IDENT      RETRY
    PROGRAM LENGTH                 00546
    ENTRY POINTS        RETRY      00540
    EXTERNAL SYMBOLS
                        THEND,
                        QBCDICT,
                        QBCIFEOF
                        EFT,
                        REW,
                        TSH,
                        STB,
                        SLC,
                        SLI,
                        ONSINGL,
```

```
,4A                                                                    06/04/73

      SUBROUTINE INITRAYS                                                    INIT   1
      DIMENSION VBP(91)                                                      INIT   2
      COMMON /PATTERN/ SD,ITAP,DATE,SCALEV                                   INIT   3
      COMMON /PIDEF/ PI,DTR,TWOPI                                            INIT   4
      COMMON /RAYS/ NRAY,TGAM(1000),ZZ(1000),SS(1000),TIME(1000),            INIT   5
     1   NCTR(1000),PHASE(1000)                                              INIT   6
      COMMON /IFC/ IFE,IA,IB,IP,IC,IS,LA                                     INIT   7
      NRAY=0                                                                 INIT   8
      GG=1000.                                                               INIT   9
      PRINT 905                                                              INIT  10
  905 FORMAT ( *     GAMLD      GAMDD      DGAMD    IC   SL   PHASE *)      INIT  11
      IF (IA.EQ.0.AND.LA.EQ.0.OR.LA.EQ.1.OR.IA.EQ.2)  LPC=60                 INIT  12
      IF (IA.EQ.1.OR.IA.EQ.3) LPC=2                                          INIT  13
   10 IF(LPC.EQ.60)READ (LPC,900)GAMLD,GAMDD,DGAMD,IC,SL,PH                  INIT  14
      IF(LPC.EQ. 2)READ (LPC)    GAMLD,GAMDD,DGAMD,IC,SL,PH                  INIT  15
      IF(LA.EQ.1)WRITE ( 2)    GAMLD,GAMDD,DGAMD,IC,SL,PH                    INIT  16
      PRINT 906,GAMLD,GAMDD,DGAMD,IC,SL,PH                                   INIT  17
  906 FORMAT (1H0, 3F10.4, I5, 2F7.2 )                                       INIT  18
      SL=10.**(.1*(SL+SCALEV))                                               INIT  19
      IFF=1                                                                  INIT  20
      IF(ABS(GG+GAMLD).LT..001) GO TO 20                                     INIT  21
      IF(NRAY.EQ.0) GO TO 15                                                 INIT  22
      NRAY=NRAY+1                                                            INIT  23
      SS(NRAY)=0.                                                            INIT  24
   15 GG=+DGAMD+GAMLD                                                        INIT  25
      SGG=SIN(GG/DTR)                                                        INIT  26
      IFF=0                                                                  INIT  27
   20 G=GG+DGAMD                                                             INIT  28
      S=SIN(G/DTR)                                                           INIT  29
      NRAY=NRAY+1                                                            INIT  30
      IF(NRAY.GT.1000) GO TO 100                                             INIT  31
      TGAM(NRAY)=S/SQRT(1.+S+S)                                              INIT  32
      ZZ(NRAY)=SD                                                            INIT  33
      TIME(NRAY)=0.                                                          INIT  34
      NCTR(NRAY)=0                                                           INIT  35
      PHASE(NRAY)=PH/DTR                                                     INIT  36
      SS(NRAY)=SL+.5+ABS(S-SGG)                                              INIT  37
      IF(IFF.NE.0) SS(NRAY-1)=SS(NRAY-1)+SL+.5+ABS(S-SGG)                    INIT  38
      IFF=1                                                                  INIT  39
      GG=G                                                                   INIT  40
      SGG=S                                                                  INIT  41
      IF ( (G + .0000001) .LT. GAMLD ) GO TO 20                              INIT  42
      IF(IC.NE.0) GO TO 10                                                   INIT  43
   23 IF(ITAP.EQ.0) GO TO 35                                                 INIT  44
      IL=1                                                                   INIT  45
   25 IH=IL+19                                                               INIT  46
      IF (IA.EQ.0.AND.LA.EQ.0.OR.LA.EQ.1.OR.IA.EQ.1) LP =60                  INIT  47
      IF (IA.GE.2) LP=7                                                      INIT  48
      IF(LP.EQ.60)READ(LP ,901)(VBP(I),I=IL,IH)                              INIT  49
      IF(LP.EQ. 7)READ(LP )    (VBP(I),I=IL,IH)                              INIT  50
      IF(LA.EQ.1)WRITE( 7)     (VBP(I),I=IL,IH)                              INIT  51
      PRINT 907,(VBP(I),I=IL,IH)                                             INIT  52
  907 FORMAT(*0VBP *,20F5.1)                                                 INIT  53
      IF(VBP(IH).EQ.0.) GO TO 27                                             INIT  54
      IL=IL+20                                                               INIT  55
      GO TO 25                                                               INIT  56
```

```
,4A                                                          06/04/73

   27    IH=IH+1                                                          INIT  57
         IF(IH.EQ.1) GO TO 28                                             INIT  58
         IF(VBP(IH).EQ.0.) GO TO 27                                       INIT  59
   28    DO 29 I=IH,90                                                    INIT  60
   29    VBP(I-1)=VBP(IH)                                                 INIT  61
         DO 31 I=1,NRAY                                                   INIT  62
         D=ABS(D)*RAD*ATAN(TGAM(I))*DATD)                                 INIT  63
         N=D                                                              INIT  64
         D=D-N                                                            INIT  65
         D=(1.-D)*VBP(N+1)+D*VBP(N+2)                                     INIT  66
   31    SS(I)=SS(I)*10.**(-1.E-1*D)                                      INIT  67
   35    PRINT 902                                                        INIT  68
         PRINT 903,(I,TGAM(I),SS(I),PHASE(I),I=1,NRAY)                    INIT  69
         IF (LA.EQ.1.OR.IA.EQ.1.OR.IA.EQ.3) REWIND 2                      INIT  70
         IF (LA.EQ.1.OR.IA.GE.2) REWIND 7                                 INIT  71
         RETURN                                                           INIT  72
  100    IF(IC.EQ.0) GO TO 25                                             INIT  73
         READ 904,IC                                                      INIT  74
         GO TO 100                                                        INIT  75
  900    FORMAT (3F10.4, I5, 2F5.2 )                                      INIT  76
  901    FORMAT(20F4.1)                                                   INIT  77
  902    FORMAT(1H0  INITIAL TAN GAMMA, SIGNAL LEVEL, AND PHASE1H//)      INIT  78
  903    FORMAT ( 2(11G, 3F15.5 ))                                        INIT  79
  904    FORMAT(18X,I2)                                                   INIT  80
         END                                                              INIT  81
```

```
5  INITRAYS                                                    06/04/73        ED      0

                                                    ICEAT      INITRAYS

PROGRAM LENGTH                      01026
ENTRY POINTS      INITRAYS          00220
BLOCK NAMES
                  PATTERN           00004
                  PICEF             00003
                  RAYS              13561
                  IFC               00007
EXTERNAL SYMBOLS
                  THEAD,
                  02C07111
                  01C10100
                  01C03100
                  08LDICT,
                  SQRTF
                  SINF
                  ATANF
                  REW,
                  TSH,
                  TSB,
                  STH,
                  STB,
                  ONSIGL,
```

```
4A                                                                    06/04/73

      SUBROUTINE BRLTRD(RB) $ COMMON /PIDEF/ PI,DTR,TWOPI                    BLRD   1
      COMMON /INF0/ IDUM(2),OMEGA,IDMM(17)                                   BLRD   2
      COMMON /MIRRORS/ RSRL,BRLT(200),BPST(200)                              BLRD   3
      DIMENSION DB(50),LG(50),DTSTR(600),BR(91,4),BP(91,4),ISW(4),           BLRD   4
     1   RRL(50),ICL(50)  ,DTH (600)                                         BLRD   5
      COMMON/ABC/PLACHDB (10),INCR,NBRS,NSRS,ALIM,IFT,IFT1                   BLRD   6
      COMMON /IFC/ IFE,IA,IJ,IP,ID,IS,LA                                     BLRD   7
      EQUIVALENCE (LB,DTSTR(551)),(DG,DTSTR(501)),(ICL,DTSTR(451)),          BLRD   8
     1   (RBL,DTSTR(401)),(ISW,DTSTR(397)),(BR,DTSTR),(ISCP,DTSTR(396)),BLRD   9
     2   (IE,DTSTR(395)),(IB,DTSTR(394)),(K,DTSTR(393)),                    BLRD  10
     3   (IL,DTSTR(392)),(IM,DTSTR(391)),(IC,DTSTR(390))                    BLRD  11
      EQUIVALENCE (N,DTSTR(389)),(T,DTSTR(388)),(F,DTSTR(387)),(PHI,         BLRD  12
     1   DTSTR(386)),(DLE,DTSTR(385)),(R,DTSTR(384)),                       BLRD  13
     2   (RN,DTSTR(383)) $ EQUIVALENCE (BP,DTSTR(183))                      BLRD  14
      DATA ((DTSTR(I),I=501,600)=                                            BLRD  15
     1  19.,  35.,  40.,  52.,  6(90.),                                      BLRD  16
     2  19.,  25.,  35.,  45.,  55.,  5(90.),                               BLRD  17
     3  11.,  20.,  25.,  35.,  45.,  56.,  4(90.),                         BLRD  18
     4  11.,  20.,  30.,  40.,  55.,  5(90.),                               BLRD  19
     5   5.,  7.5, 16.5, 17.5,  19.,  20.,  21., 22.5,  2(90.),             BLRD  20
     1   0.,  3.7,  4.5,  7(6.),                                            BLRD  21
     2   0.,  2.3,  4.6,  6.5,  6(8.),                                      BLRD  22
     3   0.,   3.,  4.4,  6.7,  8.5,  5(10.),                               BLRD  23
     4   2.,  5.2,  7.7,  9.8,  6(12.),                                     BLRD  24
     5   4.,  5.2,  12., 12.8, 13.4, 13.7, 13.9,  3(14.)       )            BLRD  25
      DATA ((DTSTR(I),I=401,500)=                                            BLRD  26
     1  18.,  30.,  40.,  50.,  55.,  5(90.),                               BLRD  27
     2  17.,  20.,  30.,  40.,  50.,  55.,  4(90.),                         BLRD  28
     3  13.,  20.,  35.,  45., 52.5,  5(90.),                               BLRD  29
     4  7.5,  11.,  20.,  25.,  30.,  34.,  4(90.),                         BLRD  30
     5  2.5,   5.,  7.5,  15., 17.5,  20.,  22.,  3(90.),                   BLRD  31
     1   0.,  2.6,  4.4,  5.6,  6(6.),                                      BLRD  32
     2   0.,  1.3,  4.6,   7.,  8.5,  5(9.),                               BLRD  33
     3   3.,  5.3,  8.7, 10.3,  6(11.),                                     BLRD  34
     4   3.,   4., 10.4, 12.7, 13.7,  5(14.),                               BLRD  35
     5   6.,  8.7,  10., 14.1,  15., 15.8,  4(16.)          )               BLRD  36
      DATA ((DTSTR(I),I=301,400)=                                            BLRD  37
     1  19.,  25.,  35.,  45.,  51.,  5(90.),                               BLRD  38
     2  18.,  25.,  35.,  45.,  55.,  5(90.),                               BLRD  39
     3  14.,  20.,  30.,  40.,  50.,  53.,  4(90.),                         BLRD  40
     4   8.,  12.,  20., 22.5,  26.,  5(90.),                               BLRD  41
     5  2.5,  4.5,  7.5,  10.,  14., 17.5,  20.,  23.,  2(90.),             BLRD  42
     1   0.,  1.5,  3.5,  5.1,  6(6.),                                      BLRD  43
     2   0.,  2.8,  5.6,  7.6,  6(9.),                                      BLRD  44
     3   3.,   5.,  7.5,  9.4,  10.8,  5(11.),                              BLRD  45
     4   5.,  6.1, 12.2, 13.2,  6(14.),                                     BLRD  46
     5   9.,  10.,  12., 13.9,  16., 17.1, 17.7,  3(18.)          )          BLRD  47
      DATA ((DTSTR(I),I=201,300)=                                            BLRD  48
     1  18.,  25.,  30.,  40.,  50.,  55.,  4(90.),                         BLRD  49
     2  17.,  20.,  25.,  30.,  35.,  45.,  55.,  3(90.),                   BLRD  50
     3  13.,  25.,  30.,  35., 42.5,  45.,  50.,  3(90.),                   BLRD  51
     4   9., 12.5,  20., 22.5,  27.,  5(90.),                               BLRD  52
     5  2.5,  4.5,  7.5,  10.,  14., 17.5,  20.,  23.,  2(90.),             BLRD  53
     1   0.,   2.,   4.,   6.,  7.4,  5(8.),                               BLRD  54
     2   0.,  1.7,  3.9,  5.6,  6.8,  8.8,  4(10.),                         BLRD  55
     3   3.,  6.6,   8.,  9.1, 10.4, 10.7,  4(11.),                         BLRD  56
```

```
4A                                                                    06/04/73

      4   7.,   8.,  12.,  13.1,  6(14.),                                        BLRD  57
      5   9.,  10.,  12.,  13.9,  16.,  17.1,  17.7,  3(18.)        )            BLRD  58
       DATA  ((DTSTR(I),I=101,200)=                                             BLRD  59
      1  2.5,  10.,  12.5,  15.,  20.,  25.,  30.,  35.,  40.,  90.,            BLRD  60
      2  2.5,  7.5,  12.5,  20.,  25.,  32.5,  37.5,  42.5,  2(90.),            BLRD  61
      3  2.5,   5.,   7.5,  12.5,  17.5,  22.5,  27.5,  32.5,  2(90.),          BLRD  62
      4  2.5,  7.5,  10.,  11.5,  13.,  15.,  20.,  24.,  2(90.),               BLRD  63
      5  2.5,   5.,   8.5,  10.,  12.5,  15.,  20.,  22.5,  27.5,  90.,         BLRD  64
      1  3.5,  5.4,   6.,  6.6,  7.7,  8.6,  9.4,  9.8,  2(10.),               BLRD  65
      2  6.5,   8.,  9.5,  11.,  11.9,  13.,  13.4,  3(13.5),                   BLRD  66
      3   7.,  9.4,  11.5,  14.,  14.7,  15.1,  15.4,  3(15.5),                 BLRD  67
      4   9.,  13.5,  15.2,  16.,  16.6,  17.,  17.4,  3(17.5),                 BLRD  68
      5  11.,  13.6,  16.,  17.,  18.1,  18.8,  19.6,  19.8,  2(20.)    )       BLRD  69
       DATA ((DTSTR(I),I=1,100)=                                                BLRD  70
      1  7.5,  11.,  13.5,  15.,  17.5,  20.,  25.,  27.5,  2(90.),             BLRD  71
      2  7.5,  10.,  11.5,  14.,  15.,  17.5,  20.,  25.,  29.5,  90.,          BLRD  72
      3  7.5,  12.,  15.,  18.,  20.,  22.5,  25.,  27.,  90.,  90.,            BLRD  73
      4  7.5,  10.,  14.5,  17.5,  20.,  22.5,  25.,  28.,  90.,  90.,          BLRD  74
      5  2.5,  5.5,   8.,  10.,  15.,  17.5,  20.,  23.,  90.,  90.,            BLRD  75
      1  6.5,  6.6,  9.8,  10.8,  11.,  11.7,  12.7,  3(13.),                   BLRD  76
      2   7.,  8.8,  10.,  10.6,  11.1,  11.9,  12.5,  13.4,  2(14.),           BLRD  77
      3   8.,  11.,  12.8,  14.,  14.8,  15.4,  15.8,  3(16.),                  BLRD  78
      4   9.,  11.,  13.5,  14.8,  15.6,  16.2,  16.6,  3(17.),                 BLRD  79
      5  10.,  13.,  15.,  16.,  17.8,  18.4,  18.7,  3(19.)    )               BLRD  80
       IF (IFT.EQ.1) GO TO 2                                                    BLRD  81
       DO 1 J=1,600                                                             BLRD  82
     1 DTM(J)=DTSTR(J)                                                          BLRD  83
       IFT=1                                                                    BLRD  84
       GO TO 3                                                                  BLRD  85
     2 DO 4 J=1,600                                                             BLRD  86
     4 DTSTR(J)=DTM(J)     $ IE=0                                               BLRD  87
     3 FR=OMEGA/TWOPI $ IF(FR.LT.300.) GO TO 25                                 BLRD  88
       IF(FR.GT.1500.) GO TO 10 $ IF(FR.LT.750.) GO TO 5 $ IG=301               BLRD  89
       GO TO 20                                                                 BLRD  90
     5 IG=401 $ GO TO 20                                                        BLRD  91
    10 IF(FR.LT.2750.) GO TO 15 $ IG=101 $ IF(FR.GT.6000.) IG=1                 BLRD  92
       GO TO 20                                                                 BLRD  93
    15 IG=201                                                                   BLRD  94
    20 DO 24 I=5(1,600 $ DTSTR(I)=DTSTR(IG)                                     BLRD  95
    24 IG=IG+1                                                                  BLRD  96
    25 DO 30 I=1,500                                                            BLRD  97
    30 DTSTR(I)=0. $ ISCH=HB                                                    BLRD  98
       IF (IW.EQ.0.AND.LA.EQ.0.OR.LA.EQ.1.OR.IJ.EQ.2)  LPB=60                   BLRD  99
       IF (IW.EQ.1.OR.IJ.EQ.3) LPB=9                                            BLRD 100
    40 IB=IB+1 $ IF(LPB.EQ.60)READ (LPB,900)RBL(IB),ICL(IB)                     BLRD 101
       IF(LPB.EQ.9)READ (LPB)     RBL(IB),ICL(IB)                           BLRD 102
       IF(LA.EQ.1)WRITE  ( 9)     RBL(IB),ICL(IB) $ IF(RBL(IB)) 41,41,42    BLRD 103
    41 RBL(IB)=1.E30                                                            BLRD 104
    42 IF(ICL(IB)) 43,43,44                                                     BLRD 105
    43 ICL(IB)=0 $ GO TO 60                                                     BLRD 106
    44 IF(ICL(IB)-9) 46,46,45                                                   BLRD 107
    45 ICL(IB)=ICL(IB)/10                                                       BLRD 108
    46 IF(ICL(IB)-5) 60,60,47                                                   BLRD 109
    47 K=ICL(IB)-5 $ IF(ISW(K)) 48,48,60                                        BLRD 110
    48 ISW(K)=1 $ IL=1                                                          BLRD 111
    49 IH=IL+19 $ IF(LPB.EQ.60)READ (LPB,901)(BR(I,K),I=IL,IH)                  BLRD 112
```

```
4A                                                                    06/04/73

      IF (LPB.EQ.0)READ (LFB)(BR (I,K),I=IL,IH)                                  BLRD 113
      IF (LA.EQ.1)WRITE (  9,     (BR(I,K),I=IL,IH)  $ IL=IL+20                  BLRD 114
      IF(BR(IH,K)) 51,51,49                                                      BLRD 115
50    IF(BR(IH,K)) 51,51,53                                                      BLRD 116
51    IH=IH+1 $ IF(IH) 52,52,50                                                  BLRD 117
52    IH=1                                                                       BLRD 118
53    DO 54 I=IH,90                                                              BLRD 119
54    BR(I+1,K)=BR(IH,K) $ IL=1 $ IF(ISCP) 60,60,55                              BLRD 120
55    IH=IL+19 $IF (IJ.EQ.0.AND.LA.EQ.0.OR.LA.EQ.1.OR.IJ.EQ.1) LPP=60            BLRD 121
      IF(IJ.GE.2)LPP=65 IF(LPP.EQ.60)READ  (LPP,901)   (BP(I,K),I=IL,IH)BLRD 122
      IF (LPP.EQ.0) READ (LPF) (BP(I,K),I=IL,IH)                                 BLRD 123
      IF (LA.EQ.1) WRITE(8)     (BP(I,K),I=IL,IH)   $ IL=IL+20                   BLRD 124
      IF(BP(IH,K)) 55,60,55                                                      BLRD 125
60    IF(RBL(IB),LT.1.E15) GO TO 40 $ DO 65 K=6,9                                BLRD 126
      IF(ISW(K-5)) 65,65,61                                                      BLRD 127
61    PRINT 902,K $ PRINT 903,(I,BR(I+1,K-5),BP(I+1,K-5),I=IE,90)                BLRD 128
65    CONTINUE $ PRINT 900 $ DO 70 I=2,IB $ RN=RBL(I-1)                          BLRD 129
      PRINT 904,N,RN,ICL(I+1)                                                    BLRD 130
70    R=RN $ PRINT 905,N,ICL(IH) $ IE=1                                          BLRD 131
75    IC=ICL(IE) $ IF(IC) 76,76,80                                               BLRD 132
76    DO 77 I=1,200 $ BRLT(I)=1.                                                 BLRD 133
77    BPST(I)=0. $ GO TO 100                                                     BLRD 134
80    DO 99 I=1,200 $ T=DTR*ATAN(.01*(I-1)) $ K=IC-5 $ IF(K) 81,81,95            BLRD 135
81    IL=10*IC $ IF(DG(IL-5),GE,T) GO TO 93                                      BLRD 136
82    IF(DG(IL-6),GE,T) GO TO 92 $ IL=IL+1 $ GO TO 82                            BLRD 137
92    DCB=DB(IL-9)+(T-DG(IL-5))*(DB(IL-8)-DB(IL-9))/(DG(IL-8)-DG(IL-9))          BLRD 138
      GO TO 94                                                                   BLRD 139
93    DCB=DB(IL-9)                                                               BLRD 140
94    PHI=0. $ GO TO 96                                                          BLRD 141
95    N=T $ F=T-N $ DCH=ER(N+1,K)+F*(BR(N+2,K)-BR(N+1,K)) $ PHI=0.               BLRD 142
      IF(ISCP.NE.0) PHI=EP(N+1,K)+F*(BP(N+2,K)-BP(N+1,K))                        BLRD 143
98    BPST(I)=PHI                                                                BLRD 144
99    BRLT(I)=10.**(-.1*DCE)                                                     BLRD 145
100   RB=RBL(IE) $ RETURN $ ENTRY AWARLT $ IE=IE+1                               BLRD 146
      IF(IC-ICL(IE)) 75,100,75                                                   BLRD 147
900   FORMAT(F8.4,I2)                                                            BLRD 148
901   FORMAT(20F4.2)                                                             BLRD 149
902   FORMAT(38HUUSER SUPPLIED BOTTOM LOSS TABLE CLASS  ,I5/1X                   BLRD 150
     1  3(2HGA,6X,2HDB,7X,3HPHI,10X))                                           BLRD 151
903   FORMAT(3(I3,F10.3,F8.3,9X))                                                BLRD 152
904   FORMAT(5H FROM,F10.2,3H TO,F10.2,16H KM BOTTOM CLASS,I5)                   BLRD 153
905   FORMAT(5H FROM,F10.2,3H TO,3X,23HEND OF RUN BOTTOM CLASS,I5)               BLRD 154
      END                                                                        BLRD 155
```

```
 BRLTRD                                                  06/04/73        ED      0

                                        ICENT     BRLTRD
PROGRAM LENGTH                  03503
ENTRY POINTS    BRLTRD          02561
                AWBRLT          03321
BLOCK NAMES
                PIPEF           00003
                INFO            00024
                MIRRORS         00021
                ABC             00026
                IPC             00007
EXTERNAL SYMBOLS
                01010100
                THEND,
                01003100
                02007111
                OBOLIC,
                ATANF
                TSH,
                TSB,
                STH,
                STB,
                ONSINGL,
```

```
4A                                                              07/02/73

      SUBROUTINE WORD SIZE                                                  WORD    1
      COMMON /RAYS/ NRAY,TGAM(1000),ZZ(1000),SS(1000),TIME(1000),           WORD    2
     1   NCOUNT(1000),PHASE(1000)                                           WORD    3
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,         WORD    4
     1   ISOP,IT1,IT2,IT3,IPER,IFTIME,LTRT,LTER,LTRP,LPIN,IATT              WORD    5
      COMMON /TRIANG/ AP(100,2),BP(100,2),AL(100),BL(100),ZZERO(100),       WORD    6
     1   RZERO(100),AA(100),BB(100),SST(100),CCT(100),NTRI                  WORD    7
      COMMON /TLE/ STITLE (10)                                              WORD    8
      COMMON/ABC/PLANCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1                 WORD    9
      COMMON /RANST/ RDUM,IREC,IFSK,SDUM                                    WORD   10
      DATA (JBIG=377777777777777B),(IENT=0) ,(IFSK=-1)                      WORD   11
      ENTRY INIT                                                            WORD   12
      IF (IFT1.EQ.0) GO TO 2                                                WORD   13
      JBIG=377777777777777B      $  IENT=0                                  WORD   14
    2 ITN=SQRT(SQRT(JBIG/4.))                                               WORD   15
      ITN2=ITN**2                                                           WORD   16
      ITN3=ITN2*ITN                                                         WORD   17
      IBIG=ITN3*ITN                                                         WORD   18
      RETURN                                                                WORD   19
      ENTRY RAY TAPE                                                        WORD   20
      ZB=AL(NTRI)*BL(NTRI)*RMAX                                             WORD   21
      IF (IENT.NE.0) GO TO 1                                                WORD   22
      WRITE (LTRT)STITLE,ALIM,NBRS,NSRS,ITN                                 WORD   23
      IENT=1   $ IREC=1   $  IFSK=IFSK+1                                    WORD   24
    1 WRITE (LTRT) NRAY,RMAX,ZB,(TGAM(I),I=1,NRAY),(ZZ(I),I=1,NRAY),        WORD   25
     1   (SS(I),I=1,NRAY),(NCOUNT(I),I=1,NRAY),(TIME(I),I=1,NRAY),          WORD   26
     2   (PHASE(I),I=1,NRAY)      $  IREC=IREC+1                            WORD   27
      RETURN                                                                WORD   28
      END                                                                   WORD   29
```

```
S  WORDSIZE                                        07/02/73        ED      0

                                                   ICENT      WORDSIZE

     PROGRAM LENGTH                  00217
     ENTRY POINTS    INIT            00012
                     RAYTYPE         00044
                     WORDSIZE        00005
     BLOCK NAMES
                     RAYS            13561
                     INFO            00024
                     TRIANG          02261
                     TLE             00012
                     ABC             00026
                     RANST           00004
     EXTERNAL SYMBOLS
                     01010100
                     THEND,
                     OBODICT,
                     SQRTF
                     STB,
                     SLB,
                     ONSIANGL,
```

```
4A                                                                07/30/73

      SUBROUTINE NEWPROF(ZMAX)                                                NEWP   1
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,           NEWP   2
     1    ISCP,IT1,IT2,IT3,IPER,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT               NEWP   3
      COMMON /PROFIL/ R1,N1,Z1(50),V1(50),R2,N2,Z2(50),V2(50),IBOTC,IPFLNEWP   4
      COMMON/INPUT/ RBOT(25),ZBOT(25),ZIL(2,5),VIL(2,5),NN(2),ICON(2NEWP   5
     1,5)                                                                     NEWP   6
      COMMON /TLE/STITLE (10)                                                 NEWP   7
      COMMON /PRO/ IPROP,IKNM,PLTL,RM,IPCO,IFPR                               NEWP   8
      DIMENSION TITLE(9),PM(3),LIN (114)                                      NEWP   9
      COMMON/ABC/PUNCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1                    NEWP  10
      COMMON /IFC/ IFE,IA,IB,IK,ID,IS,LA                                      NEWP  11
      COMMON /RANST/ RS,IDUM,IDUMM,SDS                                        NEWP  12
      DATA (NBPT=0),(IFEOF=0)  ,(LIN=114(1H )),(IFT2=0),(IBH=0)               NEWP  13
      IFE=IFEOF $IF (IFT1.EQ.IFT2) GO TO 952     $IBH=0  $ IFT2=IFT1          NEWP  14
   952 IF (IFT1.EQ.0.OR.IBH.EQ.1) GO TO 950  $ NBPT=0 $IFEOF=0 $IFE=IFEOFNEWP  15
      IBH=1  $ N2=0 $ R2=0.0 $ N1=0 $ R1=0.0  $  IFPR=0                       NEWP  16
      DO 951 J=1,114                                                          NEWP  17
   951 LIN(J)=1H                                                              NEWP  18
   950 IF(NBPT.GT.0) GO TO 20                                                 NEWP  19
C        FIRST ENTRY.  READ IN BOTTOM TRACK                                   NEWP  20
      IL=1 $ IF (ID.EQ.0.AND.LA.EQ.0.OR.LA.EQ.1) LPI=60$IF(ID.EQ.1)LPI=5NEWP  21
2     IH=IL+4                                                                 NEWP  22
      IF(LPI.EQ.60)READ (LPI ,900) (RBOT(I),ZBOT(I),I=IL,IH)                  NEWP  23
      IF(LPI.EQ. 5)READ (LPI)      (RBOT(I),ZBOT(I),I=IL,IH)                  NEWP  24
      IF(LA.EQ.1)WRITE ( 5)      (RBOT(I),ZBOT(I),I=IL,IH)                    NEWP  25
      IF(RBOT(IH).LE.0.) GO TO 3 $ IL=IL+5 $ GO TO 2                          NEWP  26
3     IH=IH-1  $IF(RBOT(IH).LE.0.) GO TO 3       $ NBPT=IH                    NEWP  27
      IF (LA.EQ.1.OR.ID.EQ.1) REWIND 5                                        NEWP  28
      PRINT 901,(RBOT(I),ZBOT(I),I=1,NBPT)  $ IF (IBOTC.LE.0) GO TO 1         NEWP  29
      DO 5 I=1,NBPT                                                           NEWP  30
    5 ZBOT(I)=ZBOT(I)*(1.+.5*ZBOT(I)/637122)                                  NEWP  31
    1 CONTINUE  $       WRITE (35,611),STITLE,(RBOT(J),ZBOT(J),J=1,NBPT)      NEWP  32
  611 FORMAT (10A8,/,(10F8.3))                                                NEWP  33
  911 FORMAT (10F8.3)                                                         NEWP  34
      ZMAX=0.  $DO 4 I=1,NBPT                                                 NEWP  35
      IF(ZBOT(I).GT.ZMAX) ZMAX=ZBOT(I)                                        NEWP  36
4     CONTINUE                                                                NEWP  37
      IBPT=0 $ IF (IS.EQ.0.AND.LA.EQ.0.OR.LA.EQ.1) LPN=60                     NEWP  38
      NN(2)=0 $ IF (IS.EQ.1) LPN=6                                            NEWP  39
      DO 55 I=1,2                                                             NEWP  40
      DO 55 J=1,50                                                            NEWP  41
      ZIL(I,J)=0.0                                                            NEWP  42
      VIL(I,J)=0.0                                                            NEWP  43
   55 ICON(I,J)=0                                                             NEWP  44
      NN(1)=0                                                                 NEWP  45
      NIB=0                                                                   NEWP  46
      DO 56 J=1,50                                                            NEWP  47
      Z1(J)=0.0                                                               NEWP  48
      V1(J)=0.0                                                               NEWP  49
      Z2(J)=0.0                                                               NEWP  50
   56 V2(J)=0.0                                                               NEWP  51
      ASSIGN 6 TO IRET                                                        NEWP  52
      GO TO 70                                                                NEWP  53
C        AT 70 IS THE READIN AND CONNECT ROUTINE,  RETURN IS TO IRET          NEWP  54
6     ASSIGN 20 TO IRET                                                       NEWP  55
      GO TO 70                                                                NEWP  56
```

```
4A                                                                    07/30/73

 20     IBPT=IBPT+1                                                          NEWP  57
        IF(IBPT.LE.NBPT) GO TO 21                                            NEWP  58
        RBT=.001*R2*100.                                                     NEWP  59
        IFPR=1                                                               NEWP  60
        GO TO 22                                                             NEWP  61
 21     RBT=RBOT(IBPT)                                                       NEWP  62
        ZBT=ZBOT(IBPT)                                                       NEWP  63
        IF (RM.LE.RBT.AND.IFEOF.EQ.1.AND.RS.NE.0.0) IFPR=1                   NEWP  64
 22     IF(RBT.LE.RB) GO TO 25                                               NEWP  65
 C         GET NEW INPUT PROFILE                                             NEWP  66
        ASSIGN 23 TO IRET                                                    NEWP  67
        GO TO 70                                                             NEWP  68
    23  IF (IBPT.GT.NBPT) GO TO 25                                           NEWP  69
        IBPT=IBPT+1                                                          NEWP  70
        ZBT=ZBT+(RA-RBT)*(ZBT-ZBOT(IBPT))/(RBT-RBOT(IBPT))                   NEWP  71
 C         THIS IS THE BOTTOM DEPTH AT PROFILE RANGE                         NEWP  72
        RBT=RA                                                               NEWP  73
 25     R1=R2                                                                NEWP  74
        N1=N2                                                                NEWP  75
 C         MOVE PROFILE 2 TO PROFILE 1                                       NEWP  76
        DO 27 I=1,N2                                                         NEWP  77
        Z1(I)=Z2(I)                                                          NEWP  78
 27     V1(I)=V2(I)                                                          NEWP  79
        R2=1000.*RBT                                                         NEWP  80
        FA=(RW-RBT)/(RB-RA)                                                  NEWP  81
        FB=1.-FA                                                             NEWP  82
        N2=1                                                                 NEWP  83
    29  IF (ICON(1,N2).GT.NN(1)) ICON (1,N2)=NN(1)                           NEWP  84
        IF (ICON(2,N2).GT.NN(2)) ICON (2,N2)=NN(2)                           NEWP  85
        Z=FA*ZIL(1,ICON(1,N2))+FB*ZIL(2,ICON(2,N2))                          NEWP  86
        V=FA*VIL(1,ICON(1,N2))+FB*VIL(2,ICON(2,N2))                          NEWP  87
        IF (N2.GT.1.AND.Z.LT.Z2(N2-1)) 125,126                               NEWP  88
   125  Z=Z2(N2-1)                                                           NEWP  89
        V=V2(N2-1)                                                           NEWP  90
   126  IF(Z.GT.ZBT-.1) GO TO 35                                             NEWP  91
        Z2(N2)=Z                                                             NEWP  92
        V2(N2)=V                                                             NEWP  93
        N2=N2+1                                                              NEWP  94
        IF(N2.LE.NIB) GO TO 29                                               NEWP  95
 C         EXTRAPOLATION TO BOTTOM                                           NEWP  96
        Z2(N2)=ZBT                                                           NEWP  97
        M=N2-1                                                               NEWP  98
 31     M=M-1                                                                NEWP  99
        Z=Z2(M)                                                              NEWP 100
        IF(ABS(Z-Z2(N2-1)).LT.1.E-5*Z) GO TO 31                              NEWP 101
        V=V2(M)                                                              NEWP 102
        V2(N2)=V2(M)  +(ZBT-Z)*(V2(N2-1)-V)/(Z2(N2-1)-Z)                     NEWP 103
        GO TO 40                                                             NEWP 104
 35     Z2(N2)=ZBT                                                           NEWP 105
        V2(N2)=V2(N2-1)+(ZBT-Z2(N2-1))*(V-V2(N2-1))/(Z-Z2(N2-1))             NEWP 106
 C         REMOVE DUPLICATE POINTS                                           NEWP 107
 40     M=2                                                                  NEWP 108
        IDC=0                                                                NEWP 109
    42  IF (Z2(M).GT.Z2(M-1)+0.00001) GO TO 45                               NEWP 110
        IDC=1                                                                NEWP 111
        N2=N2-1                                                              NEWP 112
```

```
4A                                                              07/30/73

      DO 44 I=M,N2                                                      NEWP 113
      Z2(I)=Z2(I+1)                                                     NEWP 114
   44 V2(I)=V2(I+1)                                                     NEWP 115
   45 M=M+1                                                             NEWP 116
      IF(M.LE.N2) GO TO 42                                              NEWP 117
      IF (IDC.GT.0) GO TO 40                                            NEWP 118
      IF (Z2(N2+1).EQ.0.0) GO TO 46                                     NEWP 119
      N5=N2+1                                                           NEWP 120
      DO 47 I=N5,50                                                     NEWP 121
      Z2(I)=0.0                                                         NEWP 122
   47 V2(I)=0.0                                                         NEWP 123
   46 IF (IPROP.EQ.0.OR.IPROP.EQ.1) GO TO 54                            NEWP 124
      PRINT 902,R2                                                      NEWP 125
      PRINT 914                                                         NEWP 126
      DO 7 J=1,N2                                                       NEWP 127
      NV=V2(J)-1455.5                                                   NEWP 128
      IF (NV.LT.4.OR.NV.GT.114) GO TO 48                                NEWP 129
      LIN(NV)=1H*                                                       NEWP 130
      PRINT 915,Z2(J),V2(J),LIN                                         NEWP 131
      LIN(NV)=1H                                                        NEWP 132
      GO TO 7                                                           NEWP 133
   48 PRINT 915,Z2(J),V2(J)                                             NEWP 134
    7 CONTINUE                                                          NEWP 135
   54 IF (IPFL.EQ.1) CALL PROFPLOT (RB,N3,INPF)                         NEWP 136
      IF (IPFL.EQ.2) CALL PROFPLIT (RB,N3,INPF)                         NEWP 137
      IF (RS.GE.RBOT(2).OR.IFEOF.EQ.1) RETURN $ PRINT 275 $ CALL BYERYE NEWP 138
  275 FORMAT (5X,*PROGRAM ABORTED, TWO SOUND SPEED PROFILES INPUT BEFORENEWP 139
     1 SECOND BOTTOM PO;NT*)                                            NEWP 140
   70 IF(NN(2).EQ.0) GO TO 75   $ NB=NN(2)  $ DO 71 I=1,NB              NEWP 141
      ZIL(1,I)=ZIL(2,I)                                                 NEWP 142
   71 VIL(1,I)=VIL(2,I)                                                 NEWP 143
      RA=RB                                                             NEWP 144
   75 NN(1)=NN(2)                                                       NEWP 145
      IF(IFEOF.EQ.0) GO TO 76                                           NEWP 146
      RB=RB+1.E6                                                        NEWP 147
      GO TO 82                                                          NEWP 148
   76 IF(LPN.EQ.60)READ (LPN ,903) NCUR,RB,TITLE                        NEWP 149
      IF(LPN.EQ. 6)READ (LPN)      NCUR,RB,TITLE                        NEWP 150
      IF(EOF,LPN ) 77,78                                                NEWP 151
   77 IFEOF=1   $ IFE=IFEOF                                             NEWP 152
      RB=RA+1.E6  $ IF (LA.EQ.1) ENDFILE  6                             NEWP 153
      IF (LA.EQ.1.OR.IS.EQ.1) REWIND 6  $ GO TO 82                      NEWP 154
   78 IL=1   $ IF (LA.EQ.1) WRITE (6)     NCUR,RB,TITLE   $ RS=RB      NEWP 155
   79 IH=IL+4                                                           NEWP 156
      IF(LPN.EQ.60)READ (LPN ,900) (ZIL(2,I),VIL(2,I),I=IL,IH)          NEWP 157
      IF(LPN.EQ. 6)READ (LPN)      (ZIL(2,I),VIL(2,I),I=IL,IH)          NEWP 158
      IF(LA.EQ.1)WRITE ( 6)       (ZIL(2,I),VIL(2,I),I=IL,IH)          NEWP 159
      IF(VIL(2,IH).LE.0.) GO TO 81                                      NEWP 160
      IL=IL+5                                                           NEWP 161
      GO TO 79                                                          NEWP 162
   81 IH=IH-1                                                           NEWP 163
      IF(VIL(2,IH).LE.0.) GO TO 81                                      NEWP 164
      NN(2)=IH                                                          NEWP 165
      N3=IH                                                             NEWP 166
      INPF=0                                                            NEWP 167
      IF (IPROP.EQ.0) GO TO 74                                          NEWP 168
```

```
.4A                                                                    07/30/73

      PRINT 904,RB,TITLE                                                NEWP 169
      PRINT 914                                                         NEWP 170
   74 DO 28 I=1,IM                                                      NEWP 171
      IF (VIL(2,I).LT.1400.0.OR.VIL(2,I).GT.1650.0) 58,57               NEWP 172
   58 PRINT 920,RB,ZIL(2,I),VIL(2,I)                                    NEWP 173
  920 FORMAT(1H1,5X,*INPUT ERROR IN PROFILE AT RANGE*,F10.4,5X,*VALUE ATNEWP 174
     1 DEPTH*,F10.3,**,F10.3,* M/SEC*)                                  NEWP 175
      CALL BYEBYE                                                       NEWP 176
   57 IF (ZIL(2,I).NE.SDS) GO TO 257 $ PRINT 258,ZIL(2,I),RBSCALL BYEBYENEWP 177
  258 FORMAT (5X,*PROGRAM ABORTED, INPUT PROFILE DEPTH*,F10.3,1X,**SOURCNEWP 178
     1E DEPTH, AT RANGE*,F10.3,* KM*)                                   NEWP 179
  257 IF (I.EQ.1) GO TO 157 $IF (ZIL(2,I).LT.ZIL (2,I-1)) GO TO 98      NEWP 180
  157 IF (IPROP.EQ.0) GO TO 28  $NV=VIL(2,I)-1455.5                     NEWP 181
      IF (NV.LT.4.OR.NV.GT.114) GO TO 38  $ LIN(NV)=1HV                 NEWP 182
      PRINT 915,ZIL(2,I),VIL(2,I),LIN                                   NEWP 183
      LIN (NV)=1H                                                       NEWP 184
      GO TO 29                                                          NEWP 185
   38 PRINT 915,ZIL(2,I),VIL(2,I)                                       NEWP 186
   28 CONTINUE                                                          NEWP 187
      IF (NCUR.GT.0) GO TO 89                                           NEWP 188
      DO 80 I=1,IM                                                      NEWP 189
      V.L(2,I)=VIL(2,I)*(1.+ZIL(2,I)/6371221.3)                         NEWP 190
   80 ZIL(2,I)=ZIL(2,I)*(1.+.5*ZIL(2,I)/6371221.3)                      NEWP 191
   89 IF (IPFL.EQ.1) CALL PROFPLOT (RB,N3,INPF)                         NEWP 192
      IF (IPFL.EQ.2) CALL PROFPLIT (RB,N3,INPF)                         NEWP 193
      IF(NN(1).EQ.0)                GO TO IRET,(6,20,23)                NEWP 194
   82 ICON(1,1)=1                                                       NEWP 195
      ICON(2,1)=1                                                       NEWP 196
      NA=2                                                              NEWP 197
      NB=2                                                              NEWP 198
      NIR=2                                                             NEWP 199
   83 IF (ZIL(2,NIB).EQ.ZIL(1,NIB)) GO TO 92                            NEWP 200
      IF(NB.LE.NN(2)) GO TO 84                                          NEWP 201
      IP=2                                                              NEWP 202
      GO TO 88                                                          NEWP 203
   84 IF(NA.LE.NN(1)) GO TO 85                                          NEWP 204
      IP=1                                                              NEWP 205
      GO TO 88                                                          NEWP 206
   85 DVMA=VIL(1,NA)-VIL(1,NA-1)                                        NEWP 207
      DVLA=DVMA                                                         NEWP 208
      DVHA=DVMA                                                         NEWP 209
      IF(NA.GT.2) DVLA=VIL(1,NA-1)-VIL(1,NA-2)                          NEWP 210
      IF(NA.LT.NN(1)) DVHA=VIL(1,NA+1)-VIL(1,NA)                        NEWP 211
      DVMB=VIL(2,NB)-VIL(2,NB-1)                                        NEWP 212
      DVLB=DVMB                                                         NEWP 213
      DVHB=DVMB                                                         NEWP 214
      IF(NB.GT.2) DVLB=VIL(2,NB-1)-VIL(2,NB-2)                          NEWP 215
      IF(NB.LT.NN(2)) DVHB=VIL(2,NB+1)-VIL(2,NB)                        NEWP 216
      PM(1)=ABS(ZIL(1,NA-1)-ZIL(2,NB))                                  NEWP 217
      IF(DVLA*DVMB.GE.0..AND.DVMA*DVHB.GE.0.) PM(1)=PM(1)-250.          NEWP 218
      PM(2)=ABS(ZIL(1,NA)-ZIL(2,NB-1))                                  NEWP 219
      IF(DVMA*DVLB.GE.0..AND.DVMA*DVHB.GE.0.) PM(2)=PM(2)-250.          NEWP 220
      PM(3)=ABS(ZIL(1,NA)-ZIL(2,NB))                                    NEWP 221
      IF(DVMA*DVHB.GE.0..AND.DVMA*DVHB.GE.0.) PM(3)=PM(3)-250.          NEWP 222
      BP=PM(1)                                                          NEWP 223
      IP=1                                                              NEWP 224
```

```
1A                                                              07/30/73

      DO 87 I=2,3                                                          NEWP 225
      IF(pM(I).GE.Bp) GO TO 87                                             NEWP 226
      IP=I                                                                 NEWP 227
      BP=PM(I)                                                             NEWP 228
87    CONTINUE                                                             NEWP 229
88    GO TO (90,91,92),IP                                                  NEWP 230
90    ICON(1,NIB)=NA-1                                                     NEWP 231
      ICON(2,NIB)=NB                                                       NEWP 232
      NB=NB+1                                                              NEWP 233
      GO TO 93                                                             NEWP 234
91    ICON(1,NIB)=NA                                                       NEWP 235
      ICON(2,NIB)=NB-1                                                     NEWP 236
      NA=NA+1                                                              NEWP 237
      GO TO 93                                                             NEWP 238
92    ICON(1,NIB)=NA                                                       NEWP 239
      ICON(2,NIB)=NB                                                       NEWP 240
      NA=NA+1                                                              NEWP 241
      NB=NB+1                                                              NEWP 242
93    IF(NA.GT.NN(1).AND.NB.GT.NN(2)) GO TO IRET,(6,20,23)                 NEWP 243
      NIB=NIB+1                                                            NEWP 244
      IF (NIB.LE.50) GO TO 83                                              NEWP 245
      PRINT 905                                                            NEWP 246
      CALL BYEBYE                                                          NEWP 247
900   FORMAT(10F8.4)                                                       NEWP 248
901   FORMAT(24H0LISTING OF BOTTOM TRACK/1H0,4X,9(6H R(KM),6X,4HZ(M),4X)NEWP 249
     1   //(1X,10F10.3))                                                  NEWP 250
902   FORMAT(30H0INTERPOLATED PROFILE AT RANGE,F10.0,2H M//)               NEWP 251
903   FORMAT(I1,F7.3,9A8)                                                  NEWP 252
904   FORMAT(23H1INPUT PROFILE AT RANGE,F11.3,3H KM,9X,9A8//)              NEWP 253
914   FORMAT (3X,*DEPTH (M)*,2X,*VELOCITY*,*1460*,6X,*1470*,6X,*1480*6X,NEWP 254
     1*1490*,6X,*1500*,6X,*1510*,6X,*1520*,6X,*1530*,6X,*1540*,6X,*1550*NEWP 255
     2,6X,*1560*,6X,*1570*,//)                                           NEWP 256
915   FORMAT (1X,F11.4,F10.4,114A1)                                        NEWP 257
905   FORMAT ( 29H0TOO MANY POINTS INTERPOLATED)                           NEWP 258
      END                                                                  NEWP 259
```

```
                                                        07/30/73          ED      0
DS   NEWPROF

                                          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.
                      Q1Q10100
                      QBODICT.
                      PROFPLOT
                      PROFPLIT
                      BYEBYE
                      QBQIFEOF
                      EFT.
                      REW.
                      TSW.
                      TSB.
                      STW.
                      STB.
                      SLB.
                      SLI.
                      QNSINGL.
```

```
3,4A                                                    06/04/73

      SUBROUTINE CONNECT                                                C0NN   1
      COMMON /PROFIL/ R1,N1,Z1(50),V1(50),R2,N2,Z2(50),V2(50),IBOTC,IPFLC0NN   2
      COMMON /TRIANG/ AP(100,2),BP(100,2),AL(100),BL(100),ZZERO(100),   C0NN   3
     1   RZERO(100),AA(100),EB(100),SST(100),CCT(100),NTRI              C0NN   4
      NA=NB=1                                                           C0NN   5
      NTRI=0                                                            C0NN   6
      IADD=0                                                            C0NN   7
   10 NTRI=NTRI+1                                                       C0NN   8
      IF(NB.EQ.N2) GO TO 12                                             C0NN   9
      IF (IADD.EQ.1.OR.NA.EQ.N1) GO TO 30                               C0NN  10
   12 RZERO(NTRI)=R2                                                    C0NN  11
      ZZERO(NTRI)=Z2(NB)                                                C0NN  12
      AL(NTRI)=Z1(NA+1)                                                 C0NN  13
      BL(NTRI)=(Z2(NB)-Z1(NA+1))/(R2-R1)                                C0NN  14
      AA(NTRI)=1./V2(NB)**2                                             C0NN  15
      BZ=(1./V1(NA)**2-1./DC/V1(NA+1)**2)/(Z1(NA)-Z1(NA+1))             C0NN  16
      BR=(1./V2(NB)**2-1./DC/V1(NA)**2-BZ*(Z2(NB)-Z1(NA)))/(R2-R1)      C0NN  17
      NA=NA+1                                                           C0NN  18
      IADD=1                                                            C0NN  19
      GO TO 40                                                          C0NN  20
   30 RZERO(NTRI)=R1                                                    C0NN  21
      ZZERO(NTRI)=Z1(NA)                                                C0NN  22
      AL(NTRI)=Z1(NA)                                                   C0NN  23
      BL(NTRI)=(Z1(NA)-Z2(NB+1))/(R1-R2)                                C0NN  24
      AA(NTRI)=1./V1(NA)**2                                             C0NN  25
      BZ=(1./V2(NB)**2-1./DC/V2(NB+1)**2)/(Z2(NB)-Z2(NB+1))             C0NN  26
      BR=(1./V1(NA)**2-1./DC/V2(NB)**2-BZ*(Z1(NA)-Z2(NB)))/(R1-R2)      C0NN  27
      NB=NB+1                                                           C0NN  28
      IADD=0                                                            C0NN  29
      GO TO 40                                                          C0NN  30
   40 BB(NTRI)=SIGN(SQRT(BZ**2+BR**2),BZ)                               C0NN  31
      IF(BB(NTRI).EQ.0.) GO TO 41                                       C0NN  32
      SST(NTRI)=BR/BB(NTRI)                                             C0NN  33
      CCT(NTRI)=BZ/BB(NTRI)                                             C0NN  34
      GO TO 42                                                          C0NN  35
   41 CCT(NTRI)=1.                                                      C0NN  36
      SST(NTRI)=0.                                                      C0NN  37
   42 AL(NTRI)=AL(NTRI)-BL(NTRI)*R1                                     C0NN  38
      TANT=SST(NTRI)/AMAX1(CCT(NTRI),1.E-100)                           C0NN  39
      BP(NTRI,2)=(BL(NTRI)-TANT)/(1.-BL(NTRI)*TANT)                     C0NN  40
      R=RL(NTRI+1)                                                      C0NN  41
      IF(NTRI.EQ.1) R=0                                                 C0NN  42
      BP(NTRI,1)=(R-TANT)/(1.+R*TANT)                                   C0NN  43
      AP(NTRI,1)=AP(NTRI,2)=0.                                          C0NN  44
      IF(NA.LT.N1.OR.NB.LT.N2) GO TO 10                                 C0NN  45
      RETURN                                                            C0NN  46
      END                                                               C0NN  47
```

```
OS   CONNECT                                                  06/04/73        ED      0

                                                IDENT     CONNECT
     PROGRAM LENGTH                  00414
     ENTRY POINTS      CONNECT       00003
     BLOCK NAMES
                       PROFIL        00316
                       TRIANG        02261
     EXTERNAL SYMBOLS
                       01C1021J
                       01C0421J
                       OBCDICT,
                       SQRTF
                       MAX1F
```

```
5.4A                                                                    07/25/73

      SUBROUTINE PROFPLOT (RI,N3,INPF)                                  PLOT   1
      COMMON /PROFIL/ R1,N1,Z1(50),V1(50),R2,N2,Z2(50),V2(50),IBOTC,IPFLPLOT   2
      DIMENSION XT(10),X(4),XP(50),Y(50),PLTARRAY(254),ZDEPTH (25PLOT   3
     1E (25),XL(50),YL(400),YP(10)                                      PLOT   4
      COMMON/INPUT/ RBOT(25),ZBOT(25),ZIL(2,50),VIL(2,50),NN(2),ICON(2PLOT   5
     1,50)                                                              PLOT   6
      COMMON /LIMITS/R0(10),DR(10),R02(10)                              PLOT   7
      COMMON /PRO/ IPROP,IKNM,PLTL,RM,IPCO,IFPR                         PLOT   8
      COMMON /TLE/STITLE (10)                                           PLOT   9
      COMMON/ABC/PUNCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1              PLOT  10
      DATA (IPLOT=0),(IST=0),(IFT2=0),(IBH=0),(IJ=0)                    PLOT  11
      IF (IPCO.EQ.1.AND.IPLOT.EQ.0.OR.IST.EQ.1) GO TO 100               PLOT  12
      IF (IPLOT.EQ.1) GO TO 1 $ CALL PLOTS (PLTARRAY,254,3)             PLOT  13
  100 IF (IFT1.EQ.IFT2) GO TO 952  $IBH=0  $ IFT2=IFT1                  PLOT  14
  952 IF (IFT1.EQ.0.AND.IJ.EQ.1.OR.IBH.EQ.1) RETURN                     PLOT  15
      IBH=1  $ IPLOT=1  $ IPCO=1 $IST=0   $ IJ=1                        PLOT  16
      RM= MAX1F(R02(1),R02(2),R02(3),R02(4),R02(5),R02(6),R02(7),R02(8),PLOT  17
     1R02(9),R02(10)) $ IDI=0 $ K=0                                     PLOT  18
   20 K=K+1 $IF (RM.GT.RBOT(K)) 20,21                                   PLOT  19
   21 ZMAX=ZBOT(1)                                                      PLOT  20
      DO22 J=2,K                                                        PLOT  21
   22 ZMAX= MAX1F(ZBOT(J),ZMAX)                                         PLOT  22
      IF (ZMAX.LE.  25.0,AND,ZMAX.GT.   0.0 ) ZMAX=  25.0               PLOT  23
      IF (ZMAX.LE.  500.0,AND,ZMAX.GT. 250.0 ) ZMAX=  500.0             PLOT  24
      IF (ZMAX.LE. 1000.0,AND,ZMAX.GT. 500.0 ) ZMAX= 1000.0             PLOT  25
      IF (ZMAX.LE. 2000.0,AND,ZMAX.GT.1000.0 ) ZMAX= 2000.0             PLOT  26
      IF (ZMAX.LE. 4000.0,AND,ZMAX.GT.2000.0 ) ZMAX= 4000.0             PLOT  27
      IF (ZMAX.LE. 5000.0,AND,ZMAX.GT.4000.0 ) ZMAX= 5000.0             PLOT  28
      IF (ZMAX.LE.10000.0,AND,ZMAX.GT.5000.0 ) ZMAX=10000.0             PLOT  29
      DO 25 J=1,11                                                      PLOT  30
      A=(ZMAX/10.0)*(J-1)                                               PLOT  31
      IF (J.EQ.6) CALL SYMBOL (-1.00,5.0,0.14,9HDEPTH (M),90.0,9)       PLOT  32
      XL(J)=0.0                                                         PLOT  33
      Y(J)=(11-J)                                                       PLOT  34
   25 CALL NUMBER(-0.80,Y(J),0.140,A,0.0,4HF5.0)                        PLOT  35
      CALL LINE (XL,Y,11,1,3,0.10**5,1)                                 PLOT  36
      DO 26 J=1,250                                                     PLOT  37
   26 YL(J)=0.0                                                         PLOT  38
      IF (PLTL.GT.156.0) CALL BYEBYE                                    PLOT  39
      RSCALE=PLTL/RM                                                    PLOT  40
      NTM=AMIN1(PLTL+1.,40.5)                                           PLOT  41
      RT=1.                                                             PLOT  42
      RMAN=RM                                                           PLOT  43
      IF (IKNM.GT.0) RMAN=RM  /1.852                                    PLOT  44
   56 NT=RMAN/RT                                                        PLOT  45
      IF(NT.LE.NTM) GO TO 57                                            PLOT  46
      RT=2.*RT                                                          PLOT  47
      NT=RMAN/RT                                                        PLOT  48
      IF(NT.LE.NTM) GO TO 57                                            PLOT  49
      RT=2.5*RT                                                         PLOT  50
      NT=RMAN/RT                                                        PLOT  51
      IF(NT.LE.NTM) GO TO 57                                            PLOT  52
      RT=2.*RT                                                          PLOT  53
      GO TO 56                                                          PLOT  54
C        PLOT SURFACE AXIS                                              PLOT  55
   57 CALL PLOT(0.,  0.,3)                                              PLOT  56
```

5.4A 07/25/73

```
      XN=0.                                                                  PLOT  57
      RSCALE1=RSCALE                                                         PLOT  58
      IF (IKNM.GT.0) RSCALE1=1.852*RSCALE                                    PLOT  59
      DX=RT*RSCALE1                                                          PLOT  60
      R=0.                                                                   PLOT  61
      IF=0                                                                   PLOT  62
   58 CALL PLOT(XN,0.,2)                                                     PLOT  63
      CALL PLOT(XN,-0.05,2)                                                  PLOT  64
      RK=R                                                                   PLOT  65
      CALL NUMBER(XN-.48,-0.19,1.4E-1,RK,0.,4HF4.0)                          PLOT  66
      IF(R.LT.RMAN/2.) GO TO 59                                              PLOT  67
      IF(IF.EQ.1) GO TO 59                                                   PLOT  68
      IF (IKNM.EQ.0) 4,7                                                     PLOT  69
    7 CALL SYMBOL(XN-0.30,-0.40,0.14,10HRANGE (NM),0.,10)                    PLOT  70
      GO TO 8                                                                PLOT  71
    4 CALL SYMBOL(XN-0.30,-0.40,0.14,10HRANGE (KM),0.,10)                    PLOT  72
    8 CALL SYMBOL (XN-7.20,10.15,0.21,5TITLE,0.,80)                          PLOT  73
      IF=1                                                                   PLOT  74
   59 CALL PLOT(XN,0.,3)                                                     PLOT  75
      IF(R.GE.RMAN) GO TO 60                                                 PLOT  76
      XN=XN+DX                                                               PLOT  77
      R=R+RT                                                                 PLOT  78
      GO TO 58                                                               PLOT  79
   60 IDP=0                                                                  PLOT  80
    1 IF (IFPR.EQ.1) GO TO 5                                                 PLOT  81
      X(3)=(R2/1000.0)*RSCALF                                                PLOT  82
      IF (INPF.EQ.0) X(3)=RI*RSCALE                                          PLOT  83
      X(1)=X(3)+1.5                                                          PLOT  84
      IF (INPF.EQ.1) GO TO  2   $ IF (X(3).GT.PLTL) GO TO 35                 PLOT  85
      DO 15 J=1,N3                                                           PLOT  86
   15 XP(J)=((0.5*VIL(2,J)-735.0)*0.1)+X(3)                                  PLOT  87
      IDI=IDI+1                                                              PLOT  88
      XL(IDI)=X(3)                                                           PLOT  89
      IF (IDI.GE.2) GO TO 50                                                 PLOT  90
      CALL SYMBOL (X(1)+0.02,10.27,0.10,16HVELOCITY (M/SEC),0.0,16)          PLOT  91
      TX=0.5                                                                 PLOT  92
   50 N=2                                                                    PLOT  93
      DO 55 J=1,N                                                            PLOT  94
      XT(J)=X(1)+(J-1)*TX                                                    PLOT  95
      YP(J)=10.02                                                            PLOT  96
      XM=1500.0                                                              PLOT  97
      DX=10.0                                                                PLOT  98
      PL=XM+(J-1)*DX                                                         PLOT  99
      IF (IDI.EQ.1) CALL NUMBER(XT(J)-0.07,10.10,.105,PL,0.0,4HF4.0)         PLOT 100
   55 CONTINUE                                                               PLOT 101
      IF(X(3).LE.PLTL) CALL LINE (XT,YP,N,1,13,0.0,7,1)                      PLOT 102
      IF (INPF.EQ.1) GO TO 2                                                 PLOT 103
      DO 3 I=1,N3 SY(I)=10.0+(1.0-(ZIL(2,I)/ZMAX))                           PLOT 104
    3 IF (Y(I).LT.0.0) Y(I)=0.0                                              PLOT 105
      IF(X(3).LE.PLTL) CALL LINE (XP,Y,N3,1,-2,0,0,0)                        PLOT 106
   35 INPF=1                                                                 PLOT 107
      GO TO 5                                                                PLOT 108
    2 DO 6 I=1,N2 SY(I)=10.0+(1.0-(Z2(I)/ZMAX))                              PLOT 109
    6 IF (Y(I).LT.0.0) Y(I)=0.0                                              PLOT 110
      IDP=IDP+1                                                              PLOT 111
      ZDEPTH(IDP)=Y(N2)                                                      PLOT 112
      XRANGE (IDP)=X(3)                                                      PLOT 113
    5 IF (IFPR.EQ.0) GO TO 30                                                PLOT 114
      CALL LINE (XRANGE,ZDEPTH,IDP,1,1,0.0,0)                                PLOT 115
      CALL LINE (XL,    YL,IDI,  1,3,0.14,0,-1)                              PLOT 116
      CALL PLOTS (0,0)  $  CALL PLOT (PLTL+10.0,0.,-3)  $ IST=1              PLOT 117
   30 RETURN                                                                 PLOT 118
      END                                                                    PLOT 119
```

```
DS  PROFPLOT                                                07/25/73        ED      0

                                                IDENT       PROFPLOT
    PROGRAM LENGTH                  03700
    ENTRY POINTS        PROFPLOT    02503
    BLOCK NAMES
                        PROFIL      00316
                        INPUT       01442
                        LIMITS      00036
                        PRO         00006
                        TLE         00012
                        ABC         00026
    EXTERNAL SYMBOLS
                        Q1Q10100
                        Q8QDICT,
                        PLOTS
                        SYMBOL
                        NUMBER
                        LINE
                        BYEBYE
                        PLOT
                        MIN1F
                        MAX1F
```

5.4A 07/25/73

```
      SUBROUTINE PROFPLIT (RI,N3,INPF)                                          PLOT   1
      COMMON /PROFIL/ R1,N1,Z1(50),V1(50),R2,N2,Z2(50),V2(50),IBOTC,IPFLPLOT   2
      DIMENSION XT(10),X(4),XP(50),Y(50),PLTARRAY(254),ZDEPTH (250),XRANGPLOT   3
     1E (250),XL(50),YL(400),YP(10),XI (100)                                    PLOT   4
      COMMON/INPUT/ RBOT(250),ZBOT(250),ZIL(2,50),VIL(2,50),NN(2),ICON(2PLOT   5
     1,50)                                                                      PLOT   6
      COMMON /LIMITS/R0(10),DR(10),R02(10)                                      PLOT   7
      COMMON /PRO/ IPROF,IKNM,PLTL,RM ,IPC0 ,IFPR                               PLOT   8
      COMMON /TLE/STITLE (10)                                                   PLOT   9
      COMMON/ABC/PUNCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1                      PLOT  10
      DATA (IPLOT=0),(IST=0),(IFT2=0),(IBH=0),(IJ=0)                            PLOT  11
      IF (IPC0.EQ.1.AND.IPLOT.EQ.0.OR.IST.EQ.1) GO TO 100                       PLOT  12
      IF (IPLOT.EQ.1) GO TO 1 $ CALL PLOTS (PLTARRAY,254,3)                     PLOT  13
  100 IF (IFT1.EQ.IFT2) GO TO 952  $IBH=0  $ IFT2=IFT1                         PLOT  14
  952 IF (IFT1.EQ.0.AND.IJ.EQ.1.OR.IBH.EQ.1) RETURN                             PLOT  15
      IBH=1  $ IPLOT=1  $ IPC0=1 $IST=0   $ IJ=1                                PLOT  16
      RM= MAX1F(R02(1),R02(2),R02(3),R02(4),R02(5),R02(6),R02(7),R02(8),PLOT  17
     1R02(9),R02(10)) $ K=0 $IDI=0 $ ITL=0                                      PLOT  18
   20 K=K+1                                                                     PLOT  19
      IF (RM.GT.RBOT(K)) 20,21                                                  PLOT  20
   21 ZMAX=ZBOT(1)                                                              PLOT  21
      DO 22 J=2,K                                                               PLOT  22
   22 ZMAX= MAX1F(ZBOT(J),ZMAX)                                                 PLOT  23
      IF (ZMAX.LE.  250.0,AND,ZMAX.GT.   0.0 ) ZMAX=  250.0                     PLOT  24
      IF (ZMAX.LE.  500.0,AND,ZMAX.GT. 250.0 ) ZMAX=  500.0                     PLOT  25
      IF (ZMAX.LE. 1000.0,AND,ZMAX.GT. 500.0 ) ZMAX= 1000.0                     PLOT  26
      IF (ZMAX.LE. 2000.0,AND,ZMAX.GT.1000.0 ) ZMAX= 2000.0                     PLOT  27
      IF (ZMAX.LE. 4000.0,AND,ZMAX.GT.2000.0 ) ZMAX= 4000.0                     PLOT  28
      IF (ZMAX.LE. 5000.0,AND,ZMAX.GT.4000.0 ) ZMAX= 5000.0                     PLOT  29
      IF (ZMAX.LE.10000.0,AND,ZMAX.GT.5000.0 ) ZMAX=10000.0                     PLOT  30
      DO 25 J=1,11$A=(ZMAX/10.0)*(J-1)                                          PLOT  31
      IF (J.EQ.6) CALL SYMBOL (-1.40,5.0,0.14,9HDEPTH (M),90.0,9)               PLOT  32
      Y(J)=(11-J) $XL(J)=-0.4                                                   PLOT  33
   25 CALL NUMBER(-1.20,Y(J),0.140,A,0.0,4HF5.0)                                PLOT  34
      CALL LINE (XL,Y,11,1,3.0,105,1) $ RSCALE=PLTL/RM $ RJ=RM*RSCALE           PLOT  35
      IF (PLTL.GT.1.56.0) CALL BYEBYE  $ DO 26 J=1,250                          PLOT  36
   26 YL(J)=-0.0525  $  IDP=0                                                   PLOT  37
      CALL SYMBOL       (1.02,10.20,0.10,16HVELOCITY (M/SEC),0.0,16)           PLOT  38
    1 IF (IFPR.EQ.1) GO TO 5  $ X(3)=(R2/1000.0)*RSCALE                         PLOT  39
      X(1)=X(3)*1.0  $ X(2)=-0.94                                               PLOT  40
      X(4)=R2/1000.0                                                            PLOT  41
      IF (IKNM.GT.0) X(4)=X(4)/1.852                                            PLOT  42
      IF (INPF.EQ.0) GO TO 60                                                   PLOT  43
      DO 15 J=1,N2                                                              PLOT  44
   15 XP(J)=V2(J)                                                               PLOT  45
      CALL SCALE (XP,N2,1,0,XM,DX,1,7X)                                         PLOT  46
      DO 30 J=1,N2                                                              PLOT  47
   30 XP(J)=XP(J)+X(1)                                                          PLOT  48
   50 N=1.0/TX+0.50                                                             PLOT  49
      N=N+1                                                                     PLOT  50
      DO 55 J=1,N                                                               PLOT  51
      XT(J)=X(1)+(J-1)*TX                                                       PLOT  52
      YP(J)=10.02                                                               PLOT  53
      PL=XM+(J-1)*DX                                                            PLOT  54
      IF (PL.GE.1600.0.AND.PL.LE.1650.0) PL=PL-1600.0                           PLOT  55
      IF (PL.GE.1500.0.AND.PL.LE.1600.0) PL=PL-1500.0                           PLOT  56
```

```
.4A                                                                    07/25/73

      IF (PL.GE.1400.0.AND.PL.LE.1500.0) PL=PL-1400.0                          PLOT  57
   99 CALL NUMBER (XT(J)-0.07,10.10.0.07,PL,0.0,4HF2.0)                        PLOT  58
      CALL LINE (XT,YP,N,1,13,0.07,1)                                          PLOT  59
      IF (INPF.EQ.1) GO TO 2                                                   PLOT  60
   60 INPF=1                                                                   PLOT  61
      IDI=IDI+1                                                                PLOT  62
      XI(IDI)=X(3)                                                             PLOT  63
      IF (X(3).GE.RJ/4.0.AND.ITL.EQ.0) 35,5                                    PLOT  64
   35 ITL=1                                                                    PLOT  65
      IF (IKNM.EQ.0) CALL SYMBOL (RJ/2.0-0.6,-0.40,0.14,10HRANGE (KM),0.PLOT  66
     10,10)                                                                    PLOT  67
      IF (IKNM.GT.0) CALL SYMBOL (RJ/2.0-0.6,-0.40,0.14,10HRANGE (NM),0.PLOT  68
     10,10)                                                                    PLOT  69
      CALL SYMBOL (RJ/2.0-4.8,10.20,0.14,STITLE,0.0,80)                        PLOT  70
      GO TO 5                                                                  PLOT  71
    2 DO 6 I=1,N2                                                              PLOT  72
      Y(I)=10.0*(1.0-(Z2(I)/ZMAX))  $IF(Y(I).LT.0.0) Y(I)=0.0                  PLOT  73
      XL(I)=X(3)                                                               PLOT  74
    6 CALL NUMBER (X(2)+X(1),Y(I),0.07,Z2(I),0.0,4HF4.0)                       PLOT  75
      CALL LINE (XL,Y,N2,1,3,0.07,1)                                           PLOT  76
      CALL LINE (XP,Y,N2,1,1,0.07,1)                                           PLOT  77
      CALL NUMBER (X(3)-0.30,-0.25,0.105,X(4),0.0,4HF4.0)                      PLOT  78
      IDP=IDP+1                                                                PLOT  79
      ZDEPTH(IDP)=Y(N2)                                                        PLOT  80
      XRANGE (IDP)=X(3)                                                        PLOT  81
      IF (X(3).GE.RJ/4.0.AND.ITL.EQ.0) 45,5                                    PLOT  82
   45 ITL=1                                                                    PLOT  83
      IF (IKNM.EQ.0) CALL SYMBOL (RJ/2.0-0.6,-0.40,0.14,10HRANGE (KM),0.PLOT  84
     10,10)                                                                    PLOT  85
      IF (IKNM.GT.0) CALL SYMBOL (RJ/2.0-0.6,-0.40,0.14,10HRANGE (NM),0.PLOT  86
     10,10)                                                                    PLOT  87
      CALL SYMBOL (RJ/2.0-0.6,10.20,0.14,STITLE,0.0,48)                        PLOT  88
    5 IF (IFPR.EQ.0) GO TO130                                                  PLOT  89
      CALL LINE (XRANGE,ZDEPTH,IDP,1,1,0.0,0)                                  PLOT  90
      CALL LINE (XRANGE,YL,IDP,1,3,0,105,1)                                    PLOT  91
      CALL LINE (XI,YL,IDI,1,3,0.2,1)                                          PLOT  92
      CALL PLOTS (0,0)  $  CALL PLOT (PLTL+10.0,0.0,-3)  $ IST=1               PLOT  93
  130 RETURN                                                                   PLOT  94
      END                                                                      PLOT  95
```

```
5  PREFPLIT                                          07/25/73        ED      0

                                                IDENT     PREFPLIT
 PROGRAM LENGTH                    03745
 ENTRY POINTS      PREFPLIT        02654
 BLOCK NAMES
                   PREFIL          00316
                   INPUT           01442
                   LIMITS          00036
                   PRE             00006
                   TLE             00012
                   ABC             00026
 EXTERNAL SYMBOLS
                   01010100
                   SUBDICT,
                   PLOTS
                   SYMBOL
                   NUMBER
                   LINE
                   BYEBYE
                   SCALE
                   PLOT
                   MAXIF
```

```
5,4A                                                              06/04/73

      SUBROUTINE ADVANCE                                                    ADVA0000
      COMMON /TRIANG/ AP(100,2),BP(100,2),AL(100),BL(100),ZZERO(100),       ADVA0001
     1   RZERO(100),AA(100),BB(100),SST(100),CCT(100),NTRI                  ADVA0002
      COMMON /RAYS/ NRAY,TGAM(1000),ZZ(1000),SS(1000),TIME(1000),           ADVA0003
     1   NCOUNT(1000),PHASE(1000)                                           ADVA0004
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,         ADVA0005
     1   ISOP,IT1,IT2,IT3,IPER,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT              ADVA0006
      COMMON /PIDEF/ PI,DTR,TWOPI                                           ADVA0007
      COMMON /MIRRORS/ SL,BRLT(200),BPST(200)                               ADVA0008
      COMMON/ABC/PUNCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1                  ADVA0009
      DIMENSION RPNEW(4),RNEW(4),ZNEW(4),ZPNEW(4)                           ADVA0010
      LOGICAL ONUP,ONLW                                                     ADVA0011
      TANSUM(A,B)=(A+B)/(1.-A*B)                                            ADVA0012
      DELT(DR,T,S)=ABS(DR)*SQRT(CMIS)*(1.+(T*(T+S)+S*S)/3.)                 ADVA0013
C        LOOP OVER ALL THE RAYS                                             ADVA0014
      DO 100 IRAY=1,NRAY    $ IHIST=0      $ SSR=SS(IRAY)                   ADVA0015
      IF (NBRS.EQ.2500.AND.NSRS.EQ.2500) GO TO 10                           ADVA0016
      NN=NCOUNT(IRAY) $M=NN/ITN $NNEW=M*ITN $NSR=M*NN*ITN $M=NN/ITN $NBR=MADVA0017
   10 IF(ABS(SSR).LT.ALIM.OR.NBR.GT.NBRS.OR.NSR.GT.NSRS) GO TO 100          ADVA0018
      ZR=ZZ(IRAY)   $  RR=RSTART                                            ADVA0019
      TGR=TGAM(IRAY)                                                        ADVA0020
      TRAY=TIME(IRAY)                                                       ADVA0021
       RR=PHASE(IRAY)                                                       ADVA0022
      NCTR=NCOUNT(IRAY)                                                     ADVA0023
      DO 20 I=1,NTRI                                                        ADVA0024
C        FIND CORRECT LAYER                                                 ADVA0025
      P=ZR-AL(I)-BL(I)*RR                                                   ADVA0026
      IF(P+.0001.GT.0.) GO TO 20                                            ADVA0027
      NTRR=I                                                                ADVA0028
      IF(ABS(P).GT..0001.OR.TGR.GT.-BL(I)) GO TO 30                         ADVA0029
   20 CONTINUE                                                              ADVA0030
      GO TO 80                                                              ADVA0031
   30 CT=CCT(NTRR)                                                          ADVA0032
      IF(IPRAY.NE.1) PRINT 666,IRAY,NTRR,ZR,RR,TGR,NCTR                     ADVA0033
      ST=SST(NTRR)                                                          ADVA0034
      Z0=ZZERO(NTRR)                                                        ADVA0035
C        TRANSFORM TO PRIMED COORDINATES                                    ADVA0036
      R0=RZERO(NTRR)                                                        ADVA0037
      ZRP=CT*(ZR-Z0)+ST*(RR-R0)                                             ADVA0038
      RRP=CT*(RR-R0)-ST*(ZR-Z0)                                             ADVA0039
      CIS=AA(NTRR)+BB(NTRR)*ZRP                                             ADVA0040
      TANT=ST/AMAX1(CT,1.E-30)                                              ADVA0041
      TGRP=TANSUM(TANT,-TGR)                                                ADVA0042
      CMIS=CIS/(1.+TGRP**2)                                                 ADVA0043
C        CALCULATE PARABOLIC RAY PATH,  ALPHA IS THE CURVATURE              ADVA0044
      ALPHA=.25*BB(NTRR)/CMIS                                               ADVA0045
      TA=2.*ALPHA                                                           ADVA0046
C        FIND INTERSECTIONS WITH UPPER AND LOWER LAYER BOUNDARIES           ADVA0047
      DO 40 I=1,2                                                           ADVA0048
      APNTR=AP(NTRR,I)                                                      ADVA0049
      BPNTR=BP(NTRR,I)                                                      ADVA0050
      C=APNTR+BPNTR*RRP-ZRP                                                 ADVA0051
      P=BPNTR*TGRP                                                          ADVA0052
      IF(ABS(ALPHA).GT.1.E-25) GO TO 303                                    ADVA0053
C        RAY PATH IS LINEAR FOR THESE STATEMENTS                            ADVA0054
      DRP=-C/P                                                              ADVA0055
```

```
3,4A                                                    06/04/73
          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(P).LT..1*ABS(F)) 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 416
          IDN=0
```

5,4A 06/04/73

```
      RTRY=RMAX                                                          ADVA0112
      DO 415 I=3,4                                                       ADVA0113
      IF(RNEW(I),LT,RR,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
      THAY=THAY+DELT(RPNEW(ITRY)+RRP,TGRP,TGRPN)                         ADVA0130
      TGRN=TANSUM(TGRPN,-TANT)                                           ADVA0131
      RR=RTRY                                                            ADVA0132
      ZR=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+PL                                                         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)*RRLT(N)+S*RRLT(N+1))                               ADVA0158
      PHR=PHR+((1.-S)*RPST(N)+S*RPST(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
```

```
F,4A                                                                    06/04/73

      P=AV*RRP*BV-ZRP                                                          ADVA0168
      P=H/*TGRP                                                                ADVA0169
      IF(ABS(ALPHA),GT,1,E-25) GO TO 501                                       ADVA0170
C        LINEAR RAYS                                                           ADVA0171
      RPNEW(1)=RRP*C/P                                                         ADVA0172
      RPNEW(2)=1,E100                                                          ADVA0173
      GO TO 505                                                                ADVA0174
C        PARABOLIC RAYS                                                        ADVA0175
501   DISC=P**4,*ALPHA*C                                                       ADVA0176
      IF(DISC,LT,0,) GO TO 80                                                  ADVA0177
      DISC=SQRT(DISC)                                                          ADVA0178
      S=1,                                                                     ADVA0179
      DO 503 I=1,2                                                             ADVA0180
      F=P+S*DISC                                                               ADVA0181
      DRP=F/TA                                                                 ADVA0182
      IF(ABS(F),LT,,1*ABS(F)) DRP=(ALPHA*((ALPHA*DRP**2-C)/P)**2-C)/P          ADVA0183
      RPNEW(I)=RRP+DRP                                                         ADVA0184
503   S=-S                                                                     ADVA0185
505   DO 51 I=1,2                                                              ADVA0186
      ZPNEW(I)=ZRP+(RPNEW(I)-RRP)*(TGRP+ALPHA*(RPNEW(I)-RRP))                  ADVA0187
51    ZNEW(I)=CT*ZPNEW(I)+ST*RPNEW(I)+Z0                                       ADVA0188
      I=2                                                                      ADVA0189
C        SELECT CORRECT INTERSECTION                                           ADVA0190
      IF(ABS(ZNEW(1)-ZR),LT,ABS(ZNEW(2)-ZR)) I=1                               ADVA0191
      TGRPN=TA+(RPNEW(I)-RRP)+TGRP                                             ADVA0192
      TRAY=TRAY+DELT(RPNEW(I)-RRP,TGRP,TGRPN)                                  ADVA0193
      TGRN=+TANSUM(TGRPN,+TANT)                                                ADVA0194
C        CHECK FOR TURNOVERS AND TURNUNDERS                                    ADVA0195
52    IF(TGR+TGRN,GE,0,) GO TO 54                                              ADVA0196
      IF(TGR,LT,0,) GO TO 53                                                   ADVA0197
      NCTR=NCTR+1                                                              ADVA0198
      GO TO 54                                                                 ADVA0199
53    NCTR=NCTR+ITN2                                                           ADVA0200
54    TGAM(IRAY)=TGRN                                                          ADVA0201
      IF(NTRR,LE,1) GO TO 545                                                  ADVA0202
C        CHECK THAT RAY IS WITHIN THE PROPER LIMITS                            ADVA0203
      IF(ZNEW(I),LT,AL(NTRR-1)+BL(NTRR-1)*RMAX*,1) GO TO 80                    ADVA0204
545   IF(ZNEW(I),GT,AL(NTRR)+BL(NTRR)*RMAX*,1) GO TO 80                        ADVA0205
C        THROW IN VOLUME ATTENUATION                                           ADVA0206
      IF(IATT,NE,0)SSR=SSR*10,**(*,0001*ATT*(TRAY-TIME(IRAY))/SQRT(CIS))       ADVA0207
55    SS(IRAY)=SSR                                                             ADVA0208
      ZZ(IRAY)=ZNEW(I)                                                         ADVA0209
      TIME(IRAY)=TRAY                                                          ADVA0210
      ACOUNT(IRAY)=NCTR                                                        ADVA0211
      PHASE(IRAY)=PHR                                                          ADVA0212
      GO TO 100                                                                ADVA0213
60    IRIS=60                                                                  ADVA0214
C        WHEN SMALL OR ZERO HORIZONTAL GRADIENTS, EQUATION FOR SECTION         ADVA0215
C        DO IS SINGULAR,  THIS IS AN ITERATIVE SOLUTION FOR SUCH A CASE        ADVA0216
C        GUESS VALUE FOR ITERATION                                             ADVA0217
      ZNW=ZR+TGR*(RMAX-RR)                                                     ADVA0218
66    DO 67 I=1,7                                                              ADVA0219
      RPNW=CT*(RMAX-R0)+ST*(ZNW-Z0)                                            ADVA0220
      DRP=RPNW-RRP                                                             ADVA0221
      TGRPAV=TGRP+ALPHA*DRP                                                    ADVA0222
      DZP=DRP*TGRPAV                                                           ADVA0223
```

```
5,4A                                                    06/04/73

      ZPNW=ZR+DZP                                                    ADVA0224
      ZNW2=CT*ZPNW-ST*RPNW+Z0                                        ADVA0225
      D=ABS(ZNW2-ZNW)                                                ADVA0226
      IF(I.EQ.3) DD=D                                                ADVA0227
47    ZNW=ZNW2                                                       ADVA0228
C        CHECK FOR CONVERGENCE                                       ADVA0229
      IF(D.LT.01) GO TO 68                                           ADVA0230
      IF(D.LT.5*DD) GO TO 66                                         ADVA0231
      IHIST=3                                                        ADVA0232
      GO TO 80                                                       ADVA0233
68    RPNEW(1)=RPNEW(2)=RPNW                                         ADVA0234
      GO TO 505                                                      ADVA0235
C        PRINT ERROR MESSAGE                                         ADVA0236
80    SGR=0.                                                         ADVA0237
      PRINT 81,IRAY,IHIST,RR,ZR,TGR                                  ADVA0238
      PRINT 82, RMAX,ZNEW(1),TGRN                                    ADVA0239
666   FORMAT(* RAY*,I5,* IN LAYER*,I5,* Z= ,F10.2,* R=*,F10.2,* TGR=*,FADVA0240
     1   10.5,*  NCTR= *,G16)                                        ADVA0241
81    FORMAT(* RAY *,I5,* TERMINATED*,5X,*IHIST=*,I2,5X,*STARTING RANGE=ADVA0242
     1*,F12.2,5X,*RAY DEPTH=*,F12.2,5X,*STARTING TANGENT=*,F12.6)    ADVA0243
82    FORMAT(5X,*MAXIMUM RANGE=*,F12.2,5X,*NEW RAY DEPTH=*,F10.2,5X,*FINADVA0244
     1AL TANGENT=*,F12.6)                                           ADVA0245
      GO TO 55                                                       ADVA0246
100   CONTINUE                                                       ADVA0247
      RETURN                                                         ADVA0248
      END                                                            ADVA0249
```

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

                                          IDENT      ADVANCE
     PROGRAM LENGTH                 01720
     ENTRY POINTS      ADVANCE      00125
     BLOCK NAMES
                       TRIANG       02261
                       RAYS         13561
                       INF6         00024
                       PIDEF        00003
                       MIRRORS      00021
                       ABC          00026
     EXTERNAL SYMBOLS
                       THEAD,
                       Q3C10140
                       Q3C00040
                       Q1C10100
                       Q1C03100
                       Q2C07111
                       Q8QDICT,
                       SQRTF
                       MAX1F
                       STH,
                       ONSINGL,
```

```
,4A                                                                  06/04/73

      SUBROUTINE CHANNEL(ZR,T,ZTG,ZTU)                                CHAN0000
      COMMON /VELPRF/ N,Z(100),C(100)                                 CHAN0001
      CALL VELCALC                                                    CHAN0002
   20 DO 25 I=2,N                                                     CHAN0003
      IF(ZR.GT.Z(I)) GO TO 25                                         CHAN0004
      IZ=I                                                            CHAN0005
      F=(ZR-Z(I-1))/(Z(I)-Z(I-1))                                     CHAN0006
      CM=SQRT(1.-T*T)*(F*C(I)+(1.-F)*C(I-1))                          CHAN0007
      GO TO 30                                                        CHAN0008
   25 CONTINUE                                                        CHAN0009
      ZTU=ZTG=1.                                                      CHAN0010
      RETURN                                                          CHAN0011
   30 IN=IZ-1                                                         CHAN0012
   31 IF(C(IN),GT,CM) GO TO 35                                        CHAN0013
      IN=IN-1                                                         CHAN0014
      IF(IN,NE,0) GO TO 31                                            CHAN0015
      ZTG=0.                                                          CHAN0016
      GO TO 40                                                        CHAN0017
   35 F=(CM-C(IN-1))/(C(IN)-C(IN-1))                                  CHAN0018
      ZTG=F*Z(IN)+(1.-F)*Z(IN-1)                                      CHAN0019
   40 IN=IZ                                                           CHAN0020
   41 IF(C(IN),GT,CM) GO TO 45                                        CHAN0021
      IN=IN+1                                                         CHAN0022
      IF(IN,LE,N) GO TO 41                                            CHAN0023
      ZTU=Z(N)                                                        CHAN0024
      RETURN                                                          CHAN0025
   45 F=(CM-C(IN-1))/(C(IN)-C(IN-1))                                  CHAN0026
      ZTU=F*Z(IN)+(1.-F)*Z(IN-1)                                      CHAN0027
      RETURN                                                          CHAN0028
      ENTRY RCALC                                                     CHAN0029
      IF(ZTG.GT.-.9) GO TO 50                                         CHAN0030
      RCYCLE=1.E30                                                    CHAN0031
      RETURN                                                          CHAN0032
   50 IN=1                                                            CHAN0033
      RCYCLE=0.                                                       CHAN0034
      TG2=0.                                                          CHAN0035
      DO 60 I=1,N                                                     CHAN0036
      IF(Z(I),GT,ZTG,AND,Z(I),LT,ZTU) GO TO 55                        CHAN0037
      IF(IN,EQ,1) GO TO 60                                            CHAN0038
      RCYCLE=RCYCLE+(ZTU-Z(I-1))/(.5*TG1)                             CHAN0039
      RETURN                                                          CHAN0040
   55 TG1=SQRT((CM/C(I))**2-1.)                                       CHAN0041
      IF(I,EQ,1) GO TO 59                                             CHAN0042
      IF(IN,EQ,1) GO TO 56                                            CHAN0043
      DR=(Z(I)-Z(I-1))/(.5*(TG1+TG2))                                 CHAN0044
      GO TO 57                                                        CHAN0045
   56 DR=(Z(I)-ZTG)/(.5*TG1)                                          CHAN0046
   57 RCYCLE=RCYCLE+DR                                                CHAN0047
   59 TG2=TG1                                                         CHAN0048
      IN=2                                                            CHAN0049
   60 CONTINUE                                                        CHAN0050
      RETURN                                                          CHAN0051
      ENTRY WUENS                                                     CHAN0052
      IF(RCYCLE,GT,1.E100) GO TO 71                                   CHAN0053
      IN=IZ                                                           CHAN0054
   65 IF(Z(IN),GT,ZR) GO TO 70                                        CHAN0055
```

```
,4A                                                                    06/04/73

      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
```

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

                                        ICENT      CHANNEL
   PROGRAM LENGTH                 00506
   ENTRY POINTS    CHANNEL        00003
                   RCALC          00191
                   WDENS          00257
   BLOCK NAMES
                   VELPRF         00311
   EXTERNAL SYMBOLS
                   OBODICT,
                   VELCALC
                   SQRTF
```

```
5,4A                                                    06/04/73

      SUBROUTINE VELCALC                                                VELC   1
      COMMON /INFO/ DDDUE,RMAX,DCDCDD(18)                               VELC   2
      COMMON /VELPRF/ N,Z(100),C(100)                                   VELC   3
      COMMON /THIANG/ AP(100,2),BP(100,2),AL(100),BL(100),ZZERO(100),   VELC   4
     1   RZERO(100),AA(100),BB(100),SST(100),CCT(100),NTRI              VELC   5
      COMMON/ABC/PUNCHDD (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1              VELC   6
      DATA (RELD=-1,E300),(IFT2=0),(IBH=0)                              VELC   7
      IF (IFT1,EQ,IFT2) GO TO 13                                        VELC   8
      IBH=0                                                             VELC   9
      IFT2=IFT1                                                         VELC  10
   13 IF (IFT1,EQ,0,OR,IBH,EC,1) GO TO 3                                VELC  11
      RELD=+1,E300                                                      VELC  12
      IBH=1                                                             VELC  13
    3 IF(ABS(RMAX-RELD),LT,1,) GO TO 20                                 VELC  14
      RELD=RMAX                                                         VELC  15
      N=NTRI+1                                                          VELC  16
      DO 10 I=1,N                                                       VELC  17
      IF(I,EQ,1) GO TO 1                                                VELC  18
      J=I-1                                                             VELC  19
      ZZ=AL(J)+BL(J)*RMAX                                               VELC  20
      GO TO 2                                                           VELC  21
    1  J=1                                                             VELC  22
      ZZ=0,                                                             VELC  23
    2 ZP=CCT(J)*(ZZ-ZZERO(J))+SST(J)*(RMAX-RZERO(J))                    VELC  24
      C(I)=1,/SQRT(AA(J)+BB(J)*ZP)                                      VELC  25
   10 Z(I)=ZZ                                                           VELC  26
   20 RETURN                                                            VELC  27
      END                                                               VELC  28
```

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

                                                ICENT      VELCALC
     PROGRAM LENGTH                  00132
     ENTRY POINTS    VELCALC         00006
     BLOCK NAMES
                     INFO            00024
                     VELPRF          00311
                     TRIANG          02261
                     ABC             00026
     EXTERNAL SYMBOLS
                     QBGDICT,
                     SQRTF
```

```
FTN5,4A                                                    01/02/75

      SUBROUTINE INTENSTY                                                INTE   1
C        JUNE 14, 1971 LLOYDS MIRROR ADDED FOR ALL RECEIVERS AND TYPES   INTE   2
C        UNUSED SWITCH IFTIMS IS NOW LLMR, 0 FOR NO LLOYDS MIRROR, AND   INTE   3
C        NON-ZERO FOR LLOYDS MIRROR.  THIS SWITCH IS THE COLUMN AFTER    INTE   4
C        IPER ON THE INPUT CARDS                                         INTE   5
C        6/15/71 RECEIVERS BELOW BOTTOM FIXED                            INTE   6
      COMMON /LOUDNESS/ LNRC,RCD(100),TYPEISC(100),TYPEIRP(100),         INTE   7
     1   TYPEII(100),TYPEIII(100)                                        INTE   8
      COMMON /TLE/STITLE(18)                                             INTE   9
      COMMON /RAYS/ NRAY,TGAM(1000),ZZ(1000),SS(1000),TIME(1000),        INTE  10
     1   NCOUNT(1000),PHASE(1000)                                        INTE  11
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,      INTE  12
     1   ISCP,IT1,IT2,IT3,IPER, LLMR ,LTRT,LTER,LTRP,LPIN,IATT           INTE  13
      COMMON /PIDEF/ PI,DTR,TWOPI                                        INTE  14
      COMMON /VELPRF/ NN,Z4(100),C(100)                                  INTE  15
      COMMON /TMPSTR/ DUD(102)                                           INTE  16
      DIMENSION QUAD(100),INP(100),SINT(100,4),SSL(100),QUS(100),TYPS(10INTE  17
     10)                                                                 INTE  18
      EQUIVALENCE (QUAD,DUD)                                             INTE  19
      COMMON/ABC/PUNCHDUB(18),INCR,NBRS,NSRS,ALIM,IFT,IFT1               INTE  20
      DATA (IENT=0),(IFT2=0),(IBH=0),(IHP=0)                             INTE  21
      SEC(T)=FVA*SQRT(1.+T*T)                                            INTE  22
      IF (IFT1.EQ.IFT2) GO TO 2 $ IBH=0 $ IFT2=IFT1                      INTE  23
    2 IF (IFT1.EQ.0.OR.IBH.EQ.1) GO TO 3 $ IENT=0 $ IBH=1                INTE  24
    3 FVA=1.                                                             INTE  25
      IF(IATT.EQ.0.AND.ATT.NE.0.) FVA=10.**(-.0001*ATT*RMAX)             INTE  26
      CALL VELCALC $WAVEL=TWOPI*C(1)/OMEGA $AK=TWOPI/WAVEL  $ FLM=1.     INTE  27
      DO 5 I=1,LNRC                                                      INTE  28
    5 TYPEISC(I)=TYPEIRP(I)=TYPEII(I)=TYPEIII(I)=QUAD(I)=0.              INTE  29
      IF(IT1.EQ.0.AND.IT2.EQ.0) GO TO 60                                 INTE  30
      SW=0.                                                              INTE  31
      SDZ=0.                                                             INTE  32
      DO 10 I=2,NRAY                                                     INTE  33
      W=AMIN1(SS(I),SS(I-1))                                             INTE  34
      SDZ=SDZ+W*ABS(ZZ(I)-ZZ(I-1))                                       INTE  35
   10 SW=SW+W                                                            INTE  36
      DZBAR=SDZ/SW                                                       INTE  37
      IF(DZBAR.LT.WAVEL) DZBAR=WAVEL                                     INTE  38
      CALL CHANNEL(1.,1000.,ZS,ZB)                                       INTE  39
      DZM=ZB/SQRT(FLOAT(NRAY))                                           INTE  40
      IF(DZBAR.GT.DZM) DZBAR=DZM                                         INTE  41
      IF(IT.EQ.0) GO TO 25                                               INTE  42
      DO 20 I=1,NRAY                                                     INTE  43
      N=NCOUNT(I)                                                        INTE  44
      M=N/ITN                                                            INTE  45
      NTO=N-M*ITN                                                        INTE  46
      N=M/ITN                                                            INTE  47
      NSR=M-N*ITN                                                        INTE  48
      M=N/ITN                                                            INTE  49
      NTU=N-M*ITN                                                        INTE  50
      NBR=M                                                              INTE  51
      IF(I.EQ.1) GO TO 19                                                INTE  52
      NDTUO=IABS(NTO-NTOO)+IABS(NTU-NTUO)                                INTE  53
      NDSBR=IABS(NSR-NSRO)+IABS(NBR-NBRO)                                INTE  54
      ID=NDSBR                                                           INTE  55
      ID=ID+NDTUO                                                        INTE  56
```

```
FTN5,4A                                                    01/02/75

      IF(ID.GT.3) ID=3                                                  INTE  57
      W=AMIN1(SS(I),SS(I-1))                                            INTE  58
      IF(W.LE.ALIM.OR.NBR.GT.NBRS.OR.NSR.GT.NSRS) ID=3                  INTE  59
      NCOUNT(I)=NCOUNT(I)+ID*IBIG                                       INTE  60
   19 NSRO=NSR                                                          INTE  61
      NBRO=NBR                                                          INTE  62
      NTUO=NTU                                                          INTE  63
      NTOO=NTO                                                          INTE  64
   20 CONTINUE      $ DO 21 I=1,LNRC                                     INTE  65
      SSL(I)=0.0                                                        INTE  66
      QUS(I)=0.0                                                        INTE  67
      TYPS(I)=0.0                                                       INTE  68
   21 IHP(I)=0  $  IPR=0                                                INTE  69
      INW=NCOUNT(2)/IBIG                                                INTE  70
      DO 30 I=2,NRAY                                                    INTE  71
      NCOUNT(I)=NCOUNT(I)-INW*IBIG                                      INTE  72
      INXT=NCOUNT(I+1)/IBIG  $ IF(I+2.LE.NRAY) INXTT=NCOUNT(I+2)/IBIG   INTE  73
      IF(INW.GE.2) GO TO 29                                             INTE  74
      IQ1=0 $ IQ2=0 $ IQ3=0                                             INTE  75
      Z1=ZZ(I-1)                                                        INTE  76
      S1=SEC(TGAM(I-1))*SS(I-1)                                         INTE  77
      DS=SEC(TGAM(I))*SS(I)-S1                                          INTE  78
      T1=TIME(I-1)                                                      INTE  79
      DT=TIME(I)-T1                                                     INTE  80
      TG1=TGAM(I-1)                                                     INTE  81
      DTG=TGAM(I)-TG1                                                   INTE  82
      DZ=ZZ(I)-Z1  $ DO 25 J=1,LNRC $ IQ1=0 $ IQ2=0 $ IQ3=0            INTE  83
      ZR=RCD(J) $ IF(ZR.GT.38) GO TO 25                                 INTE  84
      F=(ZR-Z1)/DZ  $ DZ1=ZZ(I+1)-ZZ(I)  $  F1=(ZR-ZZ(I))/DZ1           INTE  85
      IF(F.LT.-0.5.OR.F.GT.1.5) GO TO 25                                INTE  86
      IF (INW.EQ.0.AND.F.LE.1.0.AND.F.GE.0..AND.IHP(J).EQ.0) 23,24      INTE  87
   23 IQ1=1                                                             INTE  88
      GO TO 26                                                          INTE  89
   24 IF (F.GT.1.0.AND.INW.EQ.0  .AND.INXT.NE.INW.AND.IHP(J).EQ.0)31,32 INTE  90
   31 IQ2=1                                                             INTE  91
      GO TO 26                                                          INTE  92
   32 IF (F.LT.0.0.AND.IPR.NE.INW.AND.INW.EQ.0)     33,34               INTE  93
   33 IQ3=1                                                             INTE  94
      GO TO 26                                                          INTE  95
   34 IQ1=0 $IQ2=0 $IQ3=0                                               INTE  96
      GO TO 25                                                          INTE  97
   26 SL=(S1+F*DS)/(RMAX*ABS(DZ))                                       INTE  98
      IF (SL.LE.0.0) GO TO 25$ IF (ABSF(DZ).LT.0.001) GO TO 25          INTE  99
      TG=TG1+F*DTG       $  IF (IQ1.EQ.1) IHP(J)=1                      INTE 100
      TH=DTR*ATANF(TG) $ IF(INW.GE.1.AND.INXT.GE.1) GO TO 25            INTE 101
      IF(LLMR.NE.0) FLM=2.*SIN(ZR*AK*TG/SQRT(1.+TG**2))**.              INTE 102
      T=T1+F*DT                                                         INTE 103
      IF (IQ1.EQ.1.AND.SINT(J,1).EQ.0.0) SINT(J,4)=FLM                  INTE 104
      IF (IQ1.EQ.1.AND.SINT(J,1).EQ.0.0) SINT(J,1)=SL                   INTE 105
      IF (IQ2.EQ.1.AND.SINT(J,1).EQ.0.0.AND.SINT(J,2).EQ.0.0.AND.SINT(J,INTE 106
     13).EQ.0.0) SINT(J,4)=FLM                                          INTE 107
      IF (IQ2.EQ.1.AND.SINT(J,1).EQ.0.0.AND.SINT(J,2).EQ.0.0.AND.SINT(J,INTE 108
     13).EQ.0.0) SINT(J,2)=SL                                           INTE 109
      IF (IQ3.EQ.1.AND.SINT(J,1).EQ.0.0.AND.SINT(J,2).EQ.0.0.AND.SINT(J,INTE 110
     13).EQ.0.0) SINT(J,4)=FLM                                          INTE 111
      IF (IQ3.EQ.1.AND.SINT(J,1).EQ.0.0.AND.SINT(J,2).EQ.0.0.AND.SINT(J,INTE 112
```

FTN5.4A 01/02/75

```
      13).EQ.0.0) SINT(J,3)=SL                                          INTE 113
       IF(IPER.EQ.0) GO TO 22                                           INTE 114
       IF (IENT.EQ.0) WRITE(LTER,1099),STITLE                           INTE 115
       IF (IENT.EQ.0) WRITE( 49,1879),STITLE                            INTE 116
 1879 FORMAT (10A8)                                                     INTE 117
 1099 FORMAT (1H1,* EIGENRAY SET      *,10A8/                           INTE 118
       IF(IENT.EQ.0) WRITE(LTER,899)                                    INTE 119
       PR=10.*ALOG10(SL)                                                INTE 120
       N=NCOUNT(I)                                                      INTE 121
       IENT=1                                                           INTE 122
       M=N/ITN                                                          INTE 123
       NTO=N-4*ITN                                                      INTE 124
       N=M/ITN                                                          INTE 125
       NSR=M-N*ITN                                                      INTE 126
       M=N/ITN                                                          INTE 127
       NTU=N-4*ITN                                                      INTE 128
       NBR=M                                                            INTE 129
       IF (IQ3.EQ.1) IQUAL=3                                            INTE 130
       IF (IQ2.EQ.1) IQUAL=2                                            INTE 131
       IF (IQ1.EQ.1) IQUAL=1                                            INTE 132
       IREM=2                                                           INTE 133
       IF (IQ3.EQ.1.AND.SINT(J,3).NE.0.0) IREM=2H*                      INTE 134
       IF (SINT(J,3).NE.0.0.AND.IQ1.EQ.1) IREM=2H**                     INTE 135
       WRITE(LTER,900) I,NBR,NTU,NSR,NTO,RMAX,ZR,TH,T,PR,IQUAL,IREM     INTE 136
       RMKM=RMAX/1000.0                                                 INTE 137
       WRITE(49,1878 ) I,NBR,NTU,NSR,NTO,RMKM,ZR,TH,T,PR                INTE 138
 1878 FORMAT (5I5,F10.4,F10.4,F10.4,F15.5,F10.1)                        INTE 139
  899  FORMAT(*0NRAY  NBR  NTU  NSR  NTO*,10X,*RANGE      DEPTH      THETA INTE 140
     1    TIME*, 9X,*SL(DB)*,5X,*IQUAL*,4X,*REM*)                      INTE 141
  900  FORMAT(5I5,F15.0,F10.4,F10.4,F13.5,F10.1,6X,I5,5X,A2)            INTE 142
   22 FLM=SINT(J,4)                                                     INTE 143
       IF (SINT(J,1).NE.0.) SL=SINT(J,1)                                INTE 144
       IF (SINT(J,2).NE.0..AND.SINT(J,1).EQ.0.0) SL=SINT(J,2)           INTE 145
       IF (SINT(J,3).NE.0..AND.SINT(J,1).EQ.0.0) SL=SINT(J,3)           INTE 146
       IF (SINT(J,3).EQ.0.0) GO TO 27                                   INTE 147
       IF (IQ1.EQ.1.AND.SINT(J,1).NE.0.0) 71,72                         INTE 148
   71 TYPEIRP(J)=SSL(J)                                                 INTE 149
       IF (ISCP.EQ.0) GO TO 27                                          INTE 150
       TYPEISC(J)=TYPS(J)                                               INTE 151
       QUAD(J)=QUS(J)                                                   INTE 152
       GO TO 27                                                         INTE 153
   72 SSL(J)=TYPEIRP(J)                                                 INTE 154
   27 TYPEIRP(J)=TYPEIRP(J)+SL*FLM                                      INTE 155
       IF(ISCP.EQ.0) GO TO 29                                           INTE 156
       PR=SQRT(SL)                                                      INTE 157
       P=OMEGA*T+PHASE(I)                                               INTE 158
       IF (IQ3.EQ.1.AND.IQ1.EQ.0) QUS(J)=QUAD(J)                        INTE 159
       QUAD(J)=QUAD(J)+PR*SIN(P)                                        INTE 160
       IF (IQ3.EQ.1.AND.IQ1.EQ.0) TYPS(J)=TYPEISC(J)                    INTE 161
       TYPEISC(J)=TYPEISC(J)+PR*COS(P)                                  INTE 162
   25  IF (INXT.GE.1.OR.IPR.NE.INW.AND.INW.NE.INAT)IHP(J)=0             INTE 163
   29  IPR=INW                                                          INTE 164
       INW=INXT                                                         INTE 165
       IF (INW.EQ.0.OR.INW.LT.1.AND.INXTT.LT.1) GO TO 30                INTE 166
       DO 28 LL=1,LNRC                                                  INTE 167
       SINT(LL,1)=0.0                                                   INTE 168
```

FTN5.4A 01/02/75

```
      SINT(LL,2)=0.0                                                    INTE 169
      SINT(LL,3)=0.0                                                    INTE 170
      SINT(LL,4)=0.0                                                    INTE 171
   28 CONTINUE                                                          INTE 172
   30 CONTINUE                                                          INTE 173
   35 DO 37 I=1,LNRC                                                    INTE 174
      TYPEISC(I)=TYPEISC(I)*2.*QUAD(I)**2                               INTE 175
   37 QUAD(I)=EXP(-RCD(I)/DZBAR)                                        INTE 176
      IF(IT2.EQ.0) GO TO 60                                             INTE 177
      F=2.*RMAX*DZBAR                                                   INTE 178
      EB=EXP(-ZB/DZBAR)                                                 INTE 179
      DO 50 I=1,NRAY                                                    INTE 180
      IF(ABS(SS(I)).LT.ALEMI   GO TO 50                                 INTE 181
      EZ=EXP(-ZZ(I)/DZBAR)                                              INTE 182
      SL=SEC(TGAM(I),*SS(I)/F                                           INTE 183
      SGK=TGAM(I)*AK/SQRT(1.+TGAM(I)**2)                                INTE 184
      SL=SL/(1.-.5*(EB/EZ+EZ))                                          INTE 185
      DO 40 J=1,LNRC                                                    INTE 186
      IF(RCD(J).GT.ZB) GO TO 50                                         INTE 187
      ER=QUAD(J)                                                        INTE 188
      IF(LLMR.NE.0) FLM=2.*SIN(RCD(J)*SGK)**2                           INTE 189
      IF(ER.GT.EZ) GO TO 39                                             INTE 190
      S=SL*ER/EZ                                                        INTE 191
      GO TO 40                                                          INTE 192
   39 S=SL*EZ/ER                                                        INTE 193
   40 TYPEII(J)=TYPEII(J)+S*FLM                                         INTE 194
   50 CONTINUE                                                          INTE 195
   60 IF(IT3.EQ.0) RETURN                                               INTE 196
      DO 70 I=1,NRAY                                                    INTE 197
      CALL CHANNEL(ZZ(I),TGAM(I),ZTO,ZTU)                               INTE 198
      CALL RCALC                                                        INTE 199
      IF(LLMR.NE.0) CALL WDENS(ZZ(I),CTRR)                              INTE 200
      SL=FVA*SS(I)/RMAX                                                 INTE 201
      DO 65 J=1,LNRC                                                    INTE 202
      IF(RCD(J).GT.ZTU) GO TO 70                                        INTE 203
      IF(RCD(J).LT.ZTO) GO TO 65                                        INTE 204
      CALL WDENS(RCD(J),S)                                              INTE 205
      IF(LLMR.EQ.0) GO TO 64                                            INTE 206
      TG=TGAM(I)*CTRR/S                                                 INTE 207
      FLM=2.*SIN(AK*RCD(J)*TG/SQRT(1.+TG**2))**2                        INTE 208
      S=S*FLM                                                           INTE 209
   64 TYPEIII(J)=TYPEIII(J)+S*SL                                        INTE 210
   65 CONTINUE                                                          INTE 211
   70 CONTINUE                                                          INTE 212
      RETURN                                                            INTE 213
      END                                                               INTE 214
```

```
5.4OS  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)                                                ITNP   1
      COMMON /INFO/ RSTART,RMAX,RMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,             ITNP   2
     1   ISCP,IT1,IT2,IT3,IPER,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT                  ITNP   3
      COMMON /TMPSTR/ DUE(182)                                                  ITNP   4
      COMMON/LIMITS/ R1 (10), DR (10), R2 (10)                                  ITNP   5
      COMMON/ABC/PUNCHDB (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1                      ITNP   6
      COMMON /TLE/STITLE (10)                                                   ITNP   7
      DATA(INCR=1)                                                              ITNP   8
      DIMENSION LINE(90),DB(4),FMT(6),AAL(400),IS(4),ABDDD(182)                 ITNP   9
      EQUIVALENCE (LINE,DUE)                                                    ITNP  10
      COMMON /LOUDNESS/ LNRC,RCD(100),AL(100,4)                                 ITNP  11
      EQUIVALENCE (AL,AAL)                                                      ITNP  12
      DATA (HA6=3HA7,),(HF6=5HF7.1,),(B=1H ),(IS=1HS,1HR,1H2,1H3)               ITNP  13
      DATA (FMT(1)=6H(F8.3,),(FMT(6)=8H6X,90A1))                                ITNP  14
      DIMENSION ITT(4)                                                          ITNP  15
      EQUIVALENCE (ISCP,ITT)                                                    ITNP  16
      DATA (IENT=0),(IFT2=0),(IBH=0)                                            ITNP  17
      IF (IFT1.EQ.IFT2) GO TO 3 $ IBH=0 $ IFT2=IFT1                             ITNP  18
    3 IF (IFT1.EQ.0.OR.IEH.EQ.1) GO TO 2  $ INCR=1 $ IENT=0 $ HA6=3HA7,         ITNP  19
      HF6=5HF7.1,  $ B=1H  $IS(1)=1HS $ IS(2)=1HR $ IS(3)=1H2 $IS(4)=1H3        ITNP  20
      FMT(1)=6H(F8.3, $ FMT(6)=8H6X,90A1)     $ IBH=1                           ITNP  21
    2 IF(NINT.EQ.1) GO TO 40  $ AM=0, $ DO 10 I=1,400                           ITNP  22
      IF(AAL(I).GT.AM) AM=AAL(I)                                                ITNP  23
   10 CONTINUE $ DBM=10.*AINT(ALOG10(AM))    $ DBL=DBM-90.                     ITNP  24
      RK=.001*RMAX                                                              ITNP  25
      ISK=0                                                                     ITNP  26
      IF (IENT.EQ.0) WRITE (39,1) STITLE                                        ITNP  27
      IF(LNRC.GE.35) ISK=1                                                      ITNP  28
      WRITE (39,900),ISK,RK,DBL,DBM                                             ITNP  29
      DO 30 I=1,LNRC                                                            ITNP  30
      DO 15 J=1,90                                                              ITNP  31
   15 LINE(J)=1H                                                                ITNP  32
      DO 25 J=1,4                                                               ITNP  33
      IF(AL(I,J).LT.ALIM)    GO TO 20                                           ITNP  34
      FMT(J+1)=HF6                                                              ITNP  35
      DB(J)=10.*ALOG10(AL(I,J))                                                 ITNP  36
      IL=(DB(J)-DBL)+1.5                                                        ITNP  37
      IF(IL.LE.0.OR.IL.GT.90) GO TO 25                                          ITNP  38
      LINE(IL)=IS(J)                                                            ITNP  39
      GO TO 25                                                                  ITNP  40
   20 FMT(J+1)=HA6                                                              ITNP  41
      DB(J)=B                                                                   ITNP  42
   25 CONTINUE                                                                  ITNP  43
   30 WRITE (39,FMT) RCD(I),DB,LINE   $ IENT=1                                  ITNP  44
      RETURN                                                                    ITNP  45
   40 IF(IENT.NE.0) GO TO 41                                                    ITNP  46
      WRITE(39,1),STITLE                                                        ITNP  47
    1 FORMAT (1H1,10A8)                                                         ITNP  48
      WRITE (36,920),STITLE,LNRC,ITT(1),ITT(2),ITT(3),ITT(4)                    ITNP  49
      IF (IENT.EQ.0) WRITE (35,941) STITLE,(RCD(J),J=1,19)                      ITNP  50
  941 FORMAT (10A8,/,(10F8.3))                                                  ITNP  51
      IF (IENT.EQ.0.AND.ITT(1).GT.0) WRITE (45,912) ,STITLE                     ITNP  52
  912 FORMAT (* COHERENT PHASE VALLES*,/,10A8)                                  ITNP  53
      IF (IENT.EQ.0.AND.ITT(2).GT.0) WRITE (46,913),STITLE                      ITNP  54
  913 FORMAT (* RANDOM PHASE VALLES*,/,10A8)                                    ITNP  55
      IF (IENT.EQ.0.AND.ITT(3).GT.0) WRITE (47,914),STITLE                      ITNP  56
```

```
,4A                                                                    06/04/73

  914 FORMAT (* TYPE 2 VALLES*,/,10A8)                                          ITNP  57
      IF (IENT.EQ.0.AND.ITT(4).GT.0) WRITE (48,915) ,STITLE                     ITNP  58
  915 FORMAT (* TYPE 3 VALLES*,/,10A8)                                          ITNP  59
      IENT=1                                                                    ITNP  60
      WRITE(39,905) (RCD(I),I=1,LNRC)                                           ITNP  61
      WRITE (39,908)                                                            ITNP  62
  900 FORMAT(11*INTENSITIES AT*,F10.3,* KM, */*0  DEPTH    ISC     IRP        ITNP  63
     1  II    III     *,F8.1,84X,F8.1)                                         ITNP  64
  905 FORMAT(*0RECEIVED INTENSITY VS RANGE*,15X,*AT DEPTHS*/                    ITNP  65
     1   *0   R(KM)    TYPE  *,13F9.3,/,19X,13F9.3)                           ITNP  66
  908 FORMAT(1X)                                                                ITNP  67
   41 RK=RMAX/1000.                                                             ITNP  68
      IP=0                                                                      ITNP  69
      DO 50 I=1,4                                                               ITNP  70
      IF(ITT(I).EQ.0) GO TO 50                                                  ITNP  71
      DO 45 J=1,LNRC                                                            ITNP  72
      DLD(J)=                    10.*ALOG10(AMAX1(ALIM  ,AL(J,I)))              ITNP  73
      PUNCHDB(INCH)=ABSF(DLD(J))                                                ITNP  74
      ABDDD(J)=PUNCHDB(INCH)                                                    ITNP  75
      INCH=INCH+1                                                               ITNP  76
      IF  (INCH.LT.17) GO TO 45                                                 ITNP  77
      INCH=1                                                                    ITNP  78
      WRITE (36,909) (PUNCHDE(II),II=1,16)                                      ITNP  79
   45 CONTINUE                                                                  ITNP  80
      IF (I.EQ.1.AND.ITT(1).GT.0) WRITE (45,911) (ABDDD(J),J=1,19)              ITNP  81
      IF (I.EQ.2.AND.ITT(2).GT.0) WRITE (46,911) (ABDDD(J),J=1,19)              ITNP  82
      IF (I.EQ.3.AND.ITT(3).GT.0) WRITE (47,911) (ABDDD(J),J=1,19)              ITNP  83
      IF (I.EQ.4.AND.ITT(4).GT.0) WRITE (48,911) (ABDDD(J),J=1,19)              ITNP  84
      IF(IP.EQ.0) GO TO 46                                                      ITNP  85
      WRITE (39,906) IS(I),(DDD(J),J=1,LNRC)                                    ITNP  86
  906 FORMAT(16X,A1,2X,13F9.1,/,19X,13F9.1)                                     ITNP  87
      GO TO 50                                                                  ITNP  88
   46 IP=1                                                                      ITNP  89
      WRITE(39,907) RK,IS(I),(DDD(J),J=1,LNRC)                                  ITNP  90
  907 FORMAT(F9.3,7X,A1,2X,13F9.1,/,19X,13F9.1)                                 ITNP  91
   50 CONTINUE                                                                  ITNP  92
  909 FORMAT( 16F5.1)                                                           ITNP  93
  911 FORMAT (10F8.3)                                                           ITNP  94
  920 FORMAT (10A8,/,5I5)                                                       ITNP  95
      RETURN                                                                    ITNP  96
      END                                                                       ITNP  97
```

```
$  ITNPRINT                                                    06/04/73        ED      0

                                                 IDENT      ITNPRINT
   PROGRAM LENGTH                    01560
   ENTRY POINTS      ITNPRINT        00911
   BLOCK NAMES
                     INFO            00024
                     TMPSTR          00266
                     LIMITS          00096
                     ABC             00026
                     TLE             00012
                     LOUDNESS        00765
   EXTERNAL SYMBOLS
                     TMEND,
                     D1010100
                     QOCDICT,
                     ALOG10
                     MAX1F
                     STW,
                     SLO,
                     ONSINGL,
```

```
4A                                                              06/04/73

      SUBROUTINE IVSRPLOT(ITF)                                          IVSR   1
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,     IVSR   2
     1   ISCP,IT1,IT2,IT3,IPER,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT          IVSR   3
      COMMON /LOUDNESS/ LNRC,NCD(100),AL(100,4)                         IVSR   4
      COMMON /TMPSTN/ DUC(182)                                          IVSR   5
      COMMON /TLE/STITLE (10)                                           IVSR   6
      COMMON/ABC/PLACHDR (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1              IVSR   7
      DATA (IENT=0),(IFT2=0),(IBH=0)                                    IVSR   8
      DIMENSION LINE(109)                                               IVSR   9
      EQUIVALENCE (LINE,DDC)                                            IVSR  10
      IF (IFT1.EQ.IFT2) GO TO 13                                        IVSR  11
      IBH=0                                                             IVSR  12
      IFT2=IFT1                                                         IVSR  13
   13 IF (IFT1.EQ.0.OR. IBH.EQ.1) GO TO 3                               IVSR  14
      IENT=0                                                            IVSR  15
      IBH=1                                                             IVSR  16
    3 IF(IENT.NE.0) GO TO 10                                            IVSR  17
      WRITE (38,1 ),STITLE                                              IVSR  18
    1 FORMAT (1H1,10A8)                                                 IVSR  19
      IENT=1                                                            IVSR  20
      IT=ITP+1                                                          IVSR  21
      IF(IT.EQ.5) IT=1                                                  IVSR  22
      DO 2 I=1,11                                                       IVSR  23
    2 LINE(I)=170+10*I                                                  IVSR  24
      N=MIN0(LNRC,9)                                                    IVSR  25
      WRITE(36,900) (NCD(I),I,I=1,N)                                    IVSR  26
      WRITE (38,901) (LINE(I),I=1,11)                                   IVSR  27
      DO 25 I=1,11                                                      IVSR  28
   25 LINE(I)=1H*                                                       IVSR  29
      WRITE (38,903) (LINE(I),I=1,11)                                   IVSR  30
  900 FORMAT(*0*,15A,*RECEIVED INTENSITY VS RANGE*/*0RECEIVER AT DEPTH P IVSR  31
     1LOTS AS*//(F10.3,I9))                                             IVSR  32
  901 FORMAT(*0   R(KM)*,5X,11I10)                                      IVSR  33
  903 FORMAT (14X ,11(9X,A1))                                           IVSR  34
   10 IF(IT.LE.0.OR.IT.GT.4) RETURN                                     IVSR  35
      DO 15 I=1,105                                                     IVSR  36
   15 LINE(I)=48                                                        IVSR  37
      DO 20 I=1,N                                                       IVSR  38
      DB=10.*ALOG10(AMAX1(1.E-25,AL(I,IT)))                             IVSR  39
      IP=161.5+DB                                                       IVSR  40
      IF(IP.LE.0.OR.IP.GT.105) GO TO 20                                 IVSR  41
      LINE(IP)=I                                                        IVSR  42
   20 CONTINUE                                                          IVSR  43
      RK=RMAX/1000.                                                     IVSR  44
      WRITE(36,902) RK,LINE                                             IVSR  45
  902 FORMAT(F9.3,14X,105H1)                                            IVSR  46
      RETURN                                                            IVSR  47
      END                                                               IVSR  48
```

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

                                                    ICENT     IVSRPLOT

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

```
,4A                                                                    06/04/73

      SUBROUTINE RAY PLOT(NP,ZMAX)                                                RAYP   1
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,               RAYP   2
     1   ISCP,IT1,IT2,IT3,IPER,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT                    RAYP   3
      COMMON /RAYS/ NRAY,TGAM(1000),ZZ(1000),SS(1000),TIME(1000),                 RAYP   4
     1   NCOUNT(1000),PHASE(1000)                                                 RAYP   5
      COMMON /TMPSTR/ DUM(182)                                                    RAYP   6
      COMMON/ABC/PUNCHDU (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1                        RAYP   7
      DIMENSION IR(25),ISYM(25),LINE(115),INUM(9)                                 RAYP   8
      COMMON /TRIANG/ AP(100,2),BP(100,2),AL(100),BL(100),ZZERO(100),             RAYP   9
     1   RZERO(100),AA(100),BB(100),SST(100),CCT(100),NTRI                        RAYP  10
      EQUIVALENCE (LINE,DUM)                                                      RAYP  11
      DATA (ISYM=1HA,1HC,1HD,1HE,1HF,1HG,1HM,1HI,1HJ,1HK,1HL,1HM,1HN,1HO          RAYP  12
     1   ,1HP,1HQ,1HR,1HT,1HL,1HV,1HW,1HX,1HY,1HZ,1H*)                           RAYP  13
      COMMON /TLE/STITLE (10)                                                     RAYP  14
      DATA (IENT=0),(IBLAK=1H ),(IHB=1HB),(IS=1HS),(IFT2=0),(IBH=0)               RAYP  15
      DATA (INUM=1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1H9)                             RAYP  16
      IF (IFT1.EQ.IFT2) GO TO 2                                                   RAYP  17
      IBH=0                                                                       RAYP  18
      IFT2=IFT1                                                                   RAYP  19
    2 IF (IFT1.EQ.0.OR.IBH.EQ.1) GO TO 3                                         RAYP  20
      IENT=0 $ IBH=1                                                              RAYP  21
    3 IF(IENT.NE.0) GO TO 10                                                      RAYP  22
      WRITE (LTRP,1),STITLE                                                       RAYP  23
      IENT=1                                                                      RAYP  24
      ANP=FLOAT(NRAY)/FLOAT(NP)                                                   RAYP  25
      DO 5 I=1,NP                                                                 RAYP  26
      A=ANP*(FLOAT(I)-.5)+1.                                                      RAYP  27
      IR(I)=A                                                                     RAYP  28
      IF(IR(I).GT.NRAY) IR(I)=NRAY                                                RAYP  29
    5 CONTINUE                                                                    RAYP  30
      SZ=ZMAX/114.                                                                RAYP  31
      WRITE (LTRP,900) SZ                                                         RAYP  32
   10 ZB=AL(NTRI)*RL(NTRI)*RMAX                                                   RAYP  33
      RKM=.001*RMAX                                                               RAYP  34
      IB=(ZMAX-ZB)/SZ+1.5                                                         RAYP  35
      IB1=1                                                                       RAYP  36
      IF(IB.LE.0) GO TO 12                                                        RAYP  37
      IF(IB.GT.115) IB=115                                                        RAYP  38
      DO 11 I=1,IB                                                                RAYP  39
   11 LINE(I)=IHB                                                                 RAYP  40
      IB1=IB+1                                                                    RAYP  41
   12 DO 15 I=IB1,114                                                             RAYP  42
   15 LINE(I)=IBLNK                                                               RAYP  43
      LINE(115)=IS                                                                RAYP  44
      DO 20 I=1,NP                                                                RAYP  45
      K=IR(I)                                                                     RAYP  46
      IF (NBRS.EQ.2500.AND.NSRS.EQ.2500) GO TO 17                                 RAYP  47
      NN=NCOUNT(K) $M=NN/ITN $NBR=M-NN*ITN $M=NN/ITN $NBR=M                       RAYP  48
   17 IF(ABS(SS(K)).LT.ALIM.OR.NBR.GT.NBRS.OR.NSR.GT.NSRS) GO TO 20               RAYP  49
      ZR=ZZ(K)                                                                    RAYP  50
      IP=(ZMAX-ZR)/SZ+1.5                                                         RAYP  51
      IF(IP.GT.115) IP=115                                                        RAYP  52
      IF(IP.LE.0) GO TO 20                                                        RAYP  53
      IF(LINE(IP).EQ.IBLNK.OR.LINE(IP).EQ.IS.OR.LINE(IP).EQ.IHB) GOTO 19          RAYP  54
      DO 16 J=1,8                                                                 RAYP  55
      IF(LINE(IP).NE.INUM(J)) GO TO 16                                            RAYP  56
```

```
,4A                                                          06/04/73

      LINE(IP)=INUM(J+1)                                                  RAYP  57
      GO TO 20                                                            RAYP  58
16    CONTINUE                                                            RAYP  59
      LINE(IP)=INUM(1)                                                    RAYP  60
      GO TO 20                                                            RAYP  61
19    LINE(IP)=ISYM(I)                                                    RAYP  62
20    CONTINUE                                                            RAYP  63
      WRITE (LTRP,901) RKM,LINE                                           RAYP  64
    1 FORMAT (1H1,10A8)                                                   RAYP  65
900   FORMAT(27HOPLOT OF RAY PATHS    SCALE,F8.2,2X,10HM/POSITION/        RAYP  66
     1   10HORANGE(KM),3X,114(1HX),1HS)                                   RAYP  67
901   FORMAT(F11.3,2X,115A1)                                              RAYP  68
      RETURN                                                              RAYP  69
      END                                                                 RAYP  70
```

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

                                          ICENT     RAYPLOT
    PROGRAM LENGTH                 00605
    ENTRY POINTS     RAYPLOT       00145
    BLOCK NAMES
                     INFO          00024
                     RAYS          13561
                     TMPSTR        00266
                     ABC           00026
                     TRIANG        02261
                     TLE           00012
    EXTERNAL SYMBOLS
                     THEAD,
                     01010100
                     0@CDICT,
                     STH,
                     SL@,
                     ONSINGL,
```

```
1,4A                                                    06/04/73

      SUBROUTINE RAYZDIST (NP)                                          RAYZ   1
      COMMON /RAYS/ NRAY,TGAM(1000),ZZ(1000),SS(1000),TIME(1000),       RAYZ   2
     1   NCOUNT(1000),PHASE(1000)                                       RAYZ   3
      COMMON /INFO/ RSTART,RMAX,OMEGA,ATT,IPRAY,ITN,ITN2,ITN3,IBIG,     RAYZ   4
     1   ISCP,IT1,IT2,IT3,IPEN,IFTIMS,LTRT,LTER,LTRP,LPIN,IATT          RAYZ   5
      COMMON /THPSTR/ DUD(182)                                          RAYZ   6
      COMMON /TLE/STITLE (10)                                           RAYZ   7
      DIMENSION LINE(71)                                                RAYZ   8
      DIMENSION ISYM(25),IR(25)                                         RAYZ   9
      COMMON /PIDEF/ PI,DTR,TWOPI                                       RAYZ  10
      EQUIVALENCE (LINE,DUD)                                            RAYZ  11
      COMMON/ABC/PUNCHDW (16),INCR,NBRS,NSRS,ALIM,IFT,IFT1              RAYZ  12
      DATA (IENT=0),(IFT2=0),(IBW=0)                                    RAYZ  13
      DATA (ISYM=1HA,1HC,1HD,1HE,1HF,1HG,1HH,1HI,1HJ,1HK,1HL,1HM,1HN,1H0RAYZ  14
     1   ,1HP,1HQ,1HR,1HT,1HL,1HV,1HW,1HX,1HY,1HZ,1H*)                  RAYZ  15
      IF (IFT1.EQ.IFT2) GO TO 7                                         RAYZ  16
      IBW=0                                                             RAYZ  17
      IFT2=IFT1                                                         RAYZ  18
    7 IF (IFT1.EQ.0.OR.IBW.EQ.1) GO TO 6                               RAYZ  19
      IENT=0                                                            RAYZ  20
      IBW=1                                                             RAYZ  21
    6 IF (IENT.EQ.1 ) GO TO 3                                           RAYZ  22
      LTRD=37                                                           RAYZ  23
      ANP=FLOAT(NRAY)/FLOAT(NP)                                         RAYZ  24
      DO 4 I=1,NP                                                       RAYZ  25
      A=ANP*(FLOAT(I)+.5)+1.                                            RAYZ  26
      IR(I)=A                                                           RAYZ  27
      IF(IR(I).GT.NRAY) IR(I)=NRAY                                      RAYZ  28
    4 CONTINUE                                                          RAYZ  29
      IENT=1                                                            RAYZ  30
    3 WRITE (LTRD,2),STITLE                                             RAYZ  31
      INC=1                                                             RAYZ  32
    1 CALL CHANNEL(1.,1000.,25,ZB)                                      RAYZ  33
      DO 5 I=1,71                                                       RAYZ  34
    5 LINE(I)=1HX                                                       RAYZ  35
      RK=RMAX/1000.                                                     RAYZ  36
      SCALE=ZB/71.0                                                     RAYZ  37
      WRITE(LTRD,900) RK,ZB,SCALE,LINE                                  RAYZ  38
      DO 8 I=1,71                                                       RAYZ  39
    8 LINE(I)=1H                                                        RAYZ  40
      DO 40 I=1,NRAY                                                    RAYZ  41
      S=SS(I)                                                           RAYZ  42
      IF (NBRS.EQ.2500.AND.NSRS.EQ.2500) GO TO 35                       RAYZ  43
      N=NCOUNT(I)                                                       RAYZ  44
      M=N/ITN                                                           RAYZ  45
      K=M/ITN                                                           RAYZ  46
      NSR=M-N*ITN                                                       RAYZ  47
      M=N/ITN                                                           RAYZ  48
      NBR=M                                                             RAYZ  49
   35 IF(S.GT.ALIM.AND.NBR.LE.NBRS.AND.NSR.LE.NSRS) GO TO 12            RAYZ  50
      IF (I.EQ. IR(INC))10,15                                           RAYZ  51
   10 WRITE (LTRD,1901),ISYM(INC),I                                     RAYZ  52
      INC=INC+1                                                         RAYZ  53
      GO TO 40                                                          RAYZ  54
   15 WRITE(LTRD,901) I                                                 RAYZ  55
  900 FORMAT(26HCRAY DEPTH DISTRIBUTION AT,F10.4,4H KM,,10X,*BOTTOM DEPTRAYZ  56
```

```
;,4A                                                    06/04/73

      1H=*,F10,3,*  M=,10X,*SCALE=*,F10,3,* M/POSITION=,//,29HOLD  NRAY  RAYZ  97
      2NBR  NTU  NSR  NTB,3X,5HDEPTH,5X,5HTHETA,6X,4HTIME,1X,6HLOSSES,1X,RAYZ  98
      371A1)                                                          RAYZ  99
  901 FORMAT(9X,'4,10X,11HTERMINATED,)                                RAYZ  60
 1901 FORMAT (2X,A1,1X,I4,10X,11HTERMINATED,)                         RAYZ  61
      GO TO 40                                                        RAYZ  62
   12 DB=10,*ALOG10(S)                                                RAYZ  63
      T=TIME(I)                                                       RAYZ  64
      Z=ZZ(I)                                                         RAYZ  65
      N=NCOUN(I)                                                      RAYZ  66
      M=N/ITN                                                         RAYZ  67
      NTB=N-M*ITN                                                     RAYZ  68
      N=M/ITN                                                         RAYZ  69
      NSR=M-N*ITN                                                     RAYZ  70
      M=N/ITN                                                         RAYZ  71
      NTU=N-M*ITN                                                     RAYZ  72
      NBR=M                                                           RAYZ  73
      LINE(1)=1HE                                                     RAYZ  74
      LINE(71)=1HS                                                    RAYZ  75
      CALL CHANNEL(Z,TGAM(I),ZTB,ZTU)                                 RAYZ  76
      IZP=70,*(1,-ZTL/ZB)+1,5                                         RAYZ  77
      IF (IZP,GT,71,OR,IZP,LT,1) GO TO 45                             RAYZ  78
      LINE(IZP)=1H*                                                   RAYZ  79
   45 IZM=70,*(1,-ZTB/ZB)+1,5                                         RAYZ  80
      IF (IZM,GT,71,OR,IZM,LT,1) GO TO 55                             RAYZ  81
      LINE(IZM)=1H*                                                   RAYZ  82
   55 IZR=70,*(1,-Z/ZB)+1,5                                           RAYZ  83
      IF (IZR,GT,71,OR,IZR,LT,1) GO TO 60                             RAYZ  84
      LINE(IZR)=1H*                                                   RAYZ  85
   60 TH=DTR*ATAN(TGAM(I))                                            RAYZ  86
      IF (I,EQ, IR(INC))20,25                                         RAYZ  87
   20 WRITE (LTHD,902) ISYM(INC), I,NBR,NTU,NSR,NTB,Z,TH,T,DB,LINE    RAYZ  88
      INC=INC+1                                                       RAYZ  89
      GO TO 30                                                        RAYZ  90
  902 FORMAT(2X,A1,1X,5I5, F8,2,F10,5,F10,3,F7,1,1X,71A1)             RAYZ  91
   25 WRITE (LTHD,1902) I,NBR,NTU,NSR,NTB,Z,TH,T,DB,LINE              RAYZ  92
 1902 FORMAT(9X,5I5, F8,2,F10,5,F10,3,F7,1,1X,71A1)                   RAYZ  93
   30 IF (IZP,LE,71,AND,IZP,GE,1) LINE(IZP)=1H                       RAYZ  94
      IF (IZM,LE,71,AND,IZM,GE,1) LINE(IZM)=1H                        RAYZ  95
      IF (IZR,LE,71,AND,IZR,GE,1) LINE(IZR)=1H                        RAYZ  96
   40 CONTINUE                                                        RAYZ  97
    2 FORMAT (1H1,10A8,/)                                             RAYZ  98
      RETURN                                                          RAYZ  99
      END                                                             RAYZ 100
```

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

                                          IDENT     RAYZDIST
     PROGRAM LENGTH                 01754
     ENTRY POINTS    RAYZDIST       01234
     BLOCK NAMES
                     RAYS           13561
                     INFO           00024
                     TMPSTR         00266
                     TLE            00012
                     PICEF          00003
                     ABC            00026
     EXTERNAL SYMBOLS
                     G1G1010U
                     THEAD,
                     GOGDICT,
                     CHANNEL
                     ALOG10
                     ATANF
                     STH,
                     SLO,
                     ONSINGL,
```

```
,4A                                                    06/04/73

      SUBROUTINE BYEBYE                                          BYBY   1
      DIMENSION LEAVE(1)                                         BYBY   2
      J=1                                                        BYBY   3
      LEAVE(J)=6300000030C0C008                                  BYBY   4
      END                                                        BYBY   5
```

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

                                        ICENT     BYEBYE
   PROGRAM LENGTH                 00017
   ENTRY POINTS    BYEBYE         00004
   EXTERNAL SYMBOLS
                   OUCDICT,
```

```
RDS  RECOVERY
                                                        08/02/72        ED     0       PAGE NO.     1
                                           IDENT     RECOVERY
   PROGRAM LENGTH              00125
   ENTRY POINTS     DUMP       00000
                    RESTART    00057
                           ASTATUS   MACRO     P1
                           ST        STATUS    ((P1))
                                     NZJP      Q,47,ST
                                     NZJP      Q,46,ST
                                     ENDM

                                               TITLE -- DUMP AND RESTART FACILITY
                                               IDENT NAME -- QX-NRL-RECOVERY
                                               IDENT NUMBER -- Q0001R00
                                               LANGUAGE -- COMPASS 5.3
                                               COMPUTER -- CDC 3800
                                               CONTRIBUTOR -- ANNA BYRD HAYS, CODE 7817.1
                                                              DOUGLAS P. SHANNON, CODE 7817.3
                                                              RESEARCH COMPUTATION CENTER
                                                              MATH. AND INFO. SCIENCES DIVISION
                                               DATE -- JUNE 1970
                                               PURPOSE -- ALLOWS PROGRAMS WITH A LONG RUN-TIME TO
                                                          HAVE A RESTART CAPABILITY

                                     ENTRY     DUMP,RESTART
                    00017  MT1       EQU       15              ALWAYS INPUT TAPE, FIRST OUTPUT TAPE
                    00004  TRIES     EQU       5-1             PARITY RE-TRY COUNTER
                    50000  LOWCORE   EQU       50000B          OCTAL NUMBER ON DEMAND CARD
                    00052  PARITY    EQU       42              PARITY STATUS BIT
                    00000  UNLOADMT  EQU       0               1 IF UNLOAD TAPE AFTER USE. LAR SMITH
                   P00000  FWA       EQU       *
```

```
DS  RECOVERY                                                      08/02/72       ED      0         PAGE NO.      2
     00000   63  0  00000  DUMP     UMJP      **                                                              00029
             00  0  77777
     00001   77  2  04000           UDTA      (*)SAVEAQ       SAVE REGISTERS TO DUMP ON TAPE                  00030
             20  0 P00110
     00002   00  7  40053           RAT       D,A                                                             00031
             20  0 P00112           STA       SAV[illegible]                                                  00032
     00003   56  1 P00113           SIU       SAVE12,1                                                        00033
             57  2 P00113           SIL       SAVE12,2                                                        00034
     00004   56  3 P00114           SIU       SAVE34,3                                                        00035
             57  4 P00114           SIL       SAVE34,4                                                        00036
     00005   56  5 P00115           SIU       SAVE56,5                                                        00037
             57  6 P00115           SIL       SAVE56,6                                                        00038
     00006   50  1  00017           ENI       MT1,1                                                           00039
             50  0  00000
     00007                 MODE     MODE      ((0,1),0,BIN,LO)     MODE TAPE 200 BPI                          00040
     00012   50  6  00004           ENI       TRIES,6         SET RE-TRY COUNTER                              00041
             50  0  00000
     00013                 REW,1    REWIND    ((0,1),0)                                                       00042
     00016                          WRITE     ((0,1),=CWA,0)                                                  00043
     00021                          ASTATUS   ((0,1))                                                         00044
     00024   63  0  30052           ZMJP      Q,PARITY,CONT,1     JUMP IF NO PARITY ERROR                     00045
             64  0 P00050
     00026                          REWIND    ((0,1),0)                                                       00046
     0003[illegible]                READ      ((0,1),NSKIPCW,0)     MAKE SURE OF PARITY ERROR                 00047
     [illegible]                    ASTATUS   ((0,1))                                                         00048
     00040   63  0  30052           ZMJP      Q,PARITY,CONT,1       JUMP IF NO PARITY ERROR                   00049
             64  0 P00050
     00041   55  6 P00013           IJP       REW,1,6                                                         00050
             51  1  00001           INI       1,1                                                             00051
     00042                          RELEASE   ((=1,1),0)                                                      00052
                           *                                  BAD TAPE --- TRY ANOTHER UNIT                   00053
     00044   62  0  00022           RDJP,NE   B1,MT1,3,MODE   JUMP IF NOT OVER TAPE UNIT LIMIT                00054
             30  1 P00007
     00045   12  1 P00102           LDA       ERROR-MT1-1,1   ABORT MESSAGE                                   00055
             20  0 P00047           STA       *+1,1                                                           00056
     00046                          ABORT     **              KILL JOB                                        00057
                           *                  IFZ       UNLOADMT,2                                            00058
     [illegible]  62  0  00017  CONT,1   RDJP,NE   B1,MT1,0-3      JUMP IF NOT FIRST TAPE                     00060
             30  1 P00045
     000[illegible]1                REWIND    ((0,1),0)       PERFORM FREE REWIND                             00061
                           *        IFN       UNLOADMT                                                        00062
     00054   52  1 P00113           LIU       SAVE12,1        RELOAD USED INDEX REG.                          00073
             53  6 P00115           LIL       SAVE56,6                                                        00074
     00055   77  2  00000           DLDA      SAVEAQ          RESTORE A AND Q                                 00075
             12  0 P00110
     00056   75  0 P00000           UJP       DUMP            EXIT                                            00076
             50  0  00000
```

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

```
 1  RECOVERY                                                         08/02/72        ED     0          PAGE NO.       6

      00110                        SAVEAU    BSS      2                                                        00103
      00112                        SAVED     BSS      1                                                        00104
      00113    00   0   00000      SAVE12    OCT      0                                                        00105
               00   0   00000
      00114    00   0   00000      SAVE34    OCT      0                                                        00106
               00   0   00000
      00115    00   0   00000      SAVE56    OCT      0                                                        00107
               00   0   00000

      00116    50   0   77777      RCWA      IOTW,C   (1)00000,77777B      ALL OF BANK ONE                     00109
               00   1   00000
                                                      BANK ZERO FROM LOWER BOUND TO RECOVERY - 1               00110
      00117    50   0 P50000                 IOTW,C   77776B-LOWCORE,FWA=77776B+LOWCORE-1                      00111
               00   0   27776
      00120    10   0   00006                IOTW     (0)SAVEAU,6          SPACE FOR INDEZ REGISTERS           00112
               00   0 P00110
                        P00116     RCWA      EQU      RCWA                                                     00113
      00121    20   0   77777      RSKIPCW   IOSR     **,**                                                    00114
               00   0   77777
      00122    22   2   12466      ERROR     BCD      1,BADRW 15                                               00115
               51   6   001.5
      00123    22   2   12466                BCD      1,BADRW 16                                               00116
               51   6   00106
      00124    22   2   12466                BCD      1,BADRW 17                                               00117
               51   6   00107
                                             IFN      UNLOADMT,1                                               00118
                                             END                                                               00121
```

```
.5A                                                                    04/05/72

      PROGRAM TRIPLT                                                          TPLT   1
C     THIS VERSION IS COMPATIABLE WITH 4-5-72 VERSION OF TRIMAIN               TPLT   2
C        DISK VERSION OF TRIPLT                                               TPLT   3
C        IF INFO WILL FIT IN CORE DISK IS NOT OPENED                          TPLT   4
C        THIS DETERMINED BY NRMAX AND THE NUMBER OF RAYS TO PLOT              TPLT   5
C                                                                             TPLT   6
      COMMON /INFO/ ID,NR,RMAX,ZMAX,RSCALE,AL,RR(2000),ZBOT(2000),IKNM        TPLT   7
      DIMENSION TITLE(10),BUF(254),NRPLOT(512),ZR(1000),TR(1000),SS(1000      TPLT   8
     1),NCOUNT(1000)                                                          TPLT   9
      COMMON /1/ ZSTOR(16384)                                                 TPLT  10
      COMMON /2/ TSTOR(16384)                                                 TPLT  11
  900 FORMAT(10A8)                                                            TPLT  12
  901 FORMAT(28H1CALCOMP PLOT FROM RAY TAPE ,10A8)                            TPLT  13
  902 FORMAT (2F8.3,I4,6I5,F10.3)                                             TPLT  14
  903 FORMAT(8HOLENGTH=,F10.2,3X,10HMAX DEPTH=,F12.1,3X,14HNO. OF RECORDTPLT  15
     1S,I10,5X,6HKNM=,I3,5X,6HIFMC=,I3,5X,6HNFSK=,I3,5X,6HITTR=,I3,/,     TPLT  16
     2 1X,6HDB LIMIT=,F8.3,5X,6HMAXIMUM NUMBER OF SURFACE REFLECTIONS=,   TPLT  17
     3I5,5X,6HMAXIMUM NUMBER OF BOTTOM REFLECTIONS=,I5)                       TPLT  18
  904 FORMAT(2014)                                                            TPLT  19
  905 FORMAT(5HONRAY,2015)                                                    TPLT  20
  906 FORMAT(11HONO OF RAYS,I6,3X,13HLENGTH OF BLOCK,I6,3X,12HNO OF BLOCTPLT  21
     1KS,I6)                                                                  TPLT  22
 9035 FORMAT(24HOPARITY ERROR IN RECORD  ,I6)                                 TPLT  23
      IDF0=0 $ IC0=0 $READ 4,ITNC $REWIND 1                                   TPLT  24
    4 FORMAT (I2)                                                             TPLT  25
      CALL PLOTS(BUF,254,10)                                                  TPLT  26
    2 READ 902, AL,ZMAX,NRMAX,IKNM,IFMC,NFSK,ITTR,NSR1,NBR1,ALIM1             TPLT  27
      IF (EOF,60)2,7                                                          TPLT  28
    7 IC0=IC0+1                                                               TPLT  29
      DO 3 J=1,NFSK                                                           TPLT  30
    3 CALL SKIPFILE (1)                                                       TPLT  31
      READ (1),TITLE,ALIM,NBRS,NSRS,ITNSIF(ITTR.LT.0)READ 900,TITLE           TPLT  32
      IF (ALIM1.NE.0.0.AND.ALIM1.GT.ALIM) ALIM=POWRF(10.0,(+ALIM1/10.0))TPLT  33
      IF (ALIM1.EQ.0.0) ALIM1=-10.0*ALOG10(ALIM) $ PRINT 901,TITLE            TPLT  34
      IF (NSR1.NE.0.AND.NSR1.LT.NSRS) NSRS=NSR1                               TPLT  35
      IF (NBR1.NE.0.AND.NBR1.LT.NBRS) NBRS=NBR1                               TPLT  36
      PRINT 903,AL,ZMAX,NRMAX,IKNM,IFMC,NFSK,ITTR,ALIM1,NSRS,NBRS             TPLT  37
      IF(AL.LE.0..OR.AL.GT.120.) STOP $ IF (ZMAX.LE.0.) STOP $ IL=1           TPLT  38
      IF(NRMAX.LE.0.OR.NRMAX.GT.2000) STOP                                    TPLT  39
    5 IH=IL+19                                                                TPLT  40
      IF(IH.GT.511) STOP                                                      TPLT  41
      READ 904,(NRPLOT(I),I=IL,IH)                                            TPLT  42
      PRINT 905,(NRPLOT(I),I=IL,IH)                                           TPLT  43
      IF(EOF,60) 10,15                                                        TPLT  44
   10 IH=IL-1                                                                 TPLT  45
      GO TO 25                                                                TPLT  46
   15 IF(NRPLOT(IH).EQ.0) GO TO 20                                            TPLT  47
      IL=IL+20                                                                TPLT  48
      GO TO 5                                                                 TPLT  49
   20 IH=IH-1                                                                 TPLT  50
      IF(NRPLOT(IH).NE.0) GO TO 25                                            TPLT  51
      IF(IH.GT.0) GO TO 20                                                    TPLT  52
   25 NTOPLT =IH                                                              TPLT  53
      IF(IH.LE.0) STOP                                                        TPLT  54
      LBLK=32*(512/NTOPLT)                                                    TPLT  55
      MBLK=(NRMAX-1)/LBLK+1                                                   TPLT  56
```

```
5A                                                          04/05/72

      PRINT 906,NTOPLT,LRLK,MBLK                                        TPLT  57
      NDISK=MBLK*LRLK*NTOPLT*2                                          TPLT  58
      IF(NDISK.GT.2**20) STOP                                           TPLT  59
      IF(MBLK.EQ.1.OR.IDFO.EQ.1) GO TO 30                               TPLT  60
      IDFO=1                                                            TPLT  61
      CALL DKOPEN(2,3HRAN,0)                                            TPLT  62
C        PLOT TITLE AND Z-AXIS                                          TPLT  63
30    CALL SYMBOL(1.,.0,.14,TITLE,90.,80)                               TPLT  64
      CALL SYMBOL(2.8,9.95,.14,1HC,0.,1)                                TPLT  65
      Z=0.                                                              TPLT  66
      DO 31 I=1,10                                                      TPLT  67
      CALL PLOT(3.,11.,-1.5)                                            TPLT  68
      CALL PLOT(3.,10.,-1.2)                                            TPLT  69
      CALL PLOT(3.05,10.,-1,2)                                          TPLT  70
      CALL PLOT(2.95,10.,-1,2)                                          TPLT  71
      Z=Z+ZMAX/10.                                                      TPLT  72
      CALL NUMBER(2.32,9.93-I.,.14,Z,0.,4HF5.0)                         TPLT  73
      IF (I.EQ.5.AND.IFMC.GE.0) CALL SYMBOL (2.,4.5,.14,9HDEPTH (M),90.,TPLT  74
     19)                                                                TPLT  75
      IF (I.EQ.5.AND.IFMC.LT.0) CALL SYMBOL (2.,4.5,.14,10HDEPTH (FT),  TPLT  76
     190.,10)                                                           TPLT  77
31    CONTINUE                                                          TPLT  78
      IF (IFMC.LT.0) ZMAX= ZMAX*0.3048                                  TPLT  79
      NR=NRMAX                                                          TPLT  80
      M=1                                                               TPLT  81
      IREC=0                                                            TPLT  82
35    DO 50 IR=1,LBLK                                                   TPLT  83
      IREC=IREC+1 $  IFEF=0                                             TPLT  84
      READ(1) NRAY,RR(IREC),TBOT(IREC),(TR(I),I=1,NRAY),(ZR(I),I=1,NRAY)TPLT  85
     1,(SS(I),I=1,NRAY),(NCOUNT(I),I=1,NRAY)                            TPLT  86
      IF(EOF,1) 36,38                                                   TPLT  87
36    IFEF=1                                                            TPLT  88
      IF (NRMAX.LT.IREC-1) GO TO 52                                     TPLT  89
      NRMAX=IREC-1                                                      TPLT  90
      NR=NRMAX                                                          TPLT  91
      GO TO 52                                                          TPLT  92
38    IF(IOCHECK,1) 39,40                                               TPLT  93
39    PRINT 9039,IREC                                                   TPLT  94
40    DO 45 I=1,NTOPLT $ K=NRPLOT(I) $J=LBLK*(I-1)+IR $ ZSTOR(J)=ZR(K)  TPLT  95
      IF (NSRS.EQ.2500.AND.NRRS.EQ.2500) GO TO 41                       TPLT  96
      NN=NCOUNT (K)$MM=NN/ITN$NN=MM/ITN$NSR=MM-NN*ITN $MM=NN/ITN$NBR=MM TPLT  97
41    IF (SS(K).LE.ALIM.OR.NSR.GE.NSRS.OR.NBR.GE.NRRS) ZSTOR(J)=-ZR(K)  TPLT  98
      IF (ZR(K).LT.0.0) ZSTOR(J)=ZR(K)                                  TPLT  99
45    TSTOR(J)=-TR(K)                                                   TPLT 100
50    CONTINUE                                                          TPLT 101
52    IF(MBLK.EQ.1) GO TO 60 $ IDEL=MBLK*LBLK                           TPLT 102
      MDISK=(M-1)*LBLK                                                  TPLT 103
      DO 55 I=1,NTOPLT                                                  TPLT 104
      CALL DKLOCATE(MDISK)                                              TPLT 105
      J=(I-1)*LBLK+1                                                    TPLT 106
      K=J+LBLK-1                                                        TPLT 107
      CALL DKWRITE(ZSTOR(J),ZSTOR(K))                                   TPLT 108
      MDISK=MDISK+IDEL                                                  TPLT 109
      CALL DKLOCATE(MDISK)                                              TPLT 110
      CALL DKWRITE(TSTOR(J),TSTOR(K))                                   TPLT 111
55    MDISK=MDISK+IDEL                                                  TPLT 112
```

```
5A                                                          04/05/72

  80    IF(M.EQ.MBLK.OR.IREF.EQ.1) GO TO 65                                TPLT 113
        M=M+1                                                              TPLT 114
        GO TO 35                                                           TPLT 115
     85 NREC=32*((NRMAX-1)/32+1)                                           TPLT 116
        RMAX=RR(KK)                                                        TPLT 117
        RSCALE=AL/RMAX                                                     TPLT 118
        CALL PLOTOT                                                        TPLT 119
        IF(MBLK.EQ.1) GO TO 80                                             TPLT 120
        ID=1                                                               TPLT 121
        MDISK=0                                                            TPLT 122
        DO 70 I=1,NTOPLT                                                   TPLT 123
        CALL DKLOCATE(MDISK)                                               TPLT 124
        CALL DKREAD(ZSTOR(1),ZSTOR(NREC))                                  TPLT 125
        MDISK=MDISK+IDEL                                                   TPLT 126
        CALL DKLOCATE(MDISK)                                               TPLT 127
        CALL DKREAD(TSTOR(1),TSTOR(NREC))                                  TPLT 128
        MDISK=MDISK+IDEL                                                   TPLT 129
        CALL MAYPLOT(ZSTOR,TSTOR)                                          TPLT 130
  70    ID=-ID                                                             TPLT 131
        GO TO 90                                                           TPLT 132
  80    ID=1                                                               TPLT 133
        DO 85 I=1,NTOPLT                                                   TPLT 134
        L=(I-1)*LBLK+1                                                     TPLT 135
        CALL MAYPLOT(ZSTOR(L),TSTOR(L))                                    TPLT 136
  85    ID=-ID                                                             TPLT 137
  90    CALL PLOT(AL+10.,0.,-3)                                            TPLT 138
        IF (IREF.EQ.1) GO TO 91  $ IREC=0                                  TPLT 139
     92 IREC=IREC+1                                                        TPLT 140
        READ(1) NRAY,RR(IREC),ZERO(IREC),(TR(I),I=1,NRAY),(ZR(I),I=1,NRAY)TPLT 141
       1,(SS(I),I=1,NRAY),(NCOUNT(I),I=1,NRAY)                             TPLT 142
        IF (EOF,1) 91,92                                                   TPLT 143
     91 IF (ICO.LT.ITAC) GO TO 2                                           TPLT 144
        CALL STOPPLOT                                                      TPLT 145
        STOP                                                               TPLT 146
        END                                                                TPLT 147
```

```
,   TRIPLT                                          04/05/72        ED      0

                                        IDENT     TRIPLT
   PROGRAM LENGTH                 12/71
   ENTRY POINTS     TRIPLT        11432
   BLOCK NAMES
                    INFO          07647
                    1             40000
                    2             40000
   EXTERNAL SYMBOLS
                    QBCENTRY
                    THEND.
                    QBCSTOPS
                    C2QU700C
                    C1QU310C
                    QBCDICT.
                    PLOTS
                    SKIPFILE
                    DKOPEN
                    SYMBOL
                    PLOT
                    NUMBER
                    DKLOCATE
                    DKWRITE
                    PLOTBOT
                    DKREAD
                    RAYPLOT
                    STOPPLOT
                    ALOG10
                    POWRF
                    CBCIFEOF
                    CBCIFIOC
                    REW.
                    TSH.
                    TSO.
                    STH.
                    SLO.
                    SLI.
                    QNSINGL.
```

.5A 04/05/72

```
      SUBROUTINE PLOTBOT                                                    TPLT 148
      COMMON /INFO/ ID,NR,RMAX,ZMAX,RSCALE,AL,RR(2000),ZBOT(2000),IKNM      TPLT 149
      NTM=AMIN1(AL+1.,40.5)                                                 TPLT 150
      RT=1.                                                                 TPLT 151
      RMAN=RMAX                                                             TPLT 152
      IF (IKNM.LT.0) RMAN=RMAX/1.852                                        TPLT 153
   50 NT=RMAN/RT                                                            TPLT 154
      IF(NT.LE.NTM) GO TO 57                                                TPLT 155
      RT=2.*RT                                                              TPLT 156
      NT=RMAN/RT                                                            TPLT 157
      IF(NT.LE.NTM) GO TO 57                                                TPLT 158
      RT=2.5*RT                                                             TPLT 159
      NT=RMAN/RT                                                            TPLT 160
      IF(NT.LE.NTM) GO TO 57                                                TPLT 161
      RT=2.*RT                                                              TPLT 162
      GO TO 56                                                              TPLT 163
C        PLOT SURFACE AXIS                                                  TPLT 164
   57 CALL PLOT(3.,10.,3)                                                   TPLT 165
      X=3.                                                                  TPLT 166
      RSCALE1=RSCALE                                                        TPLT 167
      IF (IKNM.LT.0) RSCALE1=1.852*RSCALE                                   TPLT 168
      DX=RT*RSCALE1                                                         TPLT 169
      R=0.                                                                  TPLT 170
      IF=0                                                                  TPLT 171
   58 CALL PLOT(X,10.,2)                                                    TPLT 172
      CALL PLOT(X,9.95,2)                                                   TPLT 173
      RK=R/1000.                                                            TPLT 174
      CALL NUMBER(X-.24,10.05,.4E-1,RK,0.,4HF4.0)                           TPLT 175
      IF(R.LT.RMAN/2.) GO TO 59                                             TPLT 176
      IF(IF.EQ.1) GO TO 59                                                  TPLT 177
      IF(IKNM.LT.0)CALL SYMBOL(X-.30,10.25,.14,10HRANGE (NM),0.,10)         TPLT 178
      IF(IKNM.GE.0)CALL SYMBOL(X-.30,10.25,.14,10HRANGE (KM),0.,10)         TPLT 179
      IF=1                                                                  TPLT 180
   59 CALL PLOT(X,10.,3)                                                    TPLT 181
      IF(R.GE.RMAN) GO TO 60                                                TPLT 182
      X=X+DX                                                                TPLT 183
      R=R+RT                                                                TPLT 184
      GO TO 58                                                              TPLT 185
C        PLOT BOTTOM CONTOUR                                                TPLT 186
   60 DO 63 I=1,NR                                                          TPLT 187
      K=NR+1-I                                                              TPLT 188
      Y=10.*(1.-ZBOT(K)/ZMAX)                                               TPLT 189
      X=RR(K)*RSCALE+3.                                                     TPLT 190
      IP=2                                                                  TPLT 191
      IF(I.EQ.1) IP=3                                                       TPLT 192
      IF(Y.GE.0.) GO TO 63                                                  TPLT 193
      IP=3                                                                  TPLT 194
      Y=0.                                                                  TPLT 195
   63 CALL PLOT(X,Y,IP)                                                     TPLT 196
      RETURN                                                                TPLT 197
      END                                                                   TPLT 198
```

```
;   PLOTBOT                                                  04/05/72        ED      0

                                        IDENT     PLOTBOT
   PROGRAM LENGTH                 00305
   ENTRY POINTS      PLOTBOT      00010
   BLOCK NAMES
                     INFO         07647
   EXTERNAL SYMBOLS
                     01010100
                     CODICT,
                     PLOT
                     NUMBER
                     SYMBOL
                     MINIF
```

```
5A                                                    04/05/72

      SUBROUTINE RAYPLOT(ZSTOR,ISTOR)                                  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  $ IRH=0 $ IPR=0 $ IRT=0 $IRI=0  $ IST=0  $ IJT=0          TPLT 203
      IF(ID.LT.0) NID=NR $ IF (NID.NE.1) IPR=1                         TPLT 204
      Z0=ABSF(ZSTOR(NID))     $  IF (ZSTOR(1).LT.0.0) RETURN           TPLT 205
      T0=TSTOR(NID)                                                    TPLT 206
      R0=RR(NID)                                                       TPLT 207
      ZB0=ZBOT(NID)                                                    TPLT 208
      X=R0*RSCALE  $ IF (Z0.GT.ZB0) Z0=ZB0                             TPLT 209
      Y=10.*(1.-Z0/ZMAX)                                               TPLT 210
      IF(Y.LT.0.) Y=0.                                                 TPLT 211
      CALL PLOT(X+3.,Y,3)                                              TPLT 212
      DO 90 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-R0   TPLT 218
      IF(ZN.GT.ZBN) ZN=ZBN $ IF (ZSTOR(L).LT.0.0.AND.IPR.EQ.1) 91,93   TPLT 219
   *3 IF (NID.NE.1.AND.IRH.EQ.0) 94,95                                 TPLT 220
   *4 X=R0*RSCALE $Y=10.*(1.-Z0/ZMAX)$IF (Y.LT.0.) Y=0.0               TPLT 221
      CALL PLOT (X+3.,Y,3) $ IRH=1$IPR=0$IRI=1$IF(ZSTOR(L+1).GE.0.)IST=1TPLT 222
   *5 ZN0=ZN-DR*TN                                                     TPLT 223
      Z0N=Z0+DR*T0                                                     TPLT 224
      IF(Z0N.GE.0.) GO TO 75                                           TPLT 225
      IF(Z0N.GE.0.) GO TO 75                                           TPLT 226
      Z0=-Z0                                                           TPLT 227
      Z0N=-Z0N                                                         TPLT 228
      T0=-T0                                                           TPLT 229
 75   TB=(Z0N-Z0)/DR                                                   TPLT 230
      IF(Z0.LE.Z0) GO TO 78                                            TPLT 231
      IF(Z0N.LE.ZBN) GO TO 78                                          TPLT 232
      IF(TB.EQ.0.) GO TO 76                                            TPLT 233
      DZ=ZB0-Z0                                                        TPLT 234
      Z0=Z0+2.*DZ/(1.+TB**2)                                           TPLT 235
      R0=R0-2.*DZ/(TB+1./TB)                                           TPLT 236
      T0=(T0-TB)/(1.+T0*TB)                                            TPLT 237
      T0=(TB-T0)/(1.+T0*TB)                                            TPLT 238
      GO TO 77                                                         TPLT 239
 76   Z0=2.*ZB0-Z0                                                     TPLT 240
      T0=-T0                                                           TPLT 241
 77   DR=RN-R0                                                         TPLT 242
      Z0N=Z0+DR*T0                                                     TPLT 243
      ZN0=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 INTERPOLATION                  TPLT 252
      DZ=ZN-Z0                                                         TPLT 253
      DZ0=Z0N-Z0                                                       TPLT 254
```

```
.5A                                                                    04/05/72

      DZN=ZN-ZN0                                                                TPLT 255
 79   Z1=Z0+F*DZ                                                               TPLT 256
      Z2=Z0+F*DZ0                                                               TPLT 257
      Z3=ZN0+F*DZN                                                              TPLT 258
      G=1.-F                                                                    TPLT 259
      Z4=G*Z2+F*Z1                                                              TPLT 260
      Z5=G*Z1+F*Z3                                                              TPLT 261
      Z(II)=G*Z4+F*Z5                                                           TPLT 262
      R(II)=R0+F*DR                                                             TPLT 263
      II=II+1                                                                   TPLT 264
      F=F+DF                                                                    TPLT 265
      IF(II.LE.N) GO TO 79                                                      TPLT 266
      DO 89 II=1,N                                                              TPLT 267
      IN=0                                                                      TPLT 268
      IF(Z(II).LT.0.) IN=1                                                      TPLT 269
      IF(Z(II).GT.ZBN+(R(II)-RN)*TB) IN=-1                                      TPLT 270
      IF(II.EQ.1) GO TO 82                                                      TPLT 271
      IF(IN.EQ.IO) GO TO 82                                                     TPLT 272
      IF(IN.NE.1.AND.IO.NE.1) GO TO 80                                          TPLT 273
      RHIT=.5*(R(II)+R(II-1)+(R(II)-R(II-1))*(Z(II)+Z(II-1))/(Z(II-1)-Z(TPLT 274
     1II)))                                                                     TPLT 275
      X=RHIT*RSCALE$IP=3$IF (IBT.EQ.1.OR.NID.EQ.1.OR.IST.EQ.1)IP=2$IRT=1TPLT 276
      CALL PL0T(X+3.,.10,.IP)$ IF (ZST0R(L).GE.0.0) GO TO 82 $ IPR=1    TPLT 277
      GO TO 91                                                                  TPLT 278
 80   D=(Z(II)-Z(II-1))/(R(II)-R(II-1))-TB                                      TPLT 279
      RHIT=(Z(II-1)-ZBN-(R(II-1)-RN)*TB)/D+R(II-1)                              TPLT 280
      F=(RHIT-R(II-1))/(R(II)-R(II-1))                                          TPLT 281
      IF(F.GT.1.) GO TO 82                                                      TPLT 282
      IF(F.LT.0.) GO TO 82                                                      TPLT 283
      X=RHIT*RSCALE$IP=3$IF(IBT.EQ.1.OR.NID.EQ.1.OR.IST.EQ.1)IP=2               TPLT 284
      IBT=1                                                                     TPLT 285
      Y=10.*(1.-(ZBN+(RHIT-RN)*TB)/ZMAX)$IF(ZST0R(L).LT.0.0) IPR=1              TPLT 286
      IF(Y.GT.0.) GO TO 81                                                      TPLT 287
      Y=0.                                                                      TPLT 288
      IP=3                                                                      TPLT 289
 81   CALL PL0T(X+3.,Y,IP)                                                     TPLT 290
 82   IF(Z(II).GT.0.) GO TO 83                                                  TPLT 291
      Y=10.*(1.+Z(II)/ZMAX)                                                     TPLT 292
      X=R(II)*RSCALE$IF  (Z(II).EQ.0.0.AND.IRI.EQ.1) IJT=1                      TPLT 293
      IF (Z(II).EQ.0.0.AND.ZST0R(L).LT.0.0) IPR=1  $ GO TO 86                   TPLT 294
 83   IF(Z(II).GT.ZBN+(R(II)-RN)*TB) GO TO 84                                   TPLT 295
      Y=10.*(1.-Z(II)/ZMAX)$IF(Z(II).EQ.ZBN+(R(II)-RN)*TB.AND.ZST0R(L).LTPLT 296
     1T.0.0) IPR=1                                                              TPLT 297
      X=R(II)*RSCALE$IF(Z(II).EQ.ZBN+(R(II)-RN)*TB.AND.IRI.EQ.1)IJT=1           TPLT 298
      GO TO 86                                                                  TPLT 299
 84   DZ=Z(II)-(ZBN+(R(II)-RN)*TB)                                              TPLT 300
      ZP=Z(II)-2.*DZ/(1.+TB**2)   $ RP=R(II)                                    TPLT 301
      IF(TB.NE.0.) RP=RP+2.*DZ/(TB+1./TB) $Y=10.*(1.-ZP/ZMAX)                   TPLT 302
      IF(ZP.EQ.ZBN+(RP-RN)*TB.AND.ZST0R(L).LT.0.)IPR=1                          TPLT 303
      IF(ZP.EQ.ZBN+(RP-RN)*TB.AND.IRI.EQ.1) IJT=1 $X=RP*RSCALE                  TPLT 304
      IF (IBT.EQ.1.AND.NID.NE.1.OR.IST.EQ.1) GO TO 86                           TPLT 305
      IF (NID.NE.1) GO TO 187                                                   TPLT 306
      IF (IPR.EQ.1.OR.ZST0R(L).GE.0.0) GO TO 86                                 TPLT 307
187   IF (II.EQ.N) GO TO 186                                                    TPLT 308
      DZS=Z(II+1)-(ZBN+(R(II+1)-RN)*TB)                                         TPLT 309
      ZPS=Z(II+1)-2.*DZS/(1.+TB**2)                                             TPLT 310
```

```
5A                                                                    04/05/72

      IF (ZP.GE.ZPS.AND.NID.EQ.1.OR.DZS.LE.0.0.AND.NID.EQ.1) IPR=1      TPLT 311
      IF (ZP.GE.ZPS.AND.NID.NE.1.OR.DZS.LE.0.0.AND.NID.NE.1) IJT=1      TPLT 312
      GO TO 86                                                          TPLT 313
  100 IF (IPR.EQ.0.AND.ZSTOR(L).LT.0.0) IPR=1                           TPLT 314
      IF (IJT.EQ.0.AND.ZSTOR(L+1).LT.0.0.AND.NID.NE.1) IJT=1            TPLT 315
   80 IP=2                                                              TPLT 316
      IF(Y.LT.10.,AND.Y.GT.0.) GO TO 87                                 TPLT 317
      IP=3                                                              TPLT 318
      Y=AMIN1(10.,AMAX1(Y,0.))                                          TPLT 319
   87 IF(X.LT.AL+1..AND.X.GE.-.01) GO TO 88                             TPLT 320
      IP=3                                                              TPLT 321
      X=AMIN1(AL+1.,AMAX1(X,0.))                                        TPLT 322
   88 IF (IJT.EQ.0.AND.IRI.EQ.1.AND.IST.EQ.0)IP=3 $ CALL PLOT(X+3.,Y,IP)TPLT 323
      IR=IN $ IF(IJT.EQ.1) IRT=1 $ IF (IPR.EQ.1) GO TO 91               TPLT 324
   89 CONTINUE                                                          TPLT 325
   91 ZR9=ZRN  $  ZR=ZN                                                 TPLT 326
      TR=TN                                                             TPLT 327
   90 RR=RN                                                             TPLT 328
      RETURN                                                            TPLT 329
      END                                                               TPLT 330
```

```
                                                                                 04/05/72        ED      0
5    RAYPLOT
                                              IDENT      RAYPLOT

   PROGRAM LENGTH                    01377
   ENTRY POINTS      RAYPLOT         00065
   BLOCK NAMES
                     INFO            07647
   EXTERNAL SYMBOLS
                     01010100
                     Q8Q0ICT.
                     PLOT
                     MIN1F
                     MAX1F
```

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.

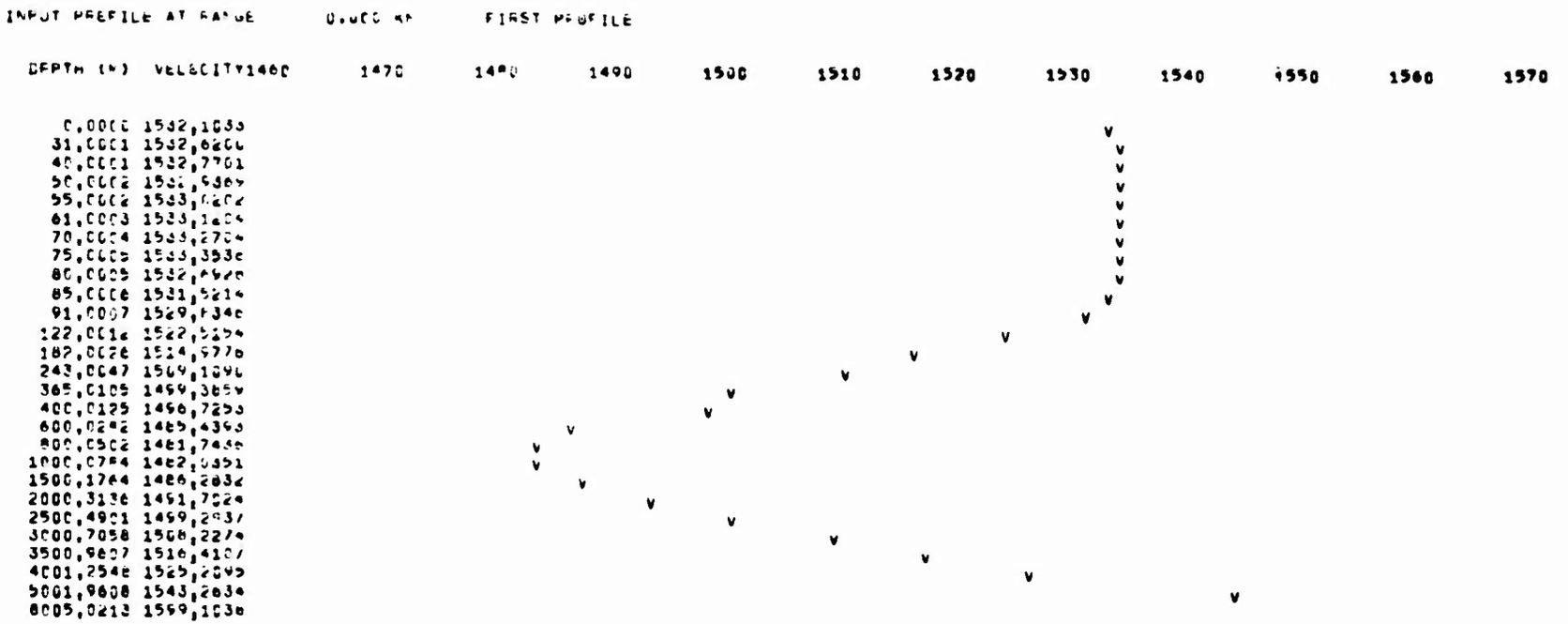


Fig. B1a — Input profile at 0 km

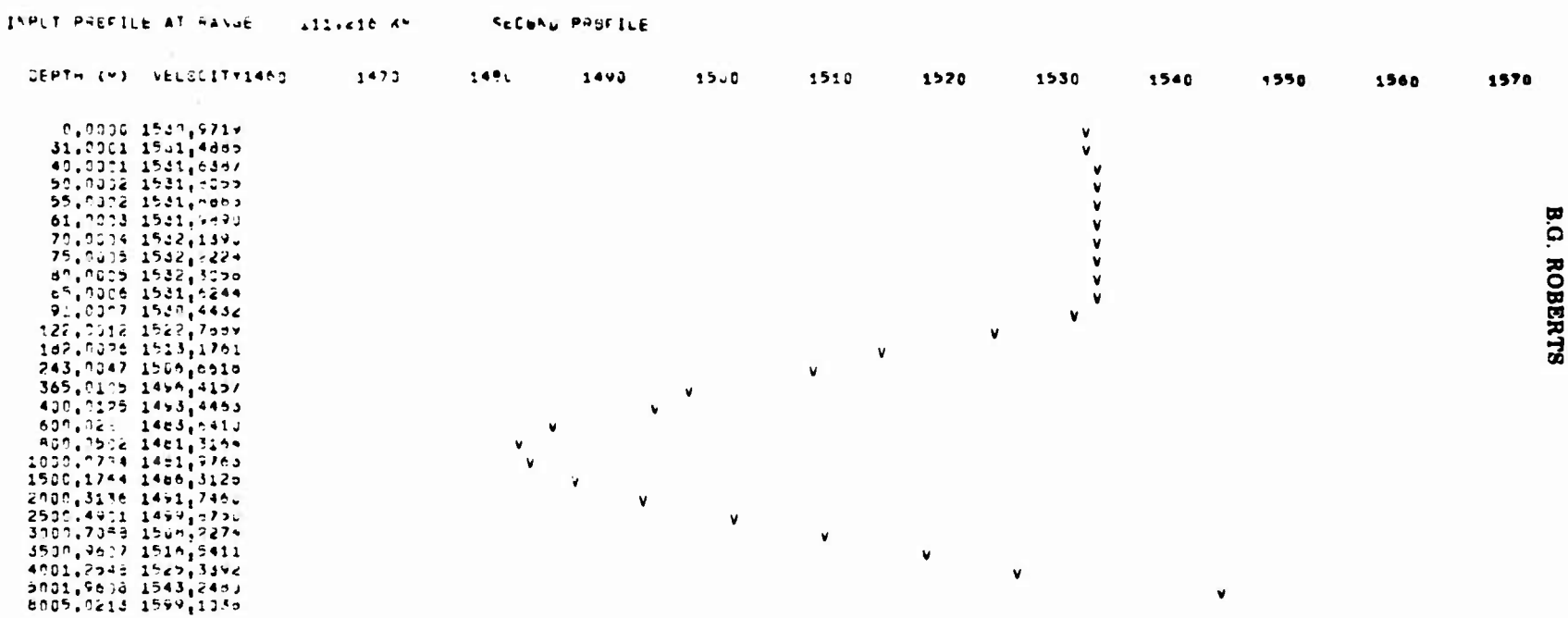


Fig. B1b — Input profile at 111.216 km

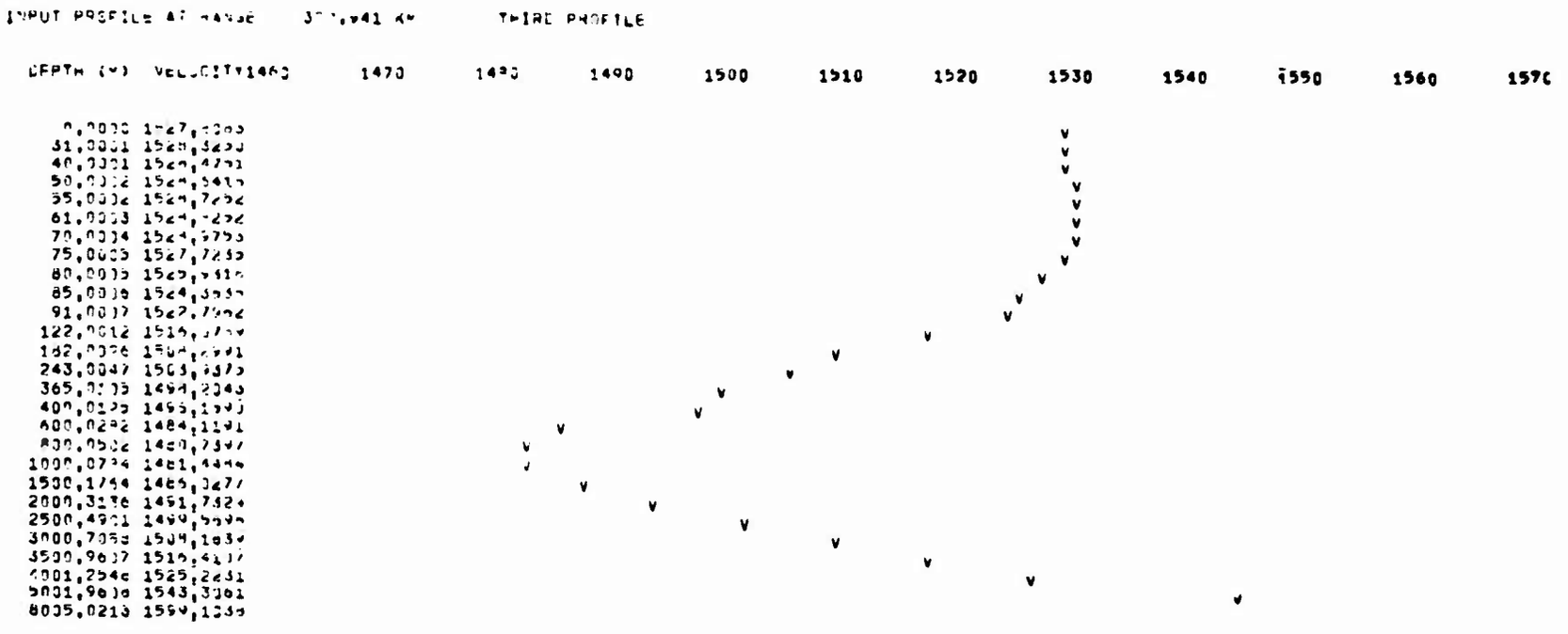


Fig. B1c — Input Profile at 329.941 km

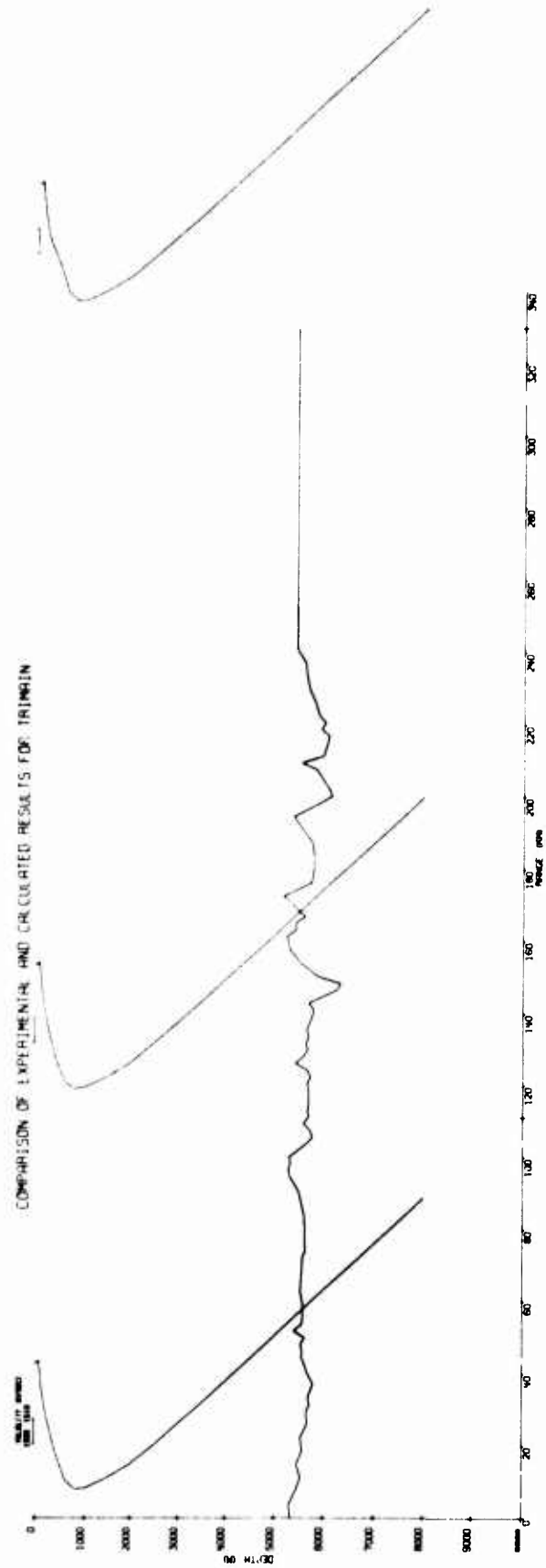


Fig. B2 — Profiles and Bottom Track

CALCULATED RESULTS

RANGE	LOSSES
1,000	88,400
2,000	83,400
3,000	86,800
4,000	88,500
5,000	89,700
6,000	78,400
7,000	83,200
8,000	85,800
9,000	87,900
10,000	83,400
11,000	87,100
12,000	87,000
13,000	87,400
14,000	87,200
15,000	87,400
16,000	87,500
17,000	87,100
18,000	87,700
19,000	87,400
20,000	88,700
21,000	88,100
22,000	88,200
23,000	88,100
24,000	88,200
25,000	88,700
26,000	88,600
27,000	90,500
28,000	90,900
29,000	90,800
30,000	90,400
31,000	90,700
32,000	90,000
33,000	89,300
34,000	88,100
35,000	87,100
36,000	87,000
37,000	87,200
38,000	87,600
39,000	87,600
40,000	87,900
41,000	87,900
42,000	88,500
43,000	89,500
44,000	89,900
45,000	90,100
46,000	89,200
47,000	88,300
48,000	86,700
49,000	85,200
50,000	83,600
51,000	83,300
52,000	83,400
53,000	83,700
54,000	83,900
55,000	84,100
56,000	84,000
57,000	83,600
58,000	82,700
59,000	82,200

60,000	87,800	120,000	91,300	180,000	98,700	240,000	105,800	
61,000	83,800	121,000	92,300	181,000	100,300	241,000	106,100	
62,000	84,900	122,000	94,000	182,000	102,400	242,000	105,800	
63,000	89,400	123,000	95,800	183,000	103,900	243,000	104,900	
64,000	86,100	124,000	96,900	184,000	106,200	244,000	103,300	
65,000	86,700	125,000	97,000	185,000	107,800	245,000	101,300	
66,000	87,200	126,000	96,600	186,000	108,100	246,000	98,900	
67,000	89,000	127,000	98,300	187,000	106,500	247,000	96,500	
68,000	90,900	128,000	100,200	188,000	105,300	248,000	94,200	
69,000	92,800	129,000	101,500	189,000	106,900	249,000	94,000	
70,000	92,700	130,000	101,600	190,000	105,800	250,000	94,100	
71,000	92,400	131,000	102,400	191,000	102,900	251,000	94,300	
72,000	92,800	132,000	103,600	192,000	102,600	252,000	94,200	
73,000	92,800	133,000	105,600	193,000	101,800	253,000	94,200	
74,000	92,900	134,000	107,800	194,000	101,800	254,000	93,700	
75,000	94,000	135,000	107,900	195,000	100,300	255,000	93,400	
76,000	93,500	136,000	105,700	196,000	98,000	256,000	92,800	
77,000	92,300	137,000	104,600	197,000	97,200	257,000	92,400	
78,000	92,300	138,000	110,600	198,000	96,000	258,000	92,600	
79,000	93,800	139,000	112,400	199,000	94,500	259,000	92,900	
80,000	95,300	140,000	110,700	200,000	93,000	260,000	93,100	
81,000	95,000	141,000	107,400	201,000	92,700	261,000	93,800	
82,000	94,600	142,000	106,100	202,000	92,800	262,000	94,100	
83,000	96,000	143,000	106,000	203,000	92,400	263,000	94,000	
84,000	98,200	144,000	104,100	204,000	92,800	264,000	94,500	
85,000	98,000	145,000	101,400	205,000	92,500	265,000	95,000	
86,000	100,800	146,000	98,900	206,000	92,400	266,000	95,800	
87,000	103,000	147,000	97,600	207,000	92,100	267,000	96,500	
88,000	103,800	148,000	97,400	208,000	91,500	268,000	97,000	
89,000	102,800	149,000	96,300	209,000	91,200	269,000	98,100	
90,000	100,300	150,000	94,600	210,000	91,300	270,000	99,200	
91,000	101,800	151,000	92,600	211,000	91,800	271,000	100,100	
92,000	104,500	152,000	90,800	212,000	92,000	272,000	100,600	
93,000	106,700	153,000	90,700	213,000	92,400	273,000	100,600	
94,000	107,500	154,000	90,800	214,000	92,900	274,000	100,300	
95,000	106,900	155,000	90,800	215,000	93,700	275,000	99,500	
96,000	105,500	156,000	90,600	216,000	94,400	276,000	98,100	
97,000	103,200	157,000	90,600	217,000	95,200	277,000	96,400	
98,000	100,500	158,000	90,300	218,000	95,500	278,000	95,700	
99,000	98,000	159,000	90,000	219,000	96,700	279,000	96,000	
100,000	95,900	160,000	89,300	220,000	96,000	280,000	95,800	
101,000	93,900	161,000	89,100	221,000	96,400	281,000	96,600	
102,000	91,900	162,000	89,500	222,000	96,400	282,000	96,700	
103,000	90,300	163,000	89,800	223,000	96,200	283,000	96,100	
104,000	88,500	164,000	90,400	224,000	95,900	284,000	95,500	
105,000	87,900	165,000	90,900	225,000	95,700	285,000	95,100	
106,000	87,900	166,000	91,700	226,000	95,100	286,000	95,300	
107,000	87,800	167,000	92,500	227,000	95,700	287,000	94,800	
108,000	87,700	168,000	92,500	228,000	95,500	288,000	96,000	
109,000	87,800	169,000	92,700	229,000	95,200	289,000	96,900	
110,000	87,600	170,000	92,700	230,000	94,500	290,000	97,400	
111,000	87,300	171,000	93,100	231,000	93,800	291,000	97,700	
112,000	87,100	172,000	93,300	232,000	94,000	292,000	98,100	
113,000	86,900	173,000	93,500	233,000	94,000	293,000	97,700	
114,000	87,100	174,000	93,200	234,000	94,500	294,000	97,600	
115,000	87,100	175,000	93,500	235,000	95,100	295,000	101,500	
116,000	87,200	176,000	93,200	236,000	95,400	296,000	102,600	
117,000	87,400	177,000	92,800	237,000	96,800	297,000	102,400	
118,000	87,500	178,000	93,300	238,000	97,000	298,000	102,200	
119,000	88,800	179,000	93,300	239,000	97,900	299,000	101,100	
120,000	89,800	180,000	93,200	240,000	98,700	300,000	99,500	
121,000	90,300	181,000	93,500	241,000	100,700	301,000	97,600	
122,000	90,700	182,000	95,000	242,000	102,700	302,000	95,600	
123,000	91,000	183,000	96,100	243,000	104,100	303,000	95,200	
124,000	91,100	184,000	97,900	244,000	105,000	304,000	95,200	
125,000	91,200	185,000	98,900	245,000	105,900	305,000	95,300	

Fig. B3a — Calculated intensity values

EXPERIMENTAL RESULTS

RANGE	LOSSES
2,515	90,630
3,966	92,250
5,258	92,160
6,469	93,130
8,901	90,630
9,773	91,880
10,744	93,370
12,916	96,000
13,467	95,370
14,859	92,620
16,951	96,500
19,460	96,750
21,951	94,870
22,403	97,750
23,774	98,250
25,146	97,000
26,518	98,000
27,969	99,500
29,961	91,120
30,432	98,870
32,004	98,250
33,376	97,750
36,576	96,620
37,948	98,370
39,319	91,880
40,491	90,750
42,962	91,500
43,434	92,250
46,177	92,500
47,549	91,750
48,920	97,620
53,761	91,120
55,093	90,000
56,464	92,000
57,936	93,500
62,746	98,750
64,118	94,380
65,469	98,620
66,970	96,000
68,283	94,120
69,723	95,370
71,095	97,370
72,466	97,370
75,209	95,370
76,581	98,370
77,953	95,120
79,324	96,880
80,696	98,000
82,067	97,870
83,439	98,130
86,182	98,000
87,554	96,880
88,965	96,500
90,297	98,130
91,669	98,500
93,040	99,500
94,412	98,620
95,763	93,370
97,155	98,750
98,567	98,750
99,958	96,120
102,441	96,500
104,913	95,870
105,365	96,620
106,756	98,370
108,128	91,880
109,499	97,500
110,871	93,620
112,243	92,000
113,614	91,250
114,986	91,120
116,357	89,500
117,939	97,120
119,210	95,000
120,582	92,870
121,954	98,870
123,325	93,370
124,697	94,260
126,068	104,120
127,440	108,870
128,912	111,120
130,183	113,120
131,555	112,620
133,502	114,370
136,246	110,750
137,617	110,500
138,989	109,620
140,360	112,250
141,732	111,500
143,104	112,120
144,475	111,750
145,847	111,500
147,218	110,370
149,276	107,500
150,447	105,750
152,919	101,870
153,391	99,750
154,762	98,120
157,505	97,370
158,977	96,000
160,249	93,130
161,620	93,250
162,992	93,500
166,878	95,120
168,250	96,120
170,993	93,250
172,364	92,500
173,736	92,620
175,108	94,120
176,479	97,870
177,951	98,500
179,222	95,120
180,594	99,380
183,764	98,130
185,166	93,130
186,538	98,500
188,585	100,500
195,906	102,620
201,278	102,620
202,449	101,620
204,021	102,500
205,393	98,370
206,764	96,880
208,136	95,870
209,507	96,500
210,879	95,370
213,612	94,500
216,356	96,500
217,427	95,750
218,999	97,620
220,370	97,620
221,742	98,620
223,114	96,620
224,485	94,750
225,857	96,500
227,228	98,500
230,260	100,120
231,572	96,120
232,943	94,870
234,315	97,000
235,687	96,620
237,058	97,750
238,430	102,250
239,801	100,370
241,173	104,500
242,545	99,380
243,916	97,750
246,888	103,250
248,631	104,750
251,003	104,250
252,374	103,870
253,746	101,620
255,118	102,000
256,489	102,250
257,961	101,250
259,232	99,120
260,604	97,370
262,850	97,000
264,262	98,370
265,633	98,500
267,005	99,250
268,376	99,500
269,748	99,380
271,160	98,130
272,491	97,120
273,963	97,000
275,284	98,370
276,606	100,250
283,117	96,750
284,489	96,120
285,860	99,380
287,231	99,500
288,612	98,620
289,975	101,870
291,346	103,500
292,718	101,750
294,089	99,500
295,461	97,750
298,720	103,120
300,152	106,120
301,523	102,870
302,895	98,250
304,267	96,250
305,638	99,870
307,010	100,620

Fig. B3b — Experimental intensity values

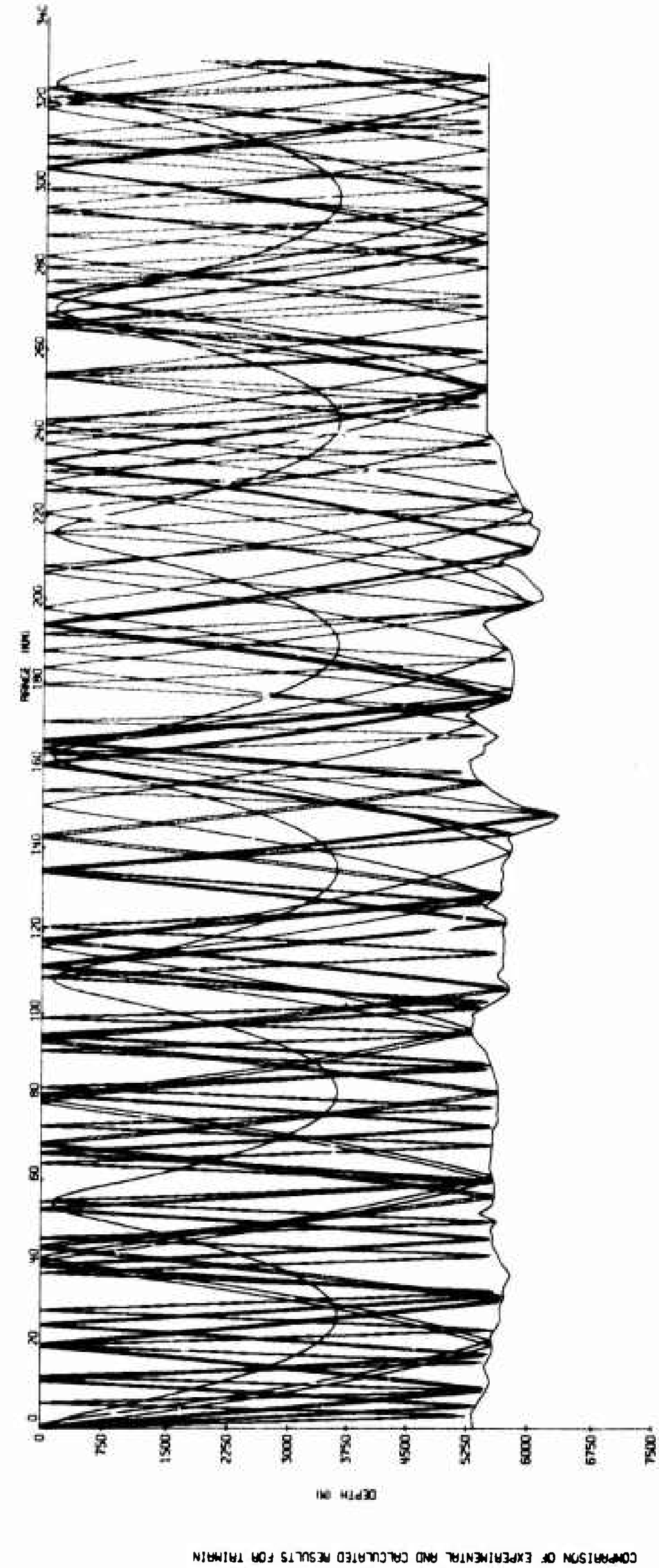


Fig. B4 — Selected rays which were traced (one ray every 15°)

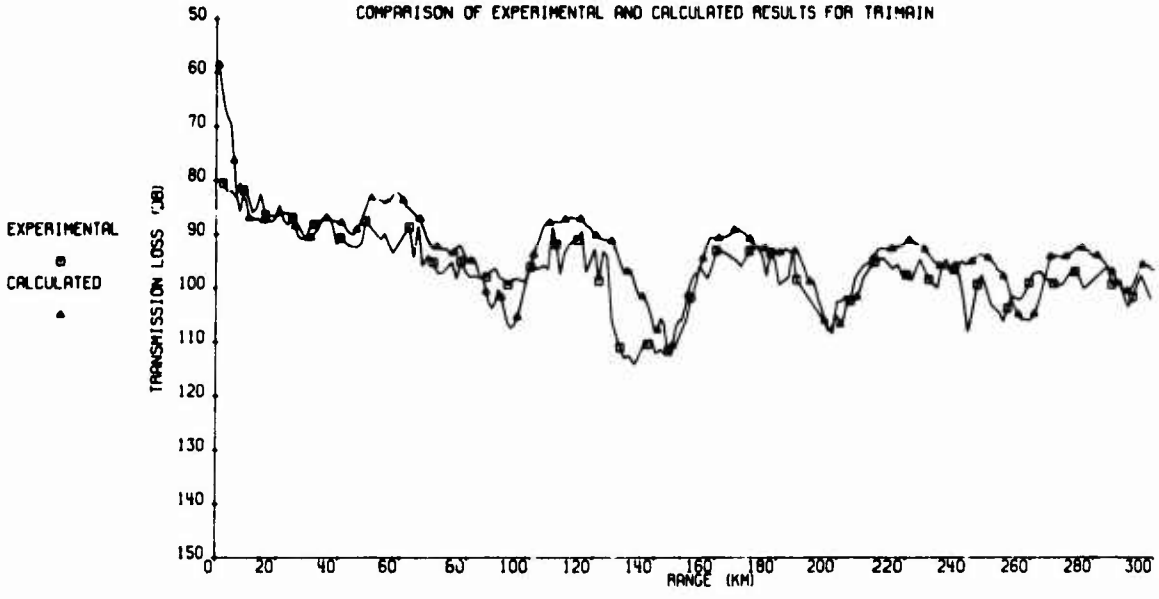


Fig. B5 — Comparison of experimental and calculated intensity values