NRL Report 7993

UNCLASSIFIED

Computer Programs for Obtaining Sound Speeds From Digitized Environmental Data

DAVID A. NUTILE

Propagation Branch
Acoustics Division

June 28, 1976

NAVAL RESEARCH LABORATORY
Washington, D.C.

Approved for public release; distribution unlimited.

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

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NRL Report 7993	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* COMPUTER PROGRAMS FOR OBTAINING SOUND SPEEDS FROM DIGITIZED ENVIRONMENTAL DATA		5. TYPE OF REPORT & PERIOD COVERED Interim report on a continuing NRL problem. 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)* David A. Nutile		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 XF52-552-701, 70107, 62759N, S01-64.201
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Electronic Systems Command Washington, D.C. 20360		12. REPORT DATE June 28, 1976 13. NUMBER OF PAGES 76
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)*

Data flow system	Nansen casts	Temperature
Digital temperature data	Oceanographic data	Water masses
Fortran computer programs	Salinity	
Gnomonic projection	Sound Speed	

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

A system of programs has been written in Fortran for obtaining sound speeds in meters per second from digitized depth vs temperature data, in most cases XBT's. Six separate programs were used to allow for human decisions at key steps in the process to ensure reliable results. Archival Nansen-cast data were used to calculate the grouped, averaged salinities. These values, along with the temperature data, are used to calculate sound speed from Leroy's second formula. Report-quality plots of the temperature and sound speed profiles are produced. This report

(Continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601 |

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

20. Abstract (Continued)

explains the steps used, describes the programs completely, and gives examples of the outputs provided.

UNCLASSIFIED

CONTENTS

1.0 INTRODUCTION 1

1.1 Objectives 1

1.2 Assumptions 3

2.0 SYSTEM ORGANIZATION 6

2.1 Introduction 6

2.2 Area Survey (XBTCHT) 6
2.2.1 Program Control Cards 6
2.2.2 Input Control and Data Cards 7
2.2.3 Subroutine GNOMONIC 9
2.2.4 Program XBTCHT Fortran Source Listing 9
2.2.5 Sample Output 14

2.3 Nansen-Cast Data Plot (ARCPLT) 17
2.3.1 Water Masses 17
2.3.2 Program Control Cards 17
2.3.3 Input Control Cards 17
2.3.4 Program ARCPLT Fortran Source Listing 18
2.3.5 Sample Output 25

2.4 Statistics and Multiple Plots (VDTSMUPT) 26
2.4.1 Program Control Cards 31
2.4.2 Input Control Cards 31
2.4.3 Program VDTSMUPT Fortran Source Listing 33
2.4.4 Sample Output 43

2.5 Sound Speed Calculations and Plots (SSCPDN) 49
2.5.1 Leroy's Second Formula 50
2.5.2 Depth vs Salinity 50
2.5.3 Program Control Cards 50
2.5.4 Input Control and Data Cards 51
2.5.5 Program SSCPDN Fortran Source Listing 54
2.5.6 Sample Output 59

2.6 Report Plots (XREPDN and SSDSDN) 62
1. Program XREPDN 63
2.6.1 Program Control Cards 63
2.6.2 Data Cards 63
2.6.3 Program XREPDN Fortran Source Listing 63
2.6.4 Sample Output 64

CONTENTS (Continued)

2. Program SSDSDN 65
2.6.5 Program Control Cards 65
2.6.6 Input Control and Data Cards 65
2.6.7 Program SSDSDN Fortran Source Listing 66
2.6.8 Sample Output 70

3.0 CONCLUSION 71

4.0 REFERENCES 72

UNCLASSIFIED

COMPUTER PROGRAMS FOR OBTAINING SOUND SPEEDS FROM DIGITIZED ENVIRONMENTAL DATA

1.0 INTRODUCTION

1.1 Objectives

The planning and analysis of many underwater acoustic experiments require highly accurate knowledge of the sound-speed structure of the ocean. The most common method for finding sound speed structure is to take depth vs temperature data, in most cases Expendable Bathythermographic (XBT) casts, during the experiment. The XBT data are later converted to sound speed profiles, using the measured temperature profile and salinity obtained from a variety of sources.

This report presents a data flow system (Fig. 1) that uses six separate Fortran programs which culminate in the calculation of sound speed profiles from digitized temperature data. Six separate programs were used because it is important to be able to make decisions at key steps in the process, to insure that values of the sound speed are reliable.

The data flow system allows the user a great degree of latitude in meeting his particular requirements. As a whole it gives a step-by-step method for obtaining sound-speed profiles. Starting with a data tape that has comprehensive sets of environmental (Nansen-cast) data extracted from the National Oceanographic Data Center (NODC) files by Program SEARCHSF [1], the user may obtain the following information.

1. A chart showing the location of each archival Nansen cast near the ship's track, as well as the locations of the temperature profiles supplied by the investigator. (Sec. 2.2)

2. Individual plots of the Nansen-cast data extracted from NODC tapes. (Sec. 2.3)

3. Multiple plots of the Nansen-cast profiles grouped by the user to characterized distinct oceanographic regions. These data are also used to calculate sound-speed statistics, mean, standard deviation, etc. of the region, and to make a depth vs average salinity punched card deck for use in sound-speed calculations. The sound-speed statistics may be used in the process of extending existing profiles to the ocean bottom. (Sec. 2.4)

4. A sound-speed table and plot calculated from the temperature data and from the average salinity obtained in item 3. If preferred, the user's salinity data may be employed instead. Also, the salinity used in the sound-speed calculation may be obtained from T-S curves or depth-salinity profiles. (Sec. 2.5)

The profile plots can include a plot of one standard deviation in sound speed above and below the mean sound speeds, for comparison with the calculated sound speed. These curves can be used to extend shallow sound-speed profiles to the full ocean depth.

Note: Manuscript submitted March 16, 1976.

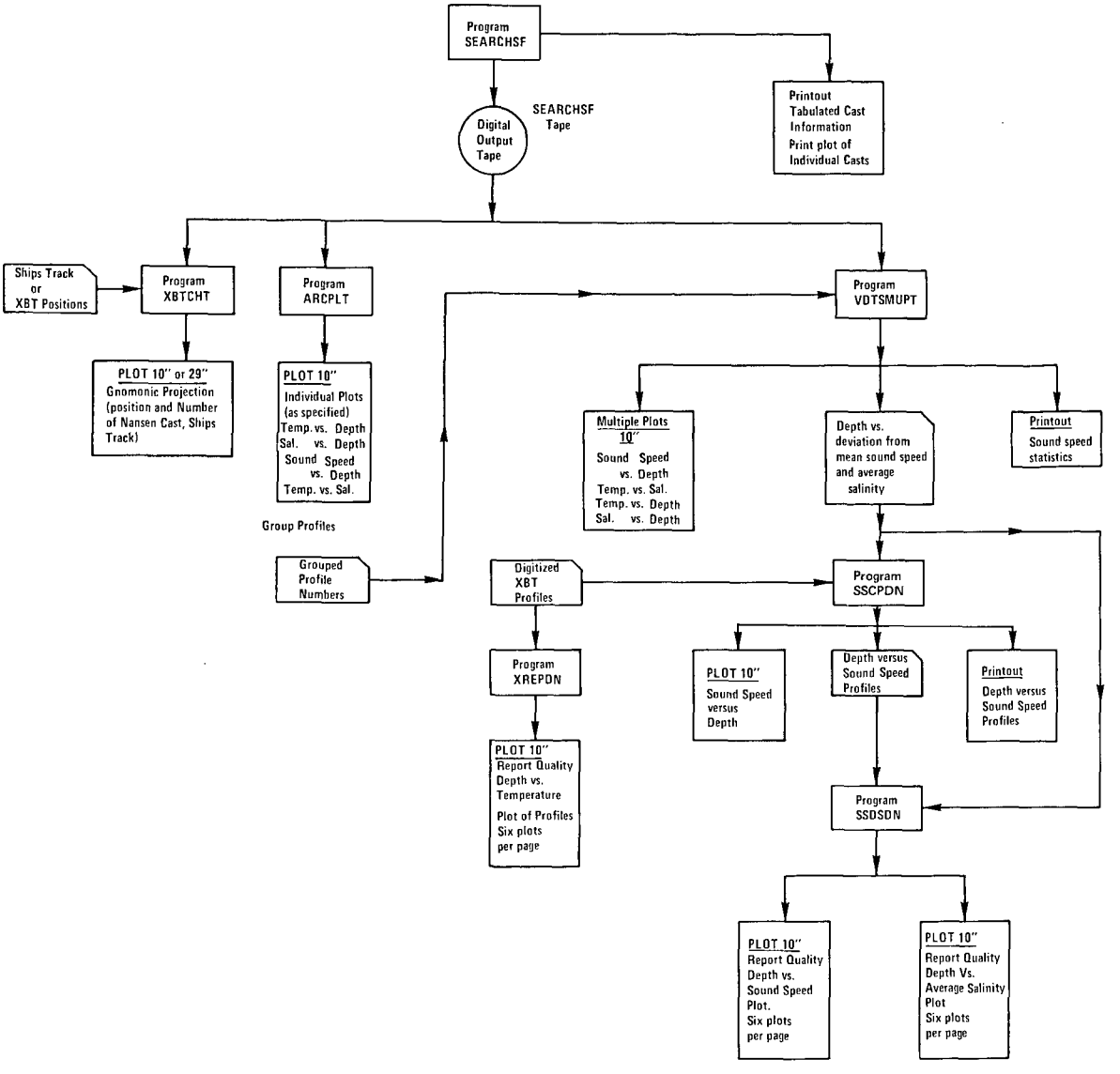

Fig. 1 — Program flow diagram

5. The temperature profiles, plotted six to a page, having the quality for use as illustrations in a report. (Sec. 2.6)

6. The sound-speed profiles, plotted six to a page; and/or the average salinity profiles, plotted three to a page. (Sec. 2.6)

Any item may be used separately or in any combination with the other items. If, for example, the user wishes to survey a proposed area, he would use item 1, or if he wished to use his own temperature-salinity data he would use item 4. In this report each item will

UNCLASSIFIED

be presented along with a description of the program used, input control and data cards needed, Fortran listing of the program, and a sample output. All of the programs were designed to be run on the CDC 3800 computer, but they were written with easy conversion to Texas Instruments ASC Fortran in mind. Where the program output is a plot, a digital tape is written for off-line plotting and retention.

1.2 Assumptions

All higher order sound-speed formulae require a value for salinity. While not the most important variable, values of salinity can significantly affect the calculated value of sound speed. The National Oceanographic Data Center (NODC) possesses an extensive collection of Nansen-cast data. This data bank is written on digital tapes and is an excellent historical source of temperature, velocity, and salinity data from around the world.

A computer program, SEARCHSF (Search Sound Speed File), written in Fortran, has been developed and reported [1] at the Laboratory. This program has output options of digital tape or tabulated printout (Fig. 2), and printed profile plots, which can be used in test cases. The digital tape of Nansen casts generated by SEARCHSF, referred to as the SEARCHSF tape, is used as input to the system reported here to obtain average values of salinity and sound-speed statistics of a given area. The SEARCHSF tape can have multiple files written on it, and to when choosing program parameters care must be taken to not read past the last file on the tape.

The tabulated printout of SEARCHSF includes a variable identified as IDENTR (Fig. 2). This variable is a record index count and is used as an input parameter in the programs which use the SEARCHSF tape.

The depth vs temperature data must have the following punch card format.

Card 1: blank card

Card 2: profile title card

Variable	Column	Format	Description
NUM	2-4	I3	user-assigned temperature profile number
JD	6-8	I3	Julian day
IMO	10-11	I2	month
IDA	13-14	I2	day of the month
IHR	16-17	I2	hour (ZULU)
IMN	19-20	I2	minute

RANGE	DIST1	MSOR	DEG	LATITUDE			LONGITUDE			MONTH	YEAR	FOBDH	NO. POINTS	ADDRESS	IDENTR
0,000	48,518	43	71	17	0	N	61	0	W	4	1960	3325	28	3360	1
0,000	100,686	43	62	16	58	N	62	6	W	4	1951	300	12	2688	2
0,000	102,734	43	72	17	22	N	62	13	W	4	1951	300	12	4032	3
0,000	116,895	43	61	16	34	N	61	58	W	4	1951	300	12	1344	4
0,000	148,103	43	72	17	32	N	62	38	W	5	1938	500	14	4704	5
0,000	172,021	42	69	16	45	N	59	46	W	5	1965	973	18	0	6
0,000	181,641	43	62	16	43	N	62	49	W	4	1938	1000	19	2016	7
104,237	96,047	43	81	18	6	N	61	52	W	5	1938	3000	28	5376	8
163,299	169,065	43	82	18	23	N	62	22	W	4	1951	300	12	6048	9
166,881	111,993	42	89	18	13	N	59	57	W	5	1965	981	18	672	10
197,427	134,096	43	92	19	0	N	62	0	W	6	1960	6551	30	7392	11
203,685	39,912	43	91	19	12	N	61	5	W	5	1957	6020	31	6720	12
302,025	162,462	79	2	20	0	N	62	0	W	6	1960	5127	30	16128	13
337,329	25,643	79	0	20	13	N	60	7	W	5	1965	951	17	15456	14
593,407	131,104	79	20	22	43	N	60	54	W	6	1952	118	7	16800	15
814,372	99,216	78	48	24	6	N	58	6	W	4	1957	5846	30	9408	16
819,604	148,204	78	37	23	57	N	57	39	W	6	1954	3399	28	8064	17
871,391	21,402	78	48	24	51	N	58	39	W	4	1957	5506	30	8736	18
876,941	53,489	78	48	24	48	N	58	20	W	6	1954	3202	26	10080	19
945,426	41,717	78	59	25	39	N	59	2	W	6	1954	3384	28	11424	20
945,624	81,171	78	59	25	44	N	59	25	W	4	1957	3145	28	10752	21
1010,384	112,124	78	69	26	21	N	59	32	W	6	1954	3430	28	12768	22
1032,785	162,223	78	69	26	37	N	59	58	W	4	1957	6131	31	12096	23
1191,365	87,310	78	77	27	24	N	57	4	W	5	1922	1000	19	13440	24
1370,554	16,195	78	97	29	15	N	57	30	W	5	1961	6060	31	14112	25
1398,371	89,775	78	98	29	40	N	58	9	W	4	1950	3396	26	14784	26
1447,657	126,227	114	8	30	10	N	58	22	W	4	1950	2961	27	18144	27
1559,264	73,698	114	17	31	1	N	57	29	W	6	1959	5309	30	19488	28
1620,322	116,510	114	5	30	59	N	55	24	W	4	1949	2712	19	17472	29
1659,842	169,612	114	28	32	5	N	58	9	W	4	1949	2196	25	23520	30

Fig. 2 — Tabulated printout from program SEARCHSF

UNCLASSIFIED

Variable	Column	Format	Description
*NPB	22-23	A2	XBT probe type (ex. T5,T7) if applicable
*TMF	25-28	F4.1	surface temperature (C)
LA	30-31	I2	latitude degrees
LAM	33-34	I2	latitude minutes
*LAB	35	A1	N or S
*LO	37-39	I3	longitude degrees
*LOM	41-42	I2	longitude minutes
*LOB	43	A1	E or W
*NPP	45-46	A2	type of paper used in XBT recorder, if applicable
*ITC	48-49	A2	temperature code, if applicable
*MSQ	50-52	I3	Marsden square number
*MDSQ	60-61	I2	one degree square number
*BLT	70-73	F4.1	base line temperature, if applicable
IGS	77-78	I2	salinity group number (will be fully explained in Section 2.5)
ICOF	80	I1	=0, if there is a question as to the accuracy of the temperature profile
			=1, if the profile is good

CAUTION: Variables marked with an asterisk (*) are not necessary for running the programs and are only included for completeness. They may be left blank on the card.

Card 3: blank card

Card 4 to N: depth vs temperature cards

Variable	Column	Format	Description
NOM	2-4	I3	temperature profile number, the same as NUM
IDT(I)	5-9	I5	depth (m)
TT(I)	10-15	F6.2	temperature (C)
IDT(I)	16-20 etc.		six pairs of depth vs temperature values are
TT(I)	21-26 etc.		entered on a card

Card N+1: blank card

Procedures:

Repeat cards 2 through N+1 for all profiles. This deck is referred to as the temperature profile deck.

2.0 SYSTEM ORGANIZATION

2.1 Introduction

Section 2.0 gives a detailed description of each step in the system. The computer programs are presented along with their control cards, input formats, and output options. Typical outputs are presented as examples.

2.2 Area Survey

A key step in the system presented is choosing those Nansen-cast profiles that will go into the calculation of average sound speeds and average salinity. Of major assistance in making these choices is a chart of the area under consideration, showing the positions of the Nansen casts retrieved as well as the position where the temperature profiles were taken. If preferred, a ship's track may be substituted for the profile's position. This is done by program XBTCHT, which constructs such a chart having a gnomonic projection on a 10- or 29-in. Calcomp plotter.

2.2.1 *Program Control Cards (XBTCHT)*

$^{7}_{9}$JOB,.....

$^{7}_{9}$EQUIP, 1=MT,HI,RO, (Title:SEARCHSF tape),DA

UNCLASSIFIED

$^{7}_{9}$EQUIP,10=**,WO,LO,DA (Plot tape)

$^{7}_{9}$FTN,L,X,R

Fortran source deck

SCOPE card

$^{7}_{9}$LOAD

$^{7}_{9}$RUN,.....

2.2.2 *Input Control and Data Cards*

Card 1: control card

Variable	Column	Format	Description
BOTLAT	1-6	F6.0	minimum latitude degrees (whole numbers) South= -, North= +
DLAT	7-12	F6.1	increment in degrees between BOTLAT and TOPLAT (ex. DLAT=1.0, one-degree increments)
TOPLAT	13-18	F6.0	maximum latitude degrees S= -, N= +
BOTLON	19-24	F6.0	minimum longitude degrees W= -, E= +
DLON	25-30	F6.1	increment in degrees between BOTLON and TOPLON
TOPLON	31-36	F6.0	maximum longitude degrees W= -, E= +
CLAT	37-42	F6.1	latitude of point of tangency
CLON	43-48	F6.1	longitude of point of tangency
SCALE	49-54	F6.1	latitude scale in inches per degree at point of tangency
HTT	55-60	F6.1	height of symbols plotted at location of each Nansen cast and temperature position in inches (approximately .07 in.)

Variable	Column	Format	Description
IREC	61-65	I5	IDENTR number of last cast to be plotted on this chart
SN	66-70	F5.1	= -1.0; Nansen casts in the south latitude =1.0; Nansen cast in the north latitude
EW	71-75	F5.1	= -1.0; Nansen casts in the west longitude =1.0; Nansen casts in the east longitude
NPLOTTER	79-80	I2	=29; plotting on 29-in. plotter =10; plotting on 10-in. plotter
EOF			(end of file card) will terminate the program.

CAUTION: If the value of SCALE chosen is too large for the plotter, it will automatically be rescaled and plotted for maximum fit. More than one chart may be generated from a particular file of the SEARCHSF tape. For the last chart of a file, IREC may be specified larger than the last IDENTR number of the file; when this occurs, the program will encounter an EOF on the input tape and either loop back to Card 1 to read parameters for the next file chart or terminate the program. This method should not be used for the last file on the tape, in this case the exact value needed for IREC should be entered. It is assumed that all files generated will be plotted, so there is no provision for skipping files. Finally, the program as currently written will not plot Nansen-cast positions on a chart that crosses from north to south latitude or from east to west longitude; separate charts must be made.

Card 2 to N: temperature profile positions or ship's track

Variable	Column	Format	Description
XLAT	1-13	F13.9	latitude in degrees and fractions of a degree S= -, N= +
XLON	14-26	F13.9	longitude in degrees and fractions of a degree W= -, E= +
IXN	31-35	I5	number of temperature profile X symbol and number plotted at each location; if left blank no number will be plotted.

UNCLASSIFIED

Procedure:

XLAT less than -100.0 will signify the last card of the position deck. The program will then loop back to Card 1 for a new chart and will continue to do so until an EOF card terminates the program.

Run time for this program depends greatly on the chart size and number of positions to be plotted, but for most cases it should be less than 1 min. per chart, including compilation.

2.2.3 *Subroutine GNOMONIC* — A subroutine named GNOMONIC is employed to construct the chart and calculate plotting positions. This program was written by E.B. Wright, NRL Code 8167, and is well documented in the program listing, Sec. 2.2.4. It will require somewhat more work to convert GNOMONIC for the ASC machine, but this should cause no large problems.

2.2.4 *Program XBTCHT Fortran Source Listing*

```
      PROGRAM XBTCHT
      DIMENSION IBUF(2),IARR(28),PLTARRAY(254)
      CALL PLOTS(PLTARRAY,254,10,29)
      CALL PLOT(1.0,0.0,-3)
    1 BUFFER IN(1,1)(A,A)
    2 IF(UNIT,1)2,3,1,3
    3 READ 100,BOTLAT,DLAT,TOPLAT,BOTLON,DLON,TOPLON,CLAT,CLON,SCALE,HTT
     $,IREC,SN,EW,NPLOTTER
  100 FORMAT(1.F6.0,I5,2F5.1,3X,I2)
      IF(EOF,6.)500,4
    4 NH=4
      CALE=SCALE
      NS=0
    5 CALL GNOMONIC(BOTLAT,DLAT,TOPLAT,BOTLON,DLON,TOPLON,CLAT,CLON,SCAL
     $E,NH,NPLOTTER,PLOT HGT,XR)
      IF(SCALE.LT.CALE)GO TO 6
      GO TO 7
    6 CALE=SCALE
      GO TO 5
    7 READ 101,XLAT,XLON,IXN
  101 FORMAT(2F13.9,4X,I5)
      CALL COORDS(XLAT,XLON,X,Y)
      CALL PLOT(X,Y,3)
      CALL SYMBOL(X,Y,HTT,4,0.0,*2)
      IF(IXN.LT.1)GO TO 8
      CALL NUMBER(X+.03,Y,HTT,IXN,0.0,2HI3)
      CALL PLOT(X,Y,3)
      CALL PLOT(X,Y,2)
    8 READ 101,XLAT,XLON,IXN
      IF(XLAT.LT.-100.0)GO TO 9
      CALL COORDS(XLAT,XLON,X,Y)
      CALL SYMBOL(X,Y,HTT,4,0.0,*2)
      IF(IXN.LT.1)GO TO 8
      CALL NUMBER(X+.03,Y,HTT,IXN,0.0,2HI3)
```

```
      CALL PLOT(X,Y,3)
      CALL PLOT(X,Y,2)
      GO TO 8
    9 PRINT 150
  150 FORMAT(24H PLOT OF TRACK COMPLETED///)
      CALL PLOT(X,Y,3)
   10 BUFFER IN(1,1)(IBUF(1),IARR(28))
   11 IF(UNIT,1)11,12,13,12
   12 XLAT=SN*ABS(FLOAT(IARR(6))+(FLOAT(IARR(7))/60.0))
      XLON=EW*ABS(FLOAT(IARR(9))+(FLOAT(IARR(10))/60.0))
      CALL COORDS(XLAT,XLON,X,Y)
      CALL SYMBOL(X,Y,HTT,NS,0.0,-1)
      CALL NUMBER(X+.03,Y,HTT,IBUF(1),0.0,2HI3)
      IF(IBUF(1).LT.IREC)GO TO 10
      CALL PLOT(XR+14,0.0,0,-3)
      PRINT 151
  151 FORMAT(36H NANSEN CAST POSITION PLOT COMPLETED///)
      CALL SPACEDO
      GO TO 3
   13 CALL PLOT(XR+14,0.0,0,-3)
      CALL SPACEDO
      GO TO 1
  500 CALL SPACEDO
      CALL STOPPLOT
      END
```

```
      SUBROUTINE GNOMONIC(BOTLATT, DLATT, TOPLATT, BOTLONN, DLONN,
     1   TOPLONN, CLATT, CLONN, SCALE, NH, NPLOTTER,PLOT HGT,XR)
      COMMON/PROJECT/R,R SEC CLAT,TAN CLAT,XMIN,YMIN
      COMMON/TABLES/DUM(91),TANLAT(90),DIM(182),SINLON(90),COSLON(181)
      DATA(DEG=.0174532925 2),(RAD=57.2957795131)
      BOTLAT=BOTLATT    $   DLAT=DLATT    $   TOPLAT=TOPLATT
      BOTLON=BOTLONN    $   DLON=DLONN    $   TOPLON=TOPLONN
      CLAT=CLATT    $   CLON=CLONN
C***   SUBROUTINE FOR DRAWING A GNOMONIC CHART ON THE CALCOMP PLOTTER.
C*****   BOTLAT,DLAT,AND TOPLAT ARE THE MINIMUM,INCREMENT,AND MAXIMUM LATITUDES
C    FOR DRAWING THE AXES.  BOTLON,DLON AND TOPLON ARE LIKEWISE FOR LONGITUDE.
C    CLAT AND CLON ARE LATITUDE AND LONGITUDE OF THE POINT OF TANGENCY.  ALL OF
C    THESE LATITUDES AND LONGITUDES ARE IN DEGREES, WEST-,EAST+ AND SOUTH-,NORTH+
C*****   SCALE IS THE LATITUDE  SCALE IN INCHES/DEGREE AT THE POINT OF TANGENCY.
C    NH GIVES THE NUMBER HEIGHT IN MULTIPLES OF .035 INCHES.
C    NPLOTTER(10 OR 29) IS THE SIZE OF THE PLOTTER DRUM USED.
C*****   AFTER THIS SUBROUTINE IS CALLED, THE X AND Y COORDINATES OF A POINT
C    WITHIN THE CHART ARE CALCULATED BY THE CALL  CALL COORDS(XLAT,XLON,X,Y).
C    INPUT PARAMETERS XLAT AND XLON ARE THE LATITUDE AND LONGITUDE OF THE
C    DESIRED POINT IN DEGREES, AND THE COORDINATES WILL BE RETURNED AS X AND Y.
C*****************   CAUTIONS TO USER   ****************
C*****   THE INPUT PARAMETERS SPECIFYING LATITUDE AND LONGITUDE LIMITS SHOULD
C    ORDINARILY BE IN WHOLE NUMBERS. IF THEY ARE NOT,THEY WILL BE CHANGED BY THIS
C    SUBROUTINE TO THE NEXT LOWER OR HIGHER WHOLE NUMBERS.
C    IF THE INPUT SCALE IS TOO LARGE FOR THE PLOTTER SIZE SPECIFIED, THE VALUE
C    OF THIS PARAMETER WILL BE REPLACED BY THE LARGEST PERMISSIBLE SCALE AND
C    CONTROL WILL RETURN TO THE CALLING ROUTINE WITH NO PLOTTING DONE.
C    THEN GNOMONIC CAN BE CALLED AGAIN WITH REVISED SCALE PARAMETER.
C****   NOTE THAT SUBROUTINE COORDS DOES NOT CHECK WHETHER XLAT AND XLON SPECIFY
C    A POINT WITHIN THE CHART LIMITS.  IF THEY ARE MORE THAN 1/2 DEGREE OUTSIDE
C    THE COORDINATE CALCULATION WILL BE INCORRECT.
```

UNCLASSIFIED

```
C*****  ALSO NEITHER CLAT NOR TOPLAT MAY BE MORE THAN 88. DEGREES UNLESS A
C   POLAR PROJECTION IS DESIRED.  IN THAT CASE ABS(CLAT) MUST BE EXACTLY 90.
C*****   THE GNOMONIC PROJECTION IS FROM THE CENTER OF THE (SPHERICAL) EARTH
C   ONTO A TANGENT PLANE.  ALL GREAT CIRCLES WILL APPEAR AS STRAIGHT LINES ON
C   THE MAP.  THE PROJECTION IS NOT CONFORMAL, AND DISTORTION INCREASES WITH
C   DISTANCE FROM THE POINT OF TANGENCY.  IT IS USUALLY BEST TO CHOOSE A POINT
C   OF TANGENCY NEAR THE CENTER OF THE AREA BEING MAPPED.
C*****   PROGRAMMED JULY 1972 BY E B WRIGHT, NRL CODE 8167.
      PAPER=NPLOTTER
      H=.035*NH
      HALF H=.5*H
      R=SCALE*RAD
      SCALE LON=1.E+100
      SCALE NM=60./SCALE
C*****   FORMULAS CHOOSES THE EQUATIONS TO BE USED FOR COORDINATES.
      CALL FORMULAS(CLAT,CLON,X,Y)
      IF(ABSF(CLAT).EQ.90.)GO TO 10
      ARG=DEG*CLAT
      TAN CLAT=TANF(ARG)
      SEC CLAT=SQRT(TAN CLAT*TAN CLAT+1.)
      SCALE LON=SCALE/SEC CLAT
      R SEC CLAT=R*SEC CLAT
   10 PRINT 900,CLAT,CLON,BOTLAT,TOPLAT,DLAT,BOTLON,TOPLON,DLON
      PRINT 903,NH,H
      PRINT 902,SCALE,SCALE LON,SCALE NM
      DATELINE=0.
      IF(BOTLON.GT.TOPLON)DATELINE=1.
      E=0.
      IF(BOTLAT.LT.0.)E=.99
      BOTLAT=LAT1=BOTLAT-E
      E=.99
      IF(TOPLAT.LT.0.)E=0.
      TOPLAT=LAT2=TOPLAT+E
      E=0.
      IF(BOTLON.LT.0.)E=.99
      BOTLON=LON1=BOTLON-E
      E=.99
      IF(TOPLON.LT.0.)E=0.
      TOPLON=LON2=TOPLON+E
      IF(DATELINE.NE.0.)LON2=LON2+360
      DXLON=.02/SCALE
      NDXLON=(LON2-LON1)/DXLON+.5
C*****   TABLES TAN LAT, SIN LON, AND COS LON ARE FOR INTERPOLATION OF C
C   NOTE FILLING IN OF COTANGENTS IF TANGENCY IS AT LATITUDE 90.
      NLAT=LAT2-LAT1+1
      NNLAT=NLAT+2
      LAT=LAT1-1
      IF(CLAT.EQ.90.)LAT=89-LAT2
      IF(CLAT.EQ.-90.)LAT=-89-LAT2
      ARG=LAT*DEG
      DO 100 J=1,NNLAT
      TAN LAT(LAT)=TANF(ARG)
      LAT=LAT+1
  100 ARG=ARG+DEG
      NLON=LON2-LON1+1
      NNLON=NLON+2
      LON=LON1-1
```

```
      ARG=(LON-CLON)*DEG
      DO 200 I=1,NNLON
      SIN LON(LON)=SIN(ARG)
      COS LON(LON)=COS(ARG)
      IF(LON.EQ.181)LON=-179
      LON=LON+1
  200 ARG=ARG+DEG
      IF(DATELINE.EQ.0.)GO TO 201
      DIM=SINLON(179)
      DIM(2)=SINLON(180)
      DIM(3)=SINLON(181)
      DIM(91)=COSLON(179)
      DIM(92)=COSLON(180)
      DIM(93)=COSLON(181)
C*****   COMPUTE THE SIZE OF THE PLOT AND CHECK FOR FIT ON THE PLOTTER.
  201 XMIN=YMIN=0.
      CALL COORDS(BOTLAT,CLON,X0,Y0)
      CALL COORDS(BOTLAT,BOTLON,X1,Y1)
      CALL COORDS(TOPLAT,BOTLON,X2,Y2)
      CALL COORDS(TOPLAT,CLON,X ,Y3)
      CALL COORDS(TOPLAT,TOPLON,X4,Y4)
      CALL COORDS(BOTLAT,TOPLON,X5,Y5)
      BACKLON=CLON-90.
      FRONTLON=CLON+90.
      IF(BACKLON.LE.BOTLON)GO TO 202
      CALL COORDS(BOTLAT,BACKLON,X1,Y6)
      CALL COORDS(TOPLAT,BACKLON,X2,Y6)
  202 IF(FRONTLON.GE.TOPLON)GO TO 203
      CALL COORDS(BOTLAT,FRONTLON,X5,Y6)
      CALL COORDS(TOPLAT,FRONTLON,X4,Y6)
  203 XMIN=AMIN1(X0,X1,X2,X3,X4,X5)
      YMIN=AMIN1(Y0,Y1,Y2,Y3,Y4,Y5)
      PLOT LG=AMAX1(X0,X1,X2,X3,X4,X5)-XMIN
      PLOT HGT=AMAX1(Y0,Y1,Y2,Y3,Y4,Y5)-YMIN
      PRINT 901,PLOT LG,PLOT HGT,PAPER
      IF(PLOT HGT.GT.PAPER)GO TO 86
      YMIN=YMIN-H
C*****   THE LOOP ENDING AT 300 DRAWS AND NUMBERS THE MERIDIANS.
      XL=-3.*H
      IF(NLON.GT.80)XL=1.5*XL
      A=1.-1.2*XL/PLOT LG
      B=1.+4.*H/PLOT HGT
      YL=-2.5*H
      SLAT=BOTLAT+TOPLAT
      NDLON=DLON
      XLON=BOTLON-DLON
      XLAT=BOTLAT
      NDLAT=DLAT
      DO 300 I=1,NLON,NDLON
      XLON=XLON+DLON
      IF(XLON.GT.180.)XLON=XLON-360.
      CALL COORDS(XLAT,XLON,X,Y)
      IF(XLAT.NE.BOTLAT)GO TO 299
      LABEL=ABSF(XLON)
      CALL NUMBER(A*X+XL,B*Y+YL,H,LABEL,0.,2HI3)
  299 CALL PLOT(X,Y,3)
      XLAT=SLAT-XLAT
      CALL COORDS(XLAT,XLON,X,Y)
      CALL PLOT(X,Y,2)
      IF (X .GT. XR) XR = X
      IF (XLAT .NE. BOTLAT) GO TO 300
      LABEL = ABSF (XLON)
      CALL NUMBER(A*X+XL,B*Y+YL,H,LABEL,0.,2HI3)
```

UNCLASSIFIED

```
  300 CONTINUE
C*****   THE LOOP ENDING AT 500 DRAWS AND NUMBERS THE PARALLELS.
      IF(XLAT.GT.TOPLAT-.01)DLAT=-DLAT
      XLAT=XLAT-DLAT
      IF(NLON.GT.180)YL=-YL
      DO 500 I=1,NLAT,NDLAT
      XLAT=XLAT+DLAT
      CALL COORDS(XLAT,XLON,X,Y)
      IF (DXLON .GT. 0) GO TO 301
      LABEL = ABSF (XLAT)
      IF(LABEL.EQ.90.AND.NLON.GT.180)GO TO 301
      CALL NUMBER (X+YL,Y-HALF H,H,LABEL,0.,2HI2)
  301 CALL PLOT(X,Y,3)
      DO 400 J=1,NDXLON
      XLON=XLON-DXLON
      IF(XLON.LT.-180.)XLON=XLON+360.
      IF(XLON.GT.180.)XLON=XLON-360.
      CALL COORDS(XLAT,XLON,X,Y)
      IF (X .GT. XR) XR = X
  400 CALL PLOT(X,Y,2)
      IF(DXLON.LT.0.)GO TO 500
      LABEL=ABSF(XLAT)+.5
      IF(LABEL.EQ.90.AND.NLON.GT.180)GO TO 500
      CALL NUMBER(X+YL,Y-HALF H,H,LABEL,0.,2HI2)
  500 DXLON=-DXLON
C*****   PLOT TITLE AND MARK LOCATION OF TANGENCY
      HH=H
      IF(NH.GT.2)HH=HH-.035
C     CALL SYMBOL(-9.,-H,HH,24HNRL PREDICTIVE ACOUSTICS ,0.,24)
C     CALL SYMBOL(-9.,H,HH,35HGNOMONIC PROJECTION.  TANGENCY AT X,0.,35)
      IF(CLAT.LT.BOTLAT.OR.CLAT.GT.TOPLAT.OR.CLON.LT.BOTLON.OR.
     1   CLON.GT.TOPLON)GO TO 73
      CALL COORDS(CLAT,CLON,X,Y)
      CALL SYMBOL (X,Y,H,4,0.,-1)
      CALL PLOT (0.,0.,3)
   73 PRINT 973
      RETURN
   86 SCALE=SCALE*PAPER/PLOT HGT
      PRINT 986,SCALE
      RETURN
  900 FORMAT(//* GNOMONIC CHART ROUTINE BY NRL PREDICTIVE ACOUSTICS*//
     1   * E B WRIGHT CODE 8167*///* TANGENT POINT AT*F8.3* DEGREES LATI
     2TUDE,*F8.3* DEGREES LONGITUDE*/* LATITUDE FROM*F6.1* DEGREES TO*
     3   F6.1* BY STEP*F7.2/* LONGITUDE FROM*F6.1* DEGREES TO*F6.1
     4   * BY STEP*F7.2/)
  901 FORMAT(//* PLOT SIZE*F7.2* INCHES LONG BY*F7.2* INCHES HIGH.  *
     1   * THE SPECIFIED PLOTTER DRUM SIZE IS*F4.0* INCHES.*//)
  902 FORMAT(* SCALE AT POINT OF TANGENCY=*F6.3* INCHES/DEGREE LATITUDE
     1OR *F9.3* INCHES PER DEGREE LONGITUDE OR *F8.3* NAUT MI/INCH*/)
  903 FORMAT(/* CHARACTER SIZE CONTROL=*I4
     1  * ,GIVING A PLOTTED NUMBER HEIGHT OF*F6.3* INCHES*/)
  973 FORMAT(* CHART AXES AND LABELING COMPLETE*//)
  986 FORMAT(* RETURN TO CALLING PROGRAM WITH SCALE RECOMPUTED TO MAXIMU
     1M PERMISSIBLE VALUE OF *F6.3* INCHES/DEGREE LATITUDE*//)
      END
```

```
      SUBROUTINE FORMULAS(XLAT,XLON,X,Y)
      COMMON/PROJECT/R,R SEC CLAT,TAN CLAT,XMIN,YMIN
      COMMON/TABLES/DUM(91),TANLAT(90),DIM(182),SINLON(90),COSLON(181)
C*****   CALCULATES X AND Y COORDINATES FOR GNOMONIC CHART, FOR LATITUDE
C   LONGITUDE XLAT AND XLON IN DEGREES.  NOTE THAT THE ORIGIN IS AT THE
C   OF TANGENCY OF THE PROJECTION IF XMIN AND YMIN ARE ZERO.
C*****   FIRST CALL TO FORMULAS CHOOSES THE EQUATIONS TO BE USED.
      CLAT=XLAT
      ASSIGN 100 TO KEY
      IF(ABSF(CLAT).EQ.90.)ASSIGN 200 TO KEY
      RETURN
      ENTRY COORDS
      SIN XLON=QUAD INTP(XLON,SIN LON)
      COS XLON=QUAD INTP(XLON,COS LON)
      GO TO KEY,(100,200)
C*****   THE ORDINARY CASE WHERE TANGENCY IS NOT AT POLE.
  100 TAN XLAT=QUAD INTP(XLAT,TAN LAT)
      DENOM=COS XLON+TAN CLAT*TAN XLAT
      X=R SEC CLAT*SIN XLON/DENOM-XMIN
      Y=R*(TAN XLAT-TAN CLAT*COS XLON)/DENOM-YMIN
      RETURN
C*****   THE SPECIAL CASE OF A POLAR GRAPH USES LIMITING EQUATIONS.
  200 R COT XLAT=R*QUAD INTP(CLAT-XLAT,TAN LAT)
      X=R COT XLAT*SIN XLON-XMIN
      Y=-R COT XLAT*COS XLON-YMIN
      RETURN
      END
```

```
      FUNCTION QUAD INTP(X,Y)
      DIMENSION Y(90)
C*****   QUADRATIC INTERPOLATION IN TABLE Y(X).
C   NEXT TWO STATEMENTS ENSURE TRUNCATION TO CLOSEST POINT IN TABLE.
      K=X+180.5
      K=K-180
      S=X-K
      SP=S+1.
      SM=SP-2.
      QUAD INTP=.5*S*(SP*Y(K+1)+SM*Y(K-1))-SP*SM*Y(K)
      RETURN
      END
```

2.2.5 *Sample Output* — Program XBTCHT constructs a gnomonic chart on a Calcomp plotter, which is shown in Fig. 3. Degrees of latitude and longitude are noted along the left side and bottom of the chart. The positions of the Nansen casts are denoted by a square (□) symbol with the number of the cast (IDENTR) beside it. The positions of the temperature profiles or a ship's track are denoted by a cross (X) and the number of the profile is plotted if given. The crosses are connected by straight lines. Each chart is accompanied by a printout; example shown in Fig. 4.

UNCLASSIFIED

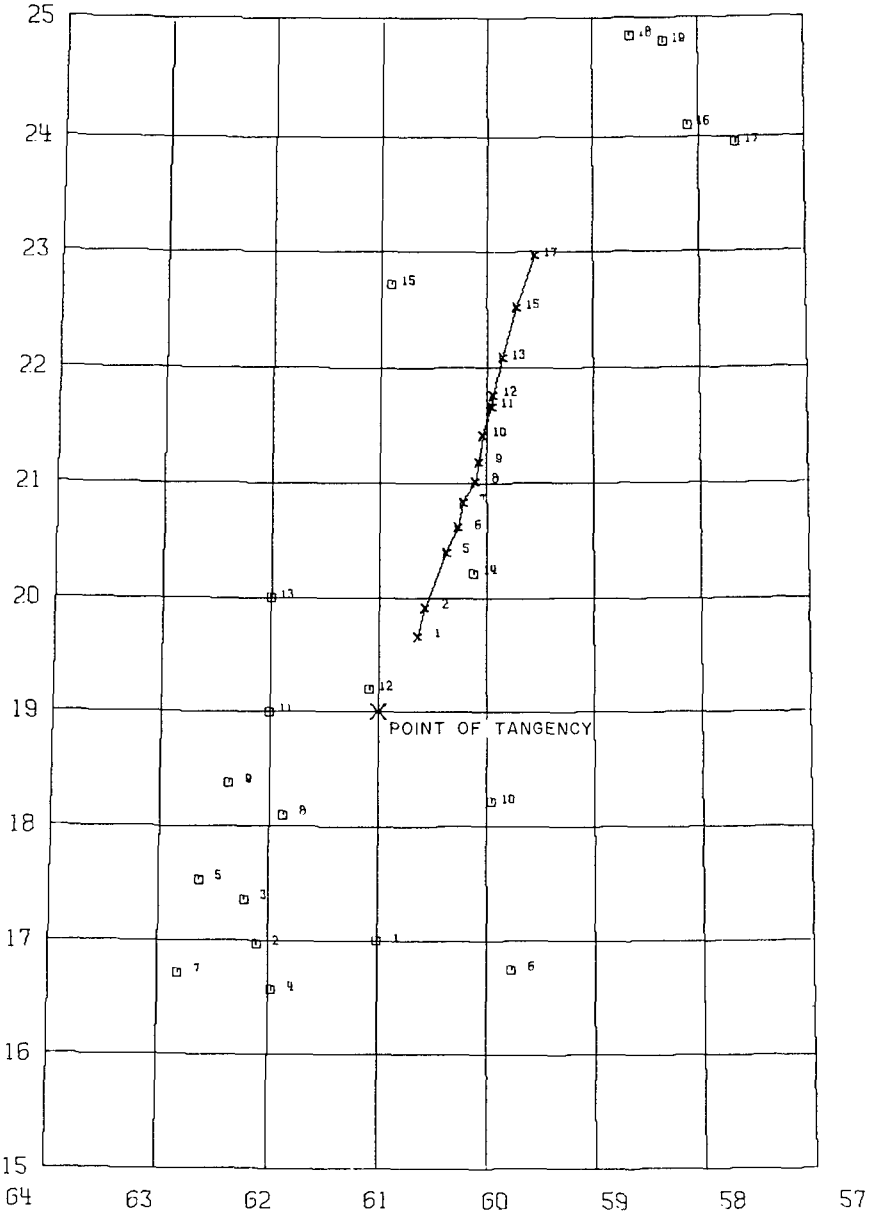

Fig. 3 — Gnomonic chart showing Nansen-cast positions and a ship's track

```
GNOMONIC CHART ROUTINE BY NRL PREDICTIVE ACOUSTICS

E B WRIGHT CODE 8167

TANGENT POINT AT  19.000 DEGREES LATITUDE, -61.000 DEGREES LONGITUDE
LATITUDE FROM  15.0 DEGREES TO  25.0 BY STEP   1.00
LONGITUDE FROM -64.0 DEGREES TO -57.0 BY STEP   1.00

CHARACTER SIZE CONTROL=   4 ,GIVING A PLOTTED NUMBER HEIGHT OF 0.140 INCHES

SCALE AT POINT OF TANGENCY= 1.000 INCHES/DEGREE LATITUDE OR     0.946 INCHES PER DEGREE LONGITUDE OR   60.000 NAUT MI/INCH

PLOT SIZE   6.79 INCHES LONG BY  10.08 INCHES HIGH.   THE SPECIFIED PLOTTER DRUM SIZE IS  10 INCHES.

RETURN TO CALLING PROGRAM WITH SCALE RECOMPUTED TO MAXIMUM PERMISSIBLE VALUE OF  0.992 INCHES/DEGREE LATITUDE

GNOMONIC CHART ROUTINE BY NRL PREDICTIVE ACOUSTICS

E B WRIGHT CODE 8167

TANGENT POINT AT  19.000 DEGREES LATITUDE, -61.000 DEGREES LONGITUDE
LATITUDE FROM  15.0 DEGREES TO  25.0 BY STEP   1.00
LONGITUDE FROM -64.0 DEGREES TO -57.0 BY STEP   1.00

CHARACTER SIZE CONTROL=   4 ,GIVING A PLOTTED NUMBER HEIGHT OF 0.140 INCHES

SCALE AT POINT OF TANGENCY= 0.992 INCHES/DEGREE LATITUDE OR     0.938 INCHES PER DEGREE LONGITUDE OR   60.496 NAUT MI/INCH

PLOT SIZE   6.73 INCHES LONG BY  10.00 INCHES HIGH.   THE SPECIFIED PLOTTER DRUM SIZE IS  10 INCHES.

CHART AXES AND LABELING COMPLETE

PLOT OF TRACK COMPLETED

NANSEN CAST POSITION PLOT COMPLETED
```

Fig. 4 — Sample printout of Program XBTCHT

UNCLASSIFIED

2.3. Nansen-Cast Data Plot (ARCPLT)

After the chart of the survey area has been studied, the groups of Nansen-cast data chosen as typical to the area are now plotted on a 10-in. Calcomp plotter. This is done using program ARCPLT. This program can produce four separate plots for each cast: temperature vs depth, salinity vs depth, sound speed vs depth, and temperature vs salinity. All depths used are the standard NODC depths.

2.3.1 *Water Masses* — The surface waters of the ocean circulate in a complex but predictable manner. For example, the colder, less saline water of the polar regions sinks, mixes with, and flows under the warmer water of the temperate regions. This produces a vertical stratification over large areas in the ocean. Water masses can be classified from their vertical temperature vs salinity distributions [2.3], and this classification can be applied to the world's major bodies of water.

The profiles produced by ARCPLT can be examined visually and then grouped according to their water masses. For this, the temperature-salinity curves are the most useful. Up to ten separate groups (1 - 10) can be accommodated by the program. See Sec. 2.4.0.

2.3.2 *Program Control Cards* — Same as Sec. 2.2.1.

2.3.3. *Input Control Cards*

Card 1 to N: control cards

Variable	Column	Format	Description
IDT	1	I1	=1; depth vs temperature plot =0; no plot
IDS	2	I1	=1; depth vs salinity plot =0; no plot
IDV	3	I1	=1; depth vs sound-speed plot =0; no plot
ITS	4	I1	=1; temperature vs salinity plot =0; no plot
IFLE	5-7	I3	number of files to skip on SEARCHSF tape
IREC	8-10	I3	number of records to skip on SEARCHSF tape. One record contains a complete profile
INUM	11-13	I3	IDENTR of last record to be plotted

CAUTION: All profiles of a SEARCHSF tape file must be plotted as a group. After INUM is reached, the rest of the file is skipped and a new control card is read to process the next file. Intervening files may be skipped, but care must be taken not to pass the last file on the tape. Note that the value of IREC is a count of the records to be skipped and not an IDENTR value. When an EOF card is read the program will end.

The running time for the program depends on the number of profiles to be plotted (approximately 10 s for a set of four plots), and on the amount of SEARCHSF tape to be read. Run times of 2 to 5 min. should be sufficient.

2.3.4 *Program ARCPLT Fortran Source Listing*

```
      PROGRAM ARCPLT
      DIMENSION IBUF(2),IARR(28),TEMS(4),IIN(128),IDP(128),SVM(128),TMP(
     $128),SAL(128),PLTARRAY(254),X(128),Y(128)
      CALL PLOTS(PLTARRAY,254,10)
      YY=0.909090909
      XX=0.1
      GXX=0.2
      GYY=0.1
      GYYY=0.2
C     IDT=1 DEPTH TEMPERATURE PLOT
C     IDS=1 DEPTH SALINITY PLOT
C     IDV=1 DEPTH VELOCITY PLOT
C     ITS=1 TEMPERATURE SALINITY PLOT
C     IFLE NO. OF FILES TO SKIP, IREC NO. OF RECORDS TO SKIP
C     INUM STOP AFTER DOING THIS RECORD NUMBER
    1 READ 2,IDT,IDS,IDV,ITS,IFLE,IREC,INUM
    2 FORMAT(4I1,3I3)
      IF(EOF,60)120,50
   50 IRN=0
      NFIL=0
    3 IF(IFLE.EQ.NFIL)GO TO 4
      CALL SKIPFILE(1)
      NFIL=NFIL+1
      GO TO 3
    4 BUFFER IN (1,1)(A,A)
    5 IF(UNIT,1)5,6,100,6
    6 IF(IRN.GE.IREC)GO TO 7
      IRN=IRN+1
      GO TO 4
    7 BUFFER IN (1,1)(IBUF(1),SAL(128))
    8 IF(UNIT,1)8,9,100,9
    9 IRN=IBUF(1)
      IF(IDT.LE.0)GO TO 16
C     D-T PLOT
      GY=0.0
      GX=0.0
      CALL PLOT(GX,GY,3)
```

UNCLASSIFIED

```
      CALL PLOT(GX,GY,2)
      CALL PLOT(GXX,GY,1)
      CALL PLOT(GXX,GYY,1)
      CALL PLOT(GXX,GY,1)
      GX=GXX+GXX
      CALL PLOT(GX,GY,1)
      DO 10 J=1,7
      CALL PLOT(GX,GYYY,1)
      CALL PLOT(GX,GY,1)
      GX=GX+GXX
      CALL PLOT(GX,GY,1)
      DO 11 JJ=1,4
      CALL PLOT(GX,GYY,1)
      CALL PLOT(GX,GY,1)
      GX=GX+GXX
      CALL PLOT(GX,GY,1)
   11 CONTINUE
   10 CONTINUE
      GMAX=GX+4.0
      CALL AX(GX,GY,YY)
      GGY=GY-0.1
      GYG=GY-0.2
      NUM=35
      YN=GY+0.1
      DO 12 J=1,7
      XN=GX-0.1
      CALL NUMBER(XN,YN,.12,NUM,0.0,2HI2)
      NUM=NUM-5
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      CALL PLOT(GX,GYG,1)
      CALL PLOT(GX,GY,1)
      GX=GX-GXX
      CALL PLOT(GX,GY,1)
      DO 13 JJ=1,4
      CALL PLOT(GX,GGY,1)
      CALL PLOT(GX,GY,1)
      GX=GX-GXX
      CALL PLOT(GX,GY,1)
   13 CONTINUE
   12 CONTINUE
      CALL PLOT(GX,GYG,1)
      XN=GX-0.1
      CALL NUMBER(XN,YN,.12,NUM,0.0,2HI2)
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      GX=GX-GXX
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GGY,1)
      CALL PLOT(GX,GY,1)
      GX=GX-GXX
      CALL PLOT(GX,GY,1)
      CALL AXX(GX,GY,YY,GXX)
      CALL SYMBOL(5.0,2.5,.12,11HDPH VS TEMP,0.0,11)
      CALL NUMBER(5.0,2.0,.12,IRN,0.0,2HI3)
      CALL NUMBER(5.0,1.5,.12,IARR(3),0.0,2HI3)
```

```
      CALL NUMBER(5.5,1.5,.12,IARR(4),0.0,2HI3)
      CALL NUMBER(5.0,1.0,.12,IARR(18),0.0,2HI4)
      CALL NUMBER(5.5,1.0,.12,IARR(19),0.0,2HI4)
      JJ=IARR(17)
      DO 14 I=1,JJ
      IF(IDP(I).GT.5500)GO TO 15
      J=I
      X(I)=(TMP(I)+2.0)*0.2
      D=IDP(I)
      Y(I)=(5500.0-D)*0.001818182
   14 CONTINUE
   15 CALL LINE(X,Y,J,1,-1,.01,1)
      CALL PLOT(GMAX,0.0,-3)
      CALL SPACE00
   16 IF(IDS.LE.0)GO TO 22
C     D-S PLOT
      GX=0.0
      GY=0.0
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      DO 17 J=1,6
      CALL PLOT(GX,GYYY,1)
      CALL PLOT(GX,GY,1)
      GX=GX+XX
      CALL PLOT(GX,GY,1)
      DO 18 JJ=1,9
      CALL PLOT(GX,GYY,1)
      CALL PLOT(GX,GY,1)
      GX=GX+XX
      CALL PLOT(GX,GY,1)
   18 CONTINUE
   17 CONTINUE
      GMAX=GX+4.0
      CALL AX(GX,GY,YY)
      GGY=GY-0.1
      GYG=GY-0.2
      NUM=38
      YN=GY+0.1
      DO 51 J=1,6
      XN=GX-0.1
      CALL NUMBER(XN,YN,.12,NUM,0.0,2HI2)
      NUM=NUM-1
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      CALL PLOT(GX,GYG,1)
      CALL PLOT(GX,GY,1)
      GX=GX-XX
      CALL PLOT(GX,GY,1)
      DO 19 JJ=1,9
      CALL PLOT(GX,GGY,1)
      CALL PLOT(GX,GY,1)
      GX=GX-XX
      CALL PLOT(GX,GY,1)
   19 CONTINUE
   51 CONTINUE
      XN=GX-0.1
```

UNCLASSIFIED

```
      CALL NUMBER(XN,YN,.12,NUM,0.0,2HI2)
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      CALL AXX(GX,GY,YY,GXX)
      CALL SYMBOL(4.0,2.5,.12,10HDPH VS SAL,0.0,10)
      CALL NUMBER(4.0,2.0,.12,IRN,0.0,2HI3)
      CALL NUMBER(4.0,1.5,.12,IARR(3),0.0,2HI3)
      CALL NUMBER(4.5,1.5,.12,IARR(4),0.0,2HI3)
      CALL NUMBER(4.0,1.0,.12,IARR(18),0.0,2HI4)
      CALL NUMBER(4.5,1.0,.12,IARR(19),0.0,2HI4)
      JJ=IARR(17)
      DO 20 I=1,JJ
      IF(IDP(I).GT.5500)GO TO 21
      J=I
      X(I)=(SAL(I)-32.0)*1.0
      D=IDP(I)
      Y(I)=(5500.0-D)*0.001818182
   20 CONTINUE
   21 CALL LINE(X,Y,J,1,-1,.01,1)
      CALL PLOT(GMAX,0.0,-3)
      CALL SPACE00
   22 IF(IDV.LE.0)GO TO 26
C     D-V PLOT
      CALL PLOT(0.0,0.0,3)
      CALL PLOT(0.0,0.0,2)
      GX=0.0
      GY=0.0
      XXX=1.0
      DO 23 J=1,11
      GX=GX+XXX
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GYYY,1)
      CALL PLOT(GX,GY,1)
   23 CONTINUE
      GMAX=GX+4.0
      CALL AX(GX,GY,YY)
      NUM=1550
      CALL NUMBER(10.8,10.1,.12,NUM,0.0,2HI4)
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      GYYYY=GY-GYYY
      DO 24 J=1,11
      GX=GX-XXX
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GYYYY,1)
      CALL PLOT(GX,GY,1)
   24 CONTINUE
      NUM=1440
      CALL NUMBER(-0.2,10.1,.12,NUM,0.0,2HI4)
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      CALL AXX(GX,GY,YY,GXX)
      CALL SYMBOL(0.5,2.5,.12,13HDPH VS S. SPD,0.0,13)
      CALL NUMBER(0.5,2.0,.12,IRN,0.0,2HI3)
      CALL NUMBER(0.5,1.5,.12,IARR(3),0.0,2HI3)
      CALL NUMBER(1.0,1.5,.12,IARR(4),0.0,2HI3)
```

```
      CALL NUMBER(0.5,1.0,.12,IARR(18),0.0,2HI4)
      CALL NUMBER(1.0,1.0,.12,IARR(19),0.0,2HI4)
      JJ=IARR(17)
      DO 25 I=1,JJ
      IF(IDP(I).GT.5500)GO TO 52
      J=I
      X(I)=(SVM(I)-1440.0)*0.1
      D=IDP(I)
      Y(I)=(5500.0-D)*0.001818182
   25 CONTINUE
   52 CALL LINE(X,Y,J,1,-1,.01,1)
      CALL PLOT(GMAX,0.0,-3)
      CALL SPACE00
   26 IF(ITS.LE.0)GO TO 37
C     T-S PLOT
      GX=0.0
      GY=0.0
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      GTY=0.25
      XX=0.1
      GSX=0.15
      CALL PLOT(GX,GTY,1)
      CALL PLOT(XX,GTY,1)
      CALL PLOT(GX,GTY,1)
      GY=GTY+GTY
      CALL PLOT(GX,GY,1)
      NUM=0
      DO 27 K=1,7
      CALL NUMBER(GX-.3,GY-.06,.12,NUM,0.0,2HI2)
      NUM=NUM+5
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      CALL PLOT(GXX,GY,1)
      CALL PLOT(GX,GY,1)
      GY=GY+GTY
      CALL PLOT(GX,GY,1)
      DO 28 KK=1,4
      CALL PLOT(XX,GY,1)
      CALL PLOT(GX,GY,1)
      GY=GY+GTY
      CALL PLOT(GX,GY,1)
   28 CONTINUE
   27 CONTINUE
      GAY=4.28
      GAX=-.4
      CALL SYMBOL(GAX,GAY,.12,8HTEMP (C),90.0,8)
      NUM=32
      GGY=GY-0.1
      GGGY=GY-.2
      DO 30 K=1,6
      CALL NUMBER(GX-.1,GY+.1,.12,NUM,0.0,2HI2)
      NUM=NUM+1
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      GX=GX+GSX
```

UNCLASSIFIED

```
      DO 31 KK=1,9
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GGY,1)
      CALL PLOT(GX,GY,1)
      GX=GX+GSX
   31 CONTINUE
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GGGY,1)
      CALL PLOT(GX,GY,1)
   30 CONTINUE
      CALL NUMBER(GX-.1,GY+.1,.12,NUM,0.0,2HI2)
      GAY=GY+.3
      GAX=3.8
      CALL SYMBOL(GAX,GAY,.12,14HSALINITY (PPT),00.0,14)
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      GMAX=GX+4.0
      DO 32 K=1,7
      DO 33 KK=1,4
      GY=GY-GTY
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX-.1,GY,1)
      CALL PLOT(GX,GY,1)
   33 CONTINUE
      GY=GY-GTY
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX-.2,GY,1)
      CALL PLOT(GX,GY,1)
   32 CONTINUE
      GY=GY-GTY
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX-.1,GY,1)
      CALL PLOT(GX,GY,1)
      GY=GY-GTY
      CALL PLOT(GX,GY,1)
      DO 34 K=1,6
      DO 35 KK=1,9
      GX=GX-GSX
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GY+.1,1)
      CALL PLOT(GX,GY,1)
   35 CONTINUE
      GX=GX-GSX
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GY+.2,1)
      CALL PLOT(GX,GY,1)
   34 CONTINUE
      CALL SYMBOL(6.5,2.5,.12,13HTEMP. VS SAL.,0.0,13)
      CALL NUMBER(6.5,2.0,.12,IRN,0.0,2HI3)
      CALL NUMBER(6.5,1.5,.12,IARR(3),0.0,2HI3)
      CALL NUMBER(7.0,1.5,.12,IARR(4),0.0,2HI3)
      CALL NUMBER(6.5,1.0,.12,IARR(18),0.0,2HI4)
      CALL NUMBER(7.0,1.0,.12,IARR(19),0.0,2HI4)
      JJ=IARR(17)
      DO 36 I=1,JJ
      Y(I)=(TMP(I)+2.0)*0.25
      X(I)=(SAL(I)-32.0)*1.5
```

```
 36 CONTINUE
    CALL LINE(X,Y,JJ,1,0,0.08,-1)
    CALL PLOT(GMAX,0.0,-3)
    CALL SPACE00
 37 IF(IRN.EQ.INUM)GO TO 110
    GO TO 7
100 NFIL=NFIL+1
    IF(NFIL.GE.3)GO TO 120
    GO TO 1
110 CALL SKIPFILE(1)
    GO TO 1
120 CALL PLOT(14.0,0.0,-3)
    CALL SPACE00
    CALL STOPPLOT
    END
```

```
    SUBROUTINE AX(GX,GY,YY)
    GGX=GX-0.2
    DO 1 J=1,11
    GY=GY+YY
    CALL PLOT(GX,GY,1)
    CALL PLOT(GGX,GY,1)
    CALL PLOT(GX,GY,1)
  1 CONTINUE
    RETURN
    END
```

```
    SUBROUTINE AXX(GX,GY,YY,GXX)
    NUM=1000
    GNY=8.121818181
    GNX=- .5
    DO 1 J=1,5
    GY=GY-YY
    CALL PLOT(GX,GY,1)
    CALL PLOT(GXX,GY,1)
    CALL PLOT(GX,GY,1)
    GY=GY-YY
    CALL PLOT(GX,GY,1)
    CALL PLOT(GXX,GY,1)
    CALL PLOT(GX,GY,1)
    CALL NUMBER(GNX,GNY,.12,NUM,0.0,2HI4)
    CALL PLOT(GX,GY,3)
    CALL PLOT(GX,GY,2)
    NUM=NUM+1000
    GNY=GY-1.878181818
  1 CONTINUE
    GY=GY-YY
    CALL PLOT(GX,GY,1)
    RETURN
    END
```

UNCLASSIFIED

2.3.5 *Sample Outputs* — The plots produced from Program ARCPLOT have the following formats.

1. Temperature (-2 to 35°C) on a 18.8-cm abscissa vs depth (0 to 5000 m) on a 25.5-cm ordinate, shown in Fig. 5.

Legend on bottom right:

Title

IDENTR number

Marsden square 1° square

Distance along track Distance from track

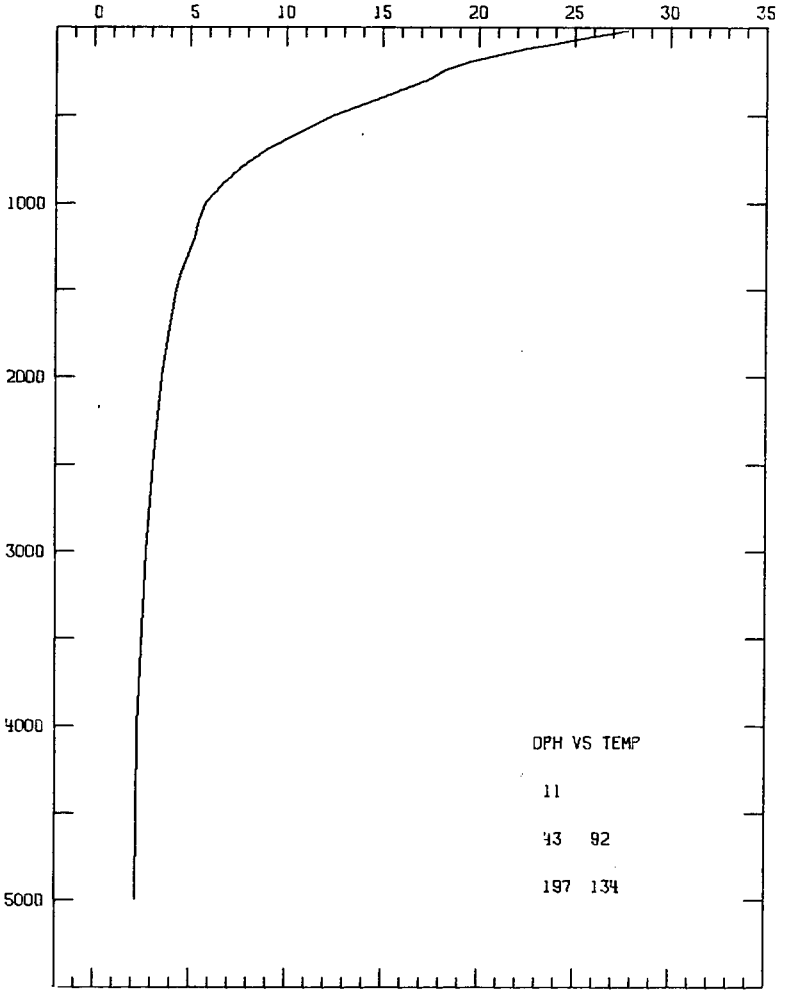

Fig. 5 — Calcomp plot, depth (m) vs temperature (C°)

2. Salinity (32 to 35 parts per thousand (ppt) on a 15.3-cm abscissa vs depth (0 to 5000 m) on a 25.5-cm ordinate, shown in Fig. 6

The legend on bottom right is the same as in item 1 above.

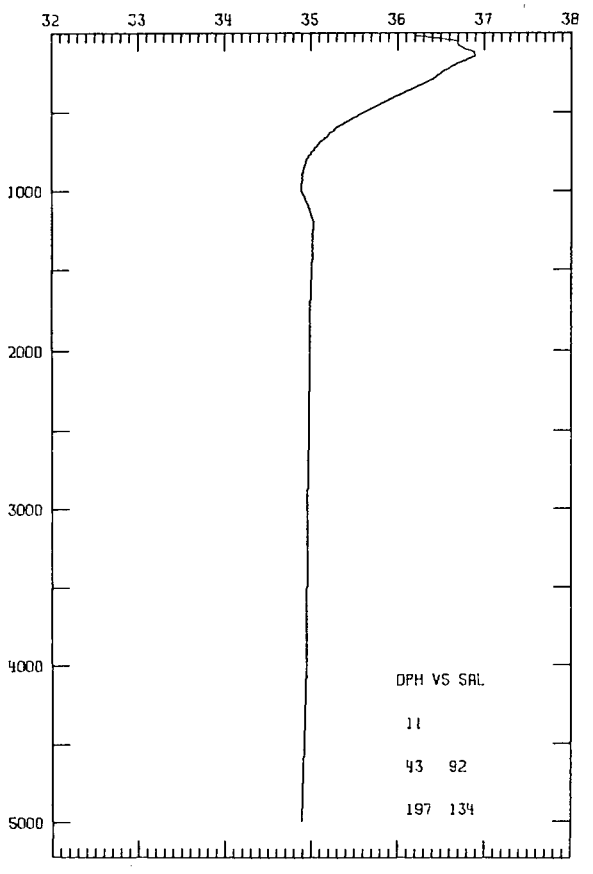

Fig. 6 — Calcomp plot, depth (m) vs salinity (ppt)

3. Sound speed (1440 to 1550 m/s) on a 28-cm abscissa vs depth (0 to 5000 m) on a 25.5-cm ordinate, shown in Figs. 7a and 7b.

The legend on bottom left is the same as in item 1 above.

4. Temperature (-2 to 35°C) on a 22.5-cm ordinate vs salinity (32 to 38 ppt) on a 22.8-cm abscissa, shown in Figs. 8a and 8b. Water masses have been noted on the T-S plots.

The legend on bottom right is the same as in item 1 above.

2.4 Statistics and Multiple Plots (VDTSMUPT)

The archival data can now be divided into as many as ten groups (numbered 1 to 10) and the IDENTR number of each profile noted. As mentioned in Sec. 2.3, each group

UNCLASSIFIED

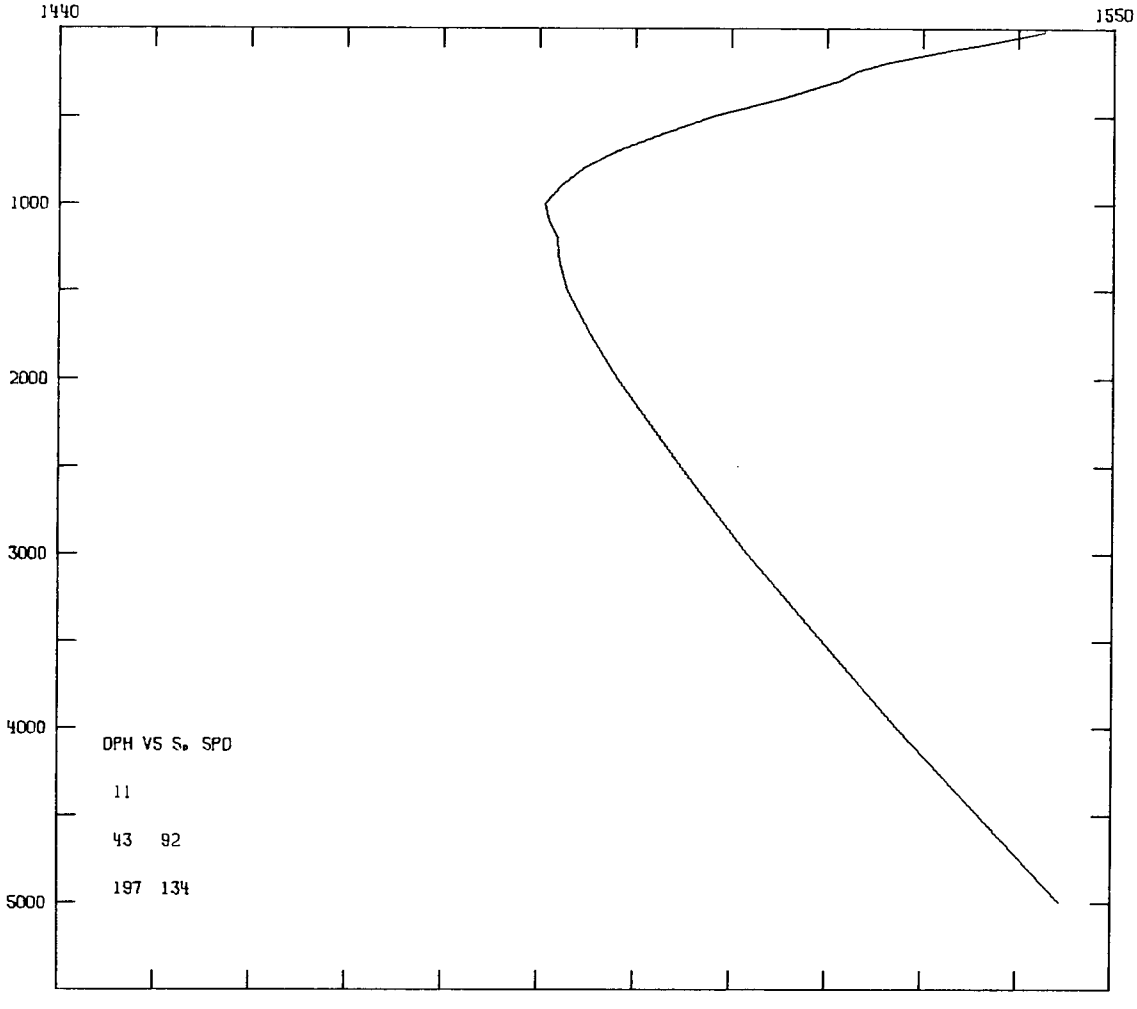

Fig. 7a — Calcomp plot, depth (m) vs sound speed (m/s), southern North Atlantic waters

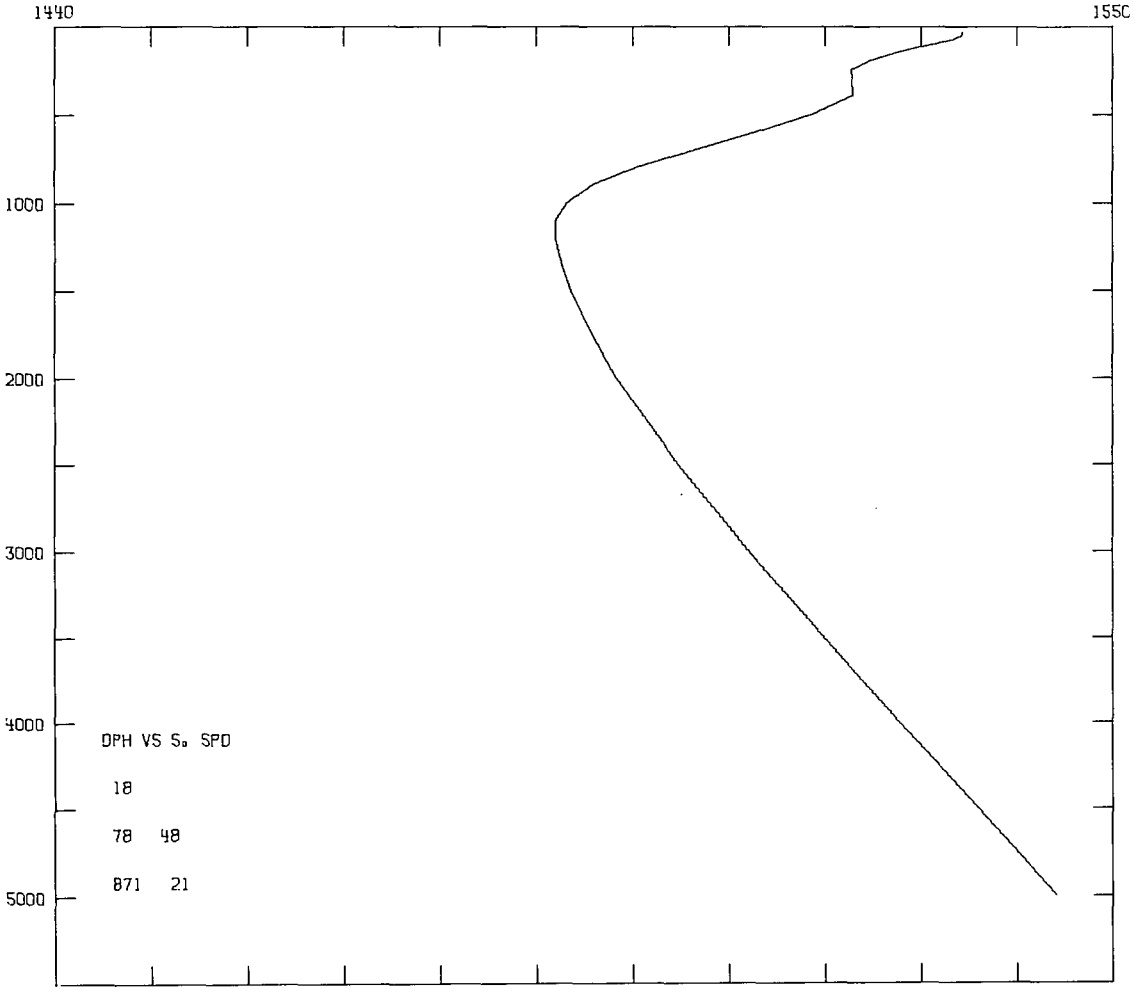

Fig. 7b — Calcomp plot, depth (m) vs sound speed (m/s), mid-North Atlantic waters showing subsurface sound channel

UNCLASSIFIED

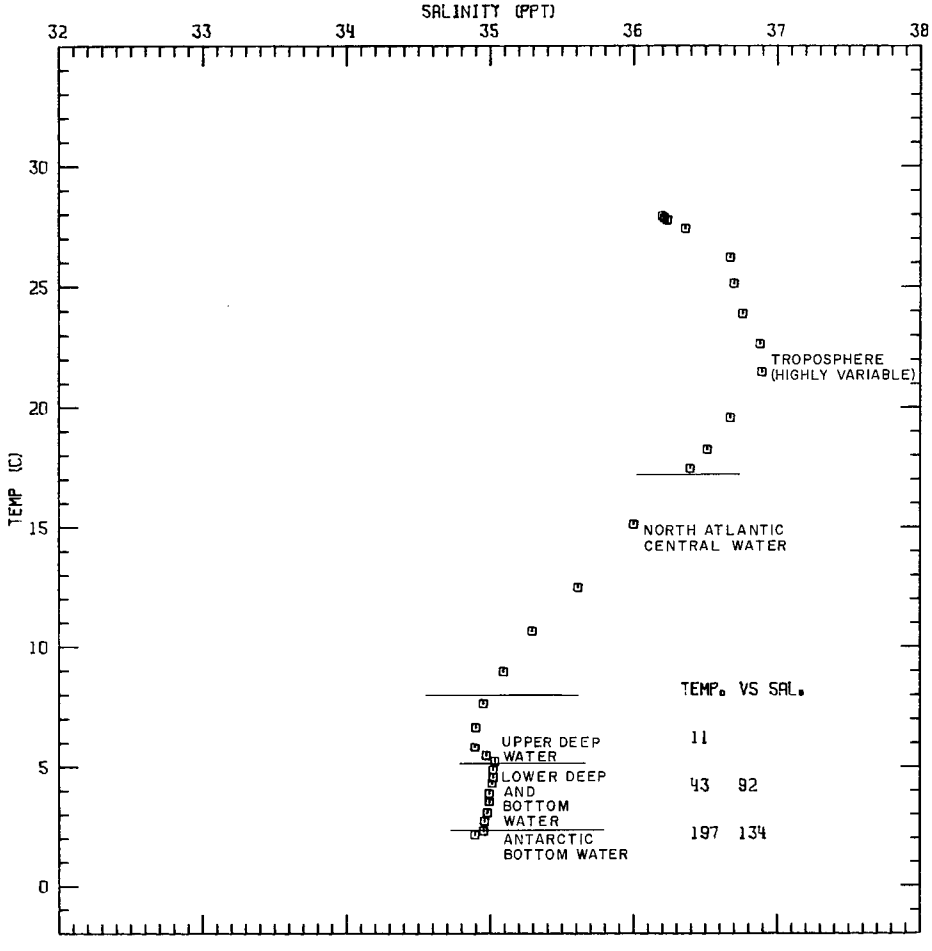

Fig. 8a — Calcomp plot, temperature (C°) vs salinity (ppt), southern North Atlantic waters; water masses noted

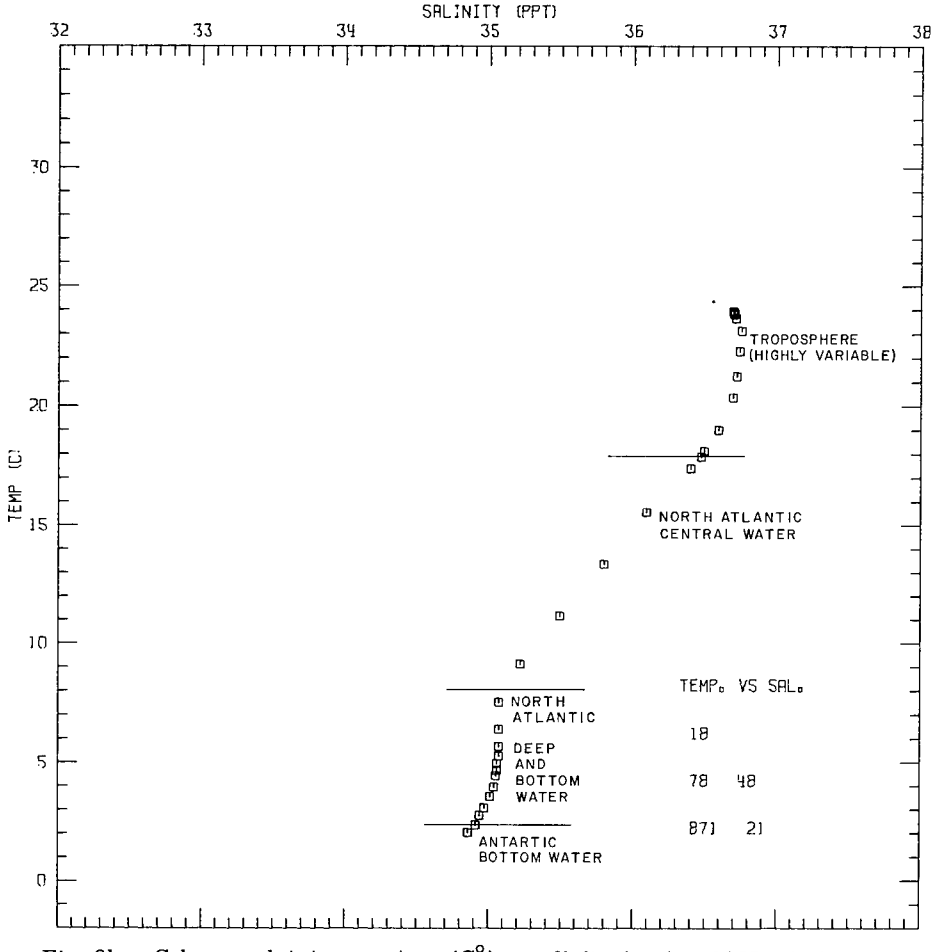

Fig. 8b — Calcomp plot, temperature (C°) vs salinity (ppt), mid-North Atlantic waters; water masses noted

UNCLASSIFIED

should characterize a distinct oceanographic region. One method is to overlay the plots produced in the previous section. The temperature vs salinity and sound-speed vs depth plots are the most useful.

The number given a particular group is arbitrary. The members of each group do not have to be consecutive, but they must ascend in number within the group. As many as 60 profiles can make up each group. If there are more than 60 profiles, they may be reduced by eliminating shallow or older profiles or by reducing several profiles taken at the same location.

Program VDTSMUPT constructs four separate plots for each group. All members of the group are plotted on the same sound-speed vs depth, temperature vs salinity, temperature vs depth, and salinity vs depth plot. The mean value, standard deviation, and standard error of the sound speed are also calculated for each standard depth of the group, as well as the average salinity. The statistical portions of the program may be suppressed, and it is a good idea to check the plots before doing a final set of plots and calculations.

The statistical portion of the program produces a printout of the sound-speed statistics and a punched card deck having the depth, standard deviation, standard error, the mean, one standard deviation above and below the mean sound speed, and the average salinity. This deck is used by the SSCPDN, next program in the calculation of sound-speed values.

2.4.1 *Program Control Cards* — Same as Sec. 2.1.1.

2.4.2 *Input Control Cards*

Card 1: control card

Variable	Column	Format	Description
IFLE	1-4	I4	number of files to skip on SEARCHSF tape
IREC	5-8	I4	Skip through this IDENTR number before starting to process. If the first profile of file is in the group, IREC=0
NDX	9-12	I4	=1; rewind SEARCHSF tape before starting to process (must be used if this is the first group and in the first file of the tape) =0; the group to be processed has its first member in the same file and beyond the last group processed =-1; causes SEARCHSF tape to be backed to the beginning of the current file before processing (i.e., to process groups that have members that reside in the current file but are of lower IDENTR number than those already processed)

Variable	Column	Format	Description
JREC	13-16	I4	IDENTR number of last profile of a group
IGP	17-20	I4	Group number arbitrarily assigned — used to designate groups for various inputs and outputs
ISSK	21-24	I4	=1; multiple plots only =0; plots, printout, and punched card deck produced
NFSK	25-28	I4	number of groups of plots to skip on output tape (LU 10) used to add plots to a tape =0; no skipping =1; will skip one group of four multiple plots, etc. This option can only be called once on the first control card of the run.

EOF card will terminate the program.

Card 2 to 4: IDENTR group deck

Variable	Column	Format	Description
INDX(I)	1-4	I4	IDENTR number of the first member of the group
INDX(I)	5-8 etc.	I4	Twenty values to a card; there must be three cards (60 values). See procedure

Procedure: Member numbers must be ascending. There must also be three cards in the group deck, leaving the field blank after the last number of the group. Misordering will cause the group to be skipped. Cards 1 to 4 are repeated for each group, up to ten sets. All members of a given group must be contained in a single file of the SEARCHSF tape. Any values to be plotted that fall outside of a grid will be revalued to the maximum or minimum limit of the grid, but the original value will be used in the statistical calculations.

The program run time is a function of the number of profiles processed, but it should be less than 2 min. for all but the largest runs (greater than 150 profiles).

When an EOF card is encountered in the Card 1 position, the program will terminate.

UNCLASSIFIED

2.4.3 *Program VDTSMUPT Fortran Source Listing*

```
      PROGRAM VDTSMUPT
      DIMENSION IBUF(2),IARR(28),TEMS(4),IIN(128),IDP(128),SVM(128),TMP(
     $128),SAL(128),PLTARRAY(254),INDX(60),DPH(30,60),VEL(30,60),TEM(30,
     $60),CAL(30,60),IDH(30)
      DATA(IDH=0,10,20,30,50,75,100,125,150,200,250,300,400,500,600,700,
     $800,900,1000,1100,1200,1300,1400,1500,1750,2000,2500,3000,4000,500
     $0)
      YY=0.909090909
      XX=0.1
      GXX=0.2
      GYY=0.1
      GYYY=0.2
    1 READ 2,IFLE,IREC,NDX,JREC,IGP,ISSK,NFSK
    2 FORMAT(7I4)
      IF(EOF,60)120,3
    3 NFLE=0
      N=1
      NN=1
      NDH=1
      IF(NFSK.LT.1)GO TO 402
      NFSK=12*NFSK
      DO 403 J=1,NFSK
      CALL SKIPFILE (10)
  403 CONTINUE
C     IFLE= SKIP THIS NO. OF FILES      IREC=SKIP THROUGH THIS REC NO.
C     NDX=.GT. ZERO REWIND FOR THIS PASS
C        =.EQ. ZERO CONTINUE ON
C        =.LT. ZERO BACKFILE
C     JREC=STOP AFTER THIS RECORD NO.   IGP=GROUP NO.
C     ISSK .GT. 0 SKIP STATISTICAL CALCULATIONS
C     NFSK= NO. OF GROUPS TO SKIP ON PLOT TAPE ,WILL START ON NEXT
C     GROUP AND GO ON. IF =0 WILL NOT SKIP FILES
  402 READ 100,(INDX(J),J=1,60)
  100 FORMAT(20I4)
C     INDX=RECORD NO. TO USE IN CALCULATIONS , MUST HAVE 4 CARDS EVEN
C     BLANK ONES
      CALL PLOTS(PLTARRAY,254,10)
      IF(NDX)4,6,5
    4 CALL BACKFILE (1)
      CALL SKIPFILE (1)
      GO TO 7
    5 REWIND 1
    7 IF(IFLE.EQ.NFLE)GO TO 8
      CALL SKIPFILE (1)
      NFLE=NFLE+1
      GO TO 7
    8 BUFFER IN (1,1)(A,A)
    9 IF(UNIT,1)9,6,1,6
    6 DO 10 J=1,30
      DO 11 JJ=1,60
      DPH(J,JJ)=-9.0
      VEL(J,JJ)=-9.0
      TEM(J,JJ)=-9.0
      CAL(J,JJ)=-9.0
   11 CONTINUE
   10 CONTINUE
```

```
   12 BUFFER IN (1,1)(IBUF(1),SAL(128))
   13 IF(UNIT,1)13,14,1,14
   14 IF(IBUF(1).LE.IREC)GO TO 12
      IF(IBUF(1).LT.INDX(N))GO TO 12
      IF(IBUF(1).GT.INDX(N))GO TO 400
   15 IF(IDH(NDH).EQ.IDP(1))GO TO 16
      NDH=NDH+1
      GO TO 15
   16 J=NDH
      JJ=IARR(17)+J-1
      JJJ=1
      IF(JJ.GT.30)JJ=30
   17 IF(IDH(J).EQ.IDP(JJJ))GO TO 18
      IF(J.GE.30)GO TO 56
      J=J+1
      GO TO 17
   18 DPH(J,N)=IDP(JJJ)
      VEL(J,N)=SVM(JJJ)
      TEM(J,N)=TMP(JJJ)
      CAL(J,N)=SAL(JJJ)
      JJJ=JJJ+1
      J=J+1
      IF(JJJ.LE.JJ)GO TO 17
   56 IF(IBUF(1).GE.JREC)GO TO 19
      N=N+1
      NDH=1
      GO TO 12
C***** D-V MULTIPLE PLOT
   19 J=1
      JJ=1
      CALL PLOT(0.0,0.0,3)
      CALL PLOT(0.0,0.0,2)
      GX=0.0
      GY=0.0
      XXX=1.0
      DO 20 K=1,11
      GX=GX+XXX
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GYYY,1)
      CALL PLOT(GX,GY,1)
   20 CONTINUE
      GMAX=GX+4.0
      CALL AX(GX,GY,YY)
      NUM=1550
      CALL NUMBER(10.8,10.1,.12,NUM,0.0,2HI4)
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      GYYYY=GY-GYYY
      DO 21 K=1,11
      GX=GX-XXX
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GYYYY,1)
      CALL PLOT(GX,GY,1)
   21 CONTINUE
      NUM=1440
      CALL NUMBER(-0.2,10.1,.12,NUM,0.0,2HI4)
```

UNCLASSIFIED

```
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      CALL AXX(GX,GY,YY,GAX)
      CALL SYMBOL(0.5,2.5,.12,15HDPH, VS S. SPD.,0.0,15)
      CALL SYMBOL(0.5,2.0,.12,13HMULTIPLE PLOT,0.0,13)
      CALL SYMBOL(0.5,1.5,.12,5HGROUP,0.0,5)
      CALL NUMBER(1.02,1.5,.12,IGP,0.0,2H13)
      CALL SYMBOL(-.6,5.0,.12,9HDEPTH (M),90.0,9)
      CALL SYMBOL(4.2,10.1,.12,14HVELOCITY (M/S),0.0,14)
      CALL SPACE00
   22 CALL PLOT(0.0,9.8,3)
      X=0.0
      Y=9.95
   23 IF(DPH(J,JJ).GE.0.0)GO TO 24
      IF(J.GE.30)GO TO 29
      CALL PLOT(X,Y,3)
      J=J+1
      GO TO 23
   24 IF(VEL(J,JJ).LT.1440.0)VEL(J,JJ)=1440.0
      IF(VEL(J,JJ).GT.1550.0)VEL(J,JJ)=1550.0
      IF(DPH(J,JJ).LT.0.0)DPH(J,JJ)=0.0
      IF(DPH(J,JJ).GT.5500.0)DPH(J,JJ)=5500.0
      X=(VEL(J,JJ)-1440.0)*0.1
      Y=(5500.0-DPH(J,JJ))*0.001818182
   25 CALL PLOT(X,Y,3)
      CALL PLOT(X,Y,2)
   26 J=J+1
      NP=2
   27 IF(DPH(J,JJ).GE.0.0)GO TO 28
      IF(J.GE.30)GO TO 29
      J=J+1
      NP=3
      GO TO 27
   28 IF(VEL(J,JJ).LT.1440.0)VEL(J,JJ)=1440.0
      IF(VEL(J,JJ).GT.1550.0)VEL(J,JJ)=1550.0
      IF(DPH(J,JJ).LT.0.0)DPH(J,JJ)=0.0
      IF(DPH(J,JJ).GT.5500.0)DPH(J,JJ)=5500.0
      X=(VEL(J,JJ)-1440.0)*0.1
      Y=(5500.0-DPH(J,JJ))*0.001818182
      CALL PLOT(X,Y,NP)
      IF(J.GE.30)GO TO 29
      GO TO 26
   29 IF(JJ.GE.N)GO TO 30
      JJ=JJ+1
      J=1
      GO TO 23
   30 CALL SPACE00
      CALL PLOT(GMAX,0.0,-3)
      CALL SPACE00
C**** T-S MULTIPLE PLOT
      GX=0.0
      GY=0.0
      J=1
      JJ=1
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
```

```
      GTY=0.25
      XX=0.1
      GSX=0.15
      CALL PLOT(GX,GTY,1)
      CALL PLOT(XX,GTY,1)
      CALL PLOT(GX,GTY,1)
      GY=GTY+GTY
      CALL PLOT(GX,GY,1)
      NUM=0
      DO 31 K=1,7
      CALL NUMBER(GX-.3,GY-.06,.12,NUM,0.0,2HI2)
      NUM=NUM+5
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      CALL PLOT(GXX,GY,1)
      CALL PLOT(GX,GY,1)
      GY=GY+GTY
      CALL PLOT(GX,GY,1)
      DO 32 KK=1,4
      CALL PLOT(XX,GY,1)
      CALL PLOT(GX,GY,1)
      GY=GY+GTY
      CALL PLOT(GX,GY,1)
   32 CONTINUE
   31 CONTINUE
      GAY=4.28
      GAX=-.4
      CALL SYMBOL(GAX,GAY,.12,8HTEMP (C),90.0,8)
      NUM=32
      GGY=G -0.1
      GGGY=GY-.2
      DO 33 K=1,6
      CALL NUMBER(GX-.1,GY+.1,.12,NUM,0.0,2HI2)
      NUM=NUM+1
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      GX=GX+GSX
      DO 34 KK=1,9
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GGY,1)
      CALL PLOT(GX,GY,1)
      GX=GX+GSX
   34 CONTINUE
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GGGY,1)
      CALL PLOT(GX,GY,1)
   33 CONTINUE
      CALL NUMBER(GX-.1,GY+.1,.12,NUM,0.0,2HI2)
      GAY=GY+.3
      GAX=3.8
      CALL SYMBOL(GAX,GAY,.12,14HSALINITY (PPT),00.0,14)
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      GMAX=GX+4.0
      DO 35 K=1,7
      DO 36 KK=1,4
```

UNCLASSIFIED

```
      GY=GY-GTY
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX-.1,GY,1)
      CALL PLOT(GX,GY,1)
   36 CONTINUE
      GY=GY-GTY
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX-.2,GY,1)
      CALL PLOT(GX,GY,1)
   35 CONTINUE
      GY=GY-GTY
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX-.1,GY,1)
      CALL PLOT(GX,GY,1)
      GY=GY-GTY
      CALL PLOT(GX,GY,1)
      DO 37 K=1,6
      DO 38 KK=1,9
      GX=GX-GSX
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GY+.1,1)
      CALL PLOT(GX,GY,1)
   38 CONTINUE
      GX=GX-GSX
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GY+.2,1)
      CALL PLOT(GX,GY,1)
   37 CONTINUE
C
      CALL SYMBOL(6.5,2.5,.12,13HTEMP. VS SAL.,0.0,13)
      CALL SYMBOL(6.5,2.0,.12,13HMULTIPLE PLOT,0.0,13)
      CALL SYMBOL(6.5,1.5,.12,5HGROUP,0.0,5)
      CALL NUMBER(7.02,1.5,.12,IGP,0.0,2HI3)
C
C
      CALL SPACE00
   39 CALL PLOT(0.0,0.0,3)
   40 IF(TEM(J,JJ).GE.0.0)GO TO 41
      IF(J.GE.30)GO TO 44
      J=J+1
      GO TO 40
   41 IF(TEM(J,JJ).LT.-2.0)TEM(J,JJ)=-2.0
      IF(TEM(J,JJ).GT.35.0)TEM(J,JJ)=35.0
      IF(CAL(J,JJ).LT.32.0)CAL(J,JJ)=32.0
      IF(CAL(J,JJ).GT.38.0)CAL(J,JJ)=38.0
      Y=(TEM(J,JJ)+2.0)*0.250
      X=(CAL(J,JJ)-32.0)*1.5
      IF(Y.GT.10.0)Y=10.0
      IF(Y.LT.0.0)Y=0.0
      CALL PLOT(X,Y,3)
      CALL PLOT(X,Y,2)
      IF(J.GE.30)GO TO 44
      J=J+1
   42 IF(TEM(J,JJ).GE.0.0)GO TO 43
      IF(J.GE.30)GO TO 44
      J=J+1
```

```
      GO TO 42
   43 IF(TEM(J,JJ).LT.-2.0)TEM(J,JJ)=-2.0
      IF(TEM(J,JJ).GT.35.0)TEM(J,JJ)=35.0
      IF(CAL(J,JJ).LT.32.0)CAL(J,JJ)=32.0
      IF(CAL(J,JJ).GT.38.0)CAL(J,JJ)=38.0
      Y=(TEM(J,JJ)+2.0)*0.250
      X=(CAL(J,JJ)-32.0)*1.5
      IF(Y.GT.10.0)Y=10.0
      IF(Y.LT.0.0)Y=0.0
      CALL PLOT(X,Y,1)
      IF(J.GE.30)GO TO 44
      J=J+1
      GO TO 42
   44 IF(JJ.GE.N)GO TO 45
      JJ=JJ+1
      J=1
      GO TO 40
   45 CALL SPACE00
      CALL PLOT(GMAX,0.0,-3)
      CALL SPACE00
C**** D-T MULTIPLE PLOT
      GY=0.0
      GX=0.0
      J=1
      JJ=1
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      CALL PLOT(GXX,GY,1)
      CALL PLOT(GXX,GYY,1)
      CALL PLOT(GXX,GY,1)
      GX=GXX+GXX
      CALL PLOT(GX,GY,1)
      DO 200 K=1,7
      CALL PLOT(GX,GYYY,1)
      CALL PLOT(GX,GY,1)
      GX=GX+GXX
      CALL PLOT(GX,GY,1)
      DO 201 KK=1,4
      CALL PLOT(GX,GYY,1)
      CALL PLOT(GX,GY,1)
      GX=GX+GXX
      CALL PLOT(GX,GY,1)
  201 CONTINUE
  200 CONTINUE
      GMAX=GX+4.0
      CALL AX(GX,GY,YY)
      GGY=GY-0.1
      GYG=GY-0.2
      NUM=35
      YN=GY+0.1
      DO 202 K=1,7
      XN=GX-0.1
      CALL NUMBER(XN,YN,.10,NUM,0.0,2HI2)
      NUM=NUM-5
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
```

UNCLASSIFIED

```
      CALL PLOT(GX,GYG,1)
      CALL PLOT(GX,GY,1)
      GX=GX-GXX
      CALL PLOT(GX,GY,1)
      DO 203 KK=1,4
      CALL PLOT(GX,GGY,1)
      CALL PLOT(GX,GY,1)
      GX=GX-GXX
      CALL PLOT(GX,GY,1)
  203 CONTINUE
  202 CONTINUE
      CALL PLOT(GX,GYG,1)
      XN=GX-0.1
      CALL NUMBER(XN,YN,.10,NUM,0.0,2HI2)
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      GX=GX-GXX
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GGY,1)
      CALL PLOT(GX,GY,1)
      GX=GX-GXX
      CALL PLOT(GX,GY,1)
      CALL AXX(GX,GY,YY,GXX)
      CALL SYMBOL(5.0,2.5,.12,13HDPH. VS TEMP.,0.0,13)
      CALL SYMBOL(5.0,2.0,.12,13HMULTIPLE PLOT,0.0,13)
      CALL SYMBOL(5.0,1.5,.12,5HGROUP,0.0,5)
      CALL NUMBER(5.52,1.5,.12,IGP,0.0,2HI3)
      CALL SYMBOL(-.6,5.0,.12,9HDEPTH (M),90.0,9)
      CALL SYMBOL(3.3,10.25,.10,8HTEMP (C),0.0,8)
      CALL SPACE00
  204 CALL PLOT(0.0,10.0,3)
      X=0.0
      Y=10.0
  205 IF(DPH(J,JJ).GE.0.0)GO TO 206
      IF(J.GE.30)GO TO 211
      CALL PLOT(X,Y,3)
      J=J+1
      GO TO 205
  206 X=(TEM(J,JJ)+2.0)*0.2
      Y=(5500.0-DPH(J,JJ))*0.001818182
  207 CALL PLOT(X,Y,3)
      CALL PLOT(X,Y,2)
  208 J=J+1
      NP=2
  209 IF(DPH(J,JJ).GE.0.0)GO TO 210
      IF(J.GE.30)GO TO 211
      J=J+1
      NP=3
      GO TO 209
  210 X=(TEM(J,JJ)+2.0)*0.2
      Y=(5500.0-DPH(J,JJ))*0.001818182
      CALL PLOT(X,Y,NP)
      IF(J.GE.30)GO TO 211
      GO TO 208
  211 IF(JJ.GE.N)GO TO 212
      JJ=JJ+1
```

```
      J=1
      GO TO 205
  212 CALL SPACE00
      CALL PLOT(GMAX,0.0,-3)
      CALL SPACE00
C**** D-S MULTIPLE PLOT
      GX=0.0
      GY=0.0
      J=1
      JJ=1
      XX=0.15
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      DO 213 K=1,6
      CALL PLOT(GX,GYYY,1)
      CALL PLOT(GX,GY,1)
      GX=GX+XX
      CALL PLOT(GX,GY,1)
      DO 214 KK=1,9
      CALL PLOT(GX,GYY,1)
      CALL PLOT(GX,GY,1)
      GX=GX+XX
      CALL PLOT(GX,GY,1)
  214 CONTINUE
  213 CONTINUE
      GMAX=GX+4.0
      CALL AX(GX,GY,YY)
      GGY=GY-0.1
      GYG=GY-0.2
      NUM=38
      YN=GY+0.1
      DO 21  K=1,6
      XN=GX-0.1
      CALL NUMBER(XN,YN,.10,NUM,0.0,2HI2)
      NUM=NUM-1
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      CALL PLOT(GX,GYG,1)
      CALL PLOT(GX,GY,1)
      GX=GX-XX
      CALL PLOT(GX,GY,1)
      DO 216 KK=1,9
      CALL PLOT(GX,GGY,1)
      CALL PLOT(GX,GY,1)
      GX=GX-XX
      CALL PLOT(GX,GY,1)
  216 CONTINUE
  215 CONTINUE
      XN=GX-0.1
      CALL NUMBER(XN,YN,.10,NUM,0.0,2HI2)
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      CALL AXX(GX,GY,YY,GXX)
      CALL SYMBOL(6.0,2.5,.12,12HDPH. VS SAL.,0.0,12)
      CALL SYMBOL(6.0,2.0,.12,13HMULTIPLE PLOT,0.0,13)
      CALL SYMBOL(6.0,1.5,.12,5HGROUP,0.0,5)
```

UNCLASSIFIED

```
      CALL NUMBER(6.52,1.5,.12,IGP,0.0,2HI3)
      CALL SYMBOL(-.6,5.0,.12,9HDEPTH (M),90.0,9)
      CALL SYMBOL(3.5,10.25,.10,14HSALINITY (PPT),0.0,14)
      CALL SPACE00
  217 CALL PLOT(0.0,10.0,3)
      X=0.0
      Y=10.0
      XX=0.1
  218 IF(DPH(J,JJ).GE.0.0)GO TO 219
      IF(J.GE.30)GO TO 224
      CALL PLOT(X,Y,3)
      J=J+1
      GO TO 218
  219 X=(CAL(J,JJ)-32.0)*1.5
      Y=(5500.0-DPH(J,JJ))*0.001818182
  220 CALL PLOT(X,Y,3)
      CALL PLOT(X,Y,2)
  221 J=J+1
      NP=2
  222 IF(DPH(J,JJ).GE.0.0)GO TO 223
      IF(J.GE.30)GO TO 224
      J=J+1
      NP=3
      GO TO 222
  223 X=(CAL(J,JJ)-32.0)*1.5
      Y=(5500.0-DPH(J,JJ))*0.001818182
      CALL PLOT(X,Y,NP)
      IF(J.GE.30)GO TO 224
      GO TO 221
  224 IF(JJ.GE.N)GO TO 225
      JJ=JJ+1
      J=1
      GO TO 218
  225 CALL SPACE00
      CALL PLOT(GMAX,0.0,-3)
      CALL SPACE00
      IF(ISSK.GT.0)GO TO 1
   46 J=1
      JJ=1
      ICOL=N
      PRINT 60
   60 FORMAT(20H VELOCITY STATISTICS//)
      PRINT  7
   47 FORMAT(102H GROUP  DEPTH     MEAN VAL.    ST. DEV.    ST. ERROR     VA
     $LUE 1     VALUE 2     SUM X      SUM X**2          N//)
   48 N=0
      SUM=0.0
      SQUM= .0
      SSAL=0.0
      DO 49 JJ=1,ICOL
      IF(VEL(J,JJ).LT.0.0)GO TO 49
      SUM=SUM+VEL(J,JJ)
      SQUM=SQUM+(VEL(J,JJ))**2
      SSAL=SSAL+CAL(J,JJ)
      N=N+1
   49 CONTINUE
```

```
      IF(N.LE.0)GO TO 52
      AN=N
      ANN=N
      AMEAN=SUM/AN
      ASAL=SSAL/AN
      IF(ANN.LE.1.0)ANN=2.0
      STDEV=SQRT((SQUM-(AN*AMEAN**2))/(ANN-1.0))
      STERR=STDEV/SQRT(AN)
      STLO=AMEAN-STDEV
      STHI=AMEAN+STDEV
      PRINT 50,IGP,IDH(J),AMEAN,STDEV,STERR,STLO,STHI,SUM,SQUM,N
   50 FORMAT(1X,I4,3X,I5,4X,F8.2,3X,F10.4,2X,F10.4,3X,F7.2,4X,F7.2,2X,F8
     $.2,2X,F14.2,3X,I3)
      PUNCH 51,IGP,IDH(J),STLO,STHI,ASAL,AMEAN,STDEV,STERR
   51 FORMAT(1X,I4,5X,I5,3X,F7.2,3X,F7.2,3X,F7.2,7X,F8.2,F10.4,F10.4)
   52 IF(J.GE.30)GO TO 53
      J=J+1
      GO TO 48
   53 IDD=-1
      PUNCH 54,IDD
   54 FORMAT(1X,I4)
      PRINT 55
   55 FORMAT(1H1)
      GO TO 1
  400 PRINT 401,IGP
  401 FORMAT(33H INDX NOS. OUT OF ORDER FOR GROUP,2X,I4,2X,15H SKIPPING
     1GROUP)
      PRINT 55
      GO TO 1
  120 CALL PLOT(5.0,0.0,-3)
      CALL SPACE00
      CALL STOPPLOT
      REWIND 1
      REWIND 10
      STOP
      END
```

```
      SUBROUTINE AX(GX,GY,YY)
      GGX=GX-0.2
      DO 1 J=1,11
      GY=GY+YY
      CALL PLOT(GX,GY,1)
      CALL PLOT(GGX,GY,1)
      CALL PLOT(GX,GY,1)
    1 CONTINUE
      RETURN
      END
```

UNCLASSIFIED

```
      SUBROUTINE AXX(GX,GY,YY,GXX)
      NUM=1000
      GNY=8.121818181
      GNX=-0.5
      DO 1 J=1,5
      GY=GY-YY
      CALL PLOT(GX,GY,1)
      CALL PLOT(GXX,GY,1)
      CALL PLOT(GX,GY,1)
      GY=GY-YY
      CALL PLOT(GX,GY,1)
      CALL PLOT(GXX,GY,1)
      CALL PLOT(GX,GY,1)
      CALL NUMBER(GNX,GNY,.12,NUM,0.0,2HI4)
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      NUM=NUM+1000
      GNY=GY-1.878181818
    1 CONTINUE
      GY=GY-YY
      CALL PLOT(GX,GY,1)
      RETURN
      END
```

2.4.4 *Sample Output* — Program VDTSMUPT produces the following outputs.

1. Multiple plot of sound speed vs depth shown in Fig. 9, having the same dimensions as 2.3.5 (3).

Legend on bottom left:

Title

MULTIPLE PLOT

GROUP** (number)

2. Multiple plot of temperature vs salinity, shown in Fig. 10, having the same dimensions as 2.3.5 (4).

The legend on bottom right is the same as in item 1 above.

3. Multiple plot of temperature vs depth, shown in Fig. 11, having the same dimensions as 2.3.5 (1).

The legend on bottom right is the same as in item 1 above.

4. Multiple plot of salinity vs depth, shown in Fig. 12, having the same dimensions as 2.3.5 (2).

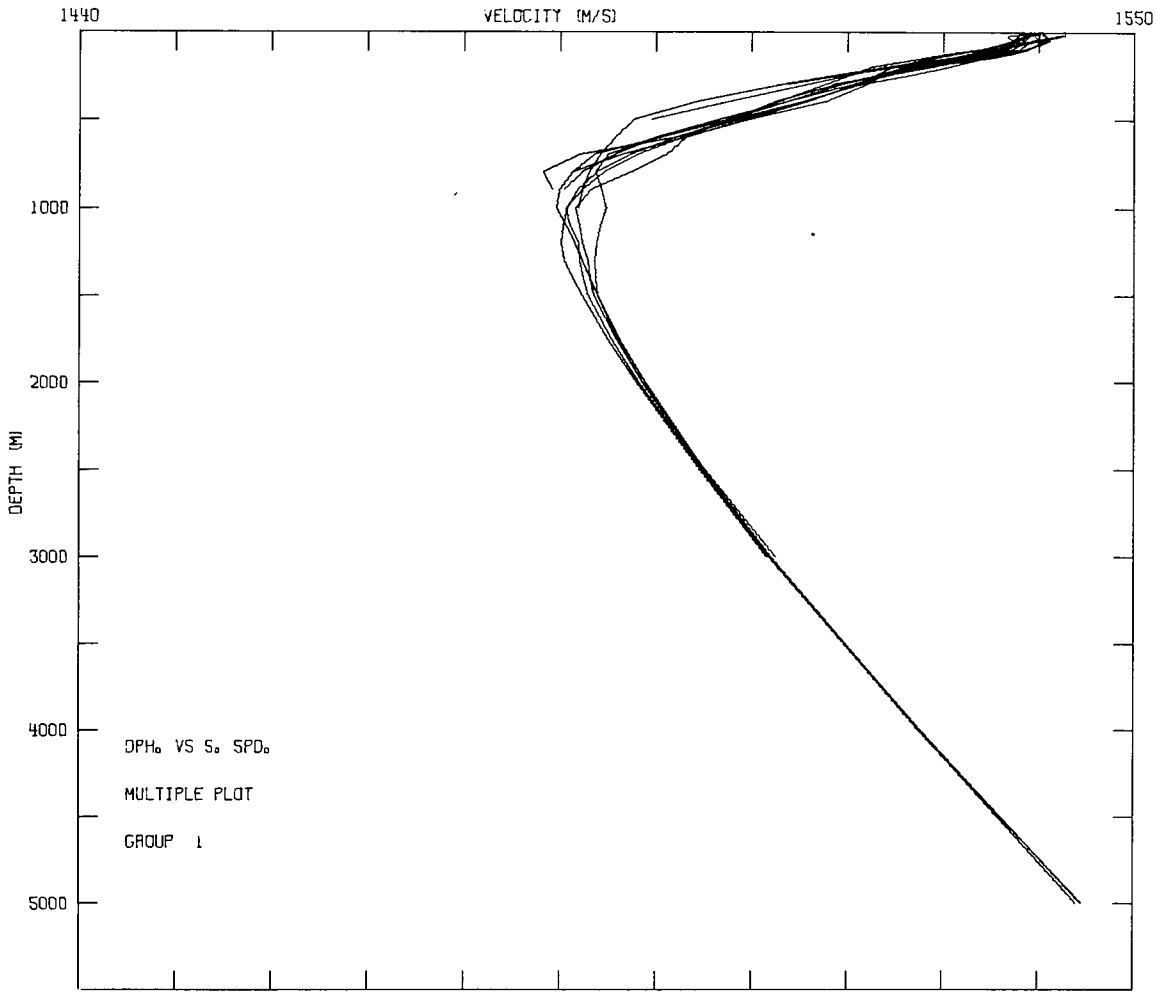

Fig. 9 — Multiple plot, depth (m) vs sound speed (m/s)

UNCLASSIFIED

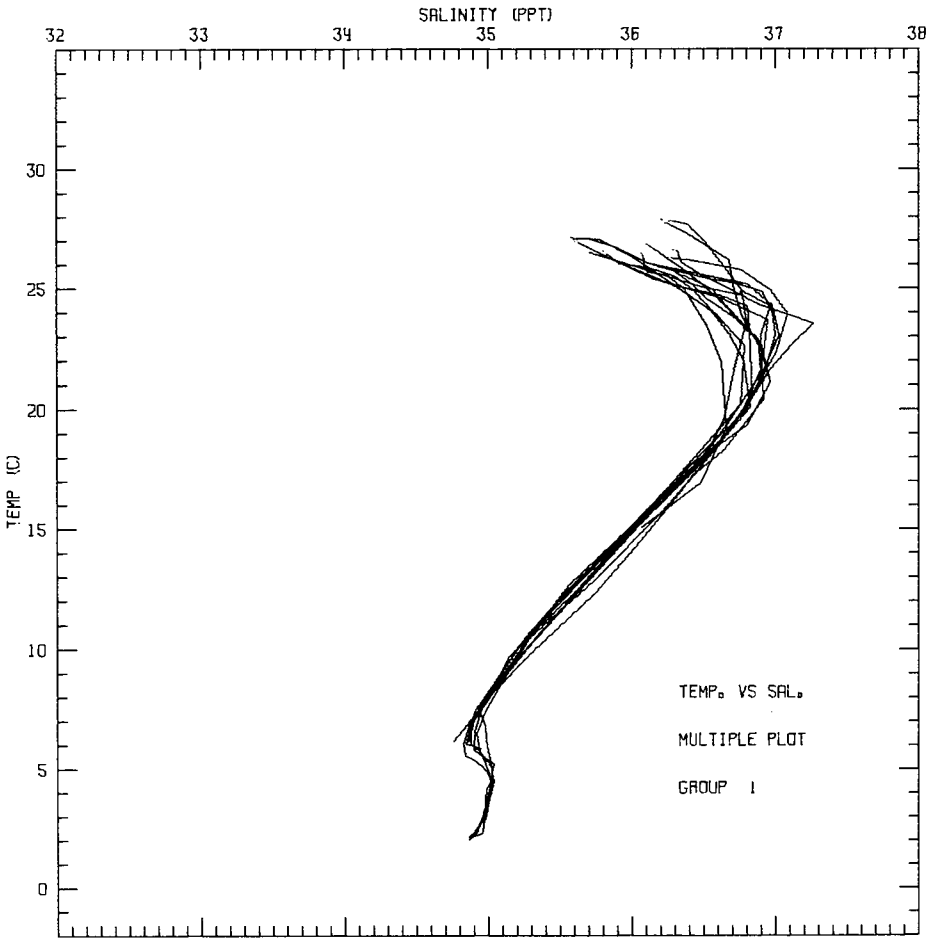

Fig. 10 — Multiple plot, temperature (C°) vs salinity (ppt)

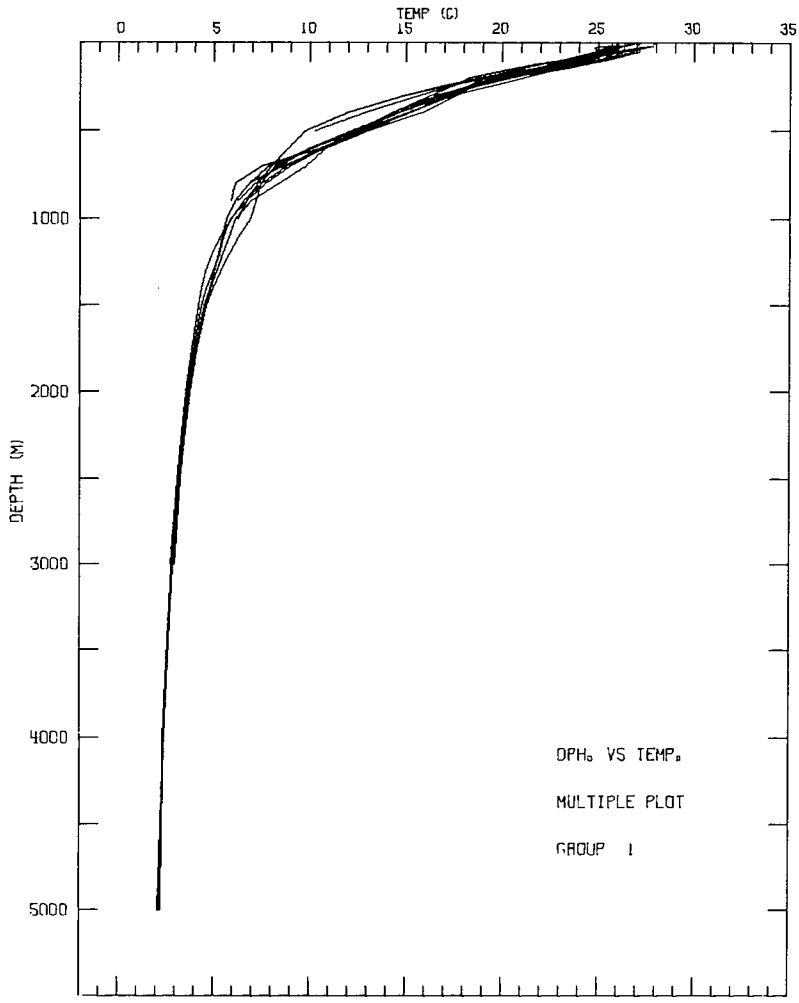

Fig. 11 — Multiple plot, depth (m) vs temperature (C°)

UNCLASSIFIED

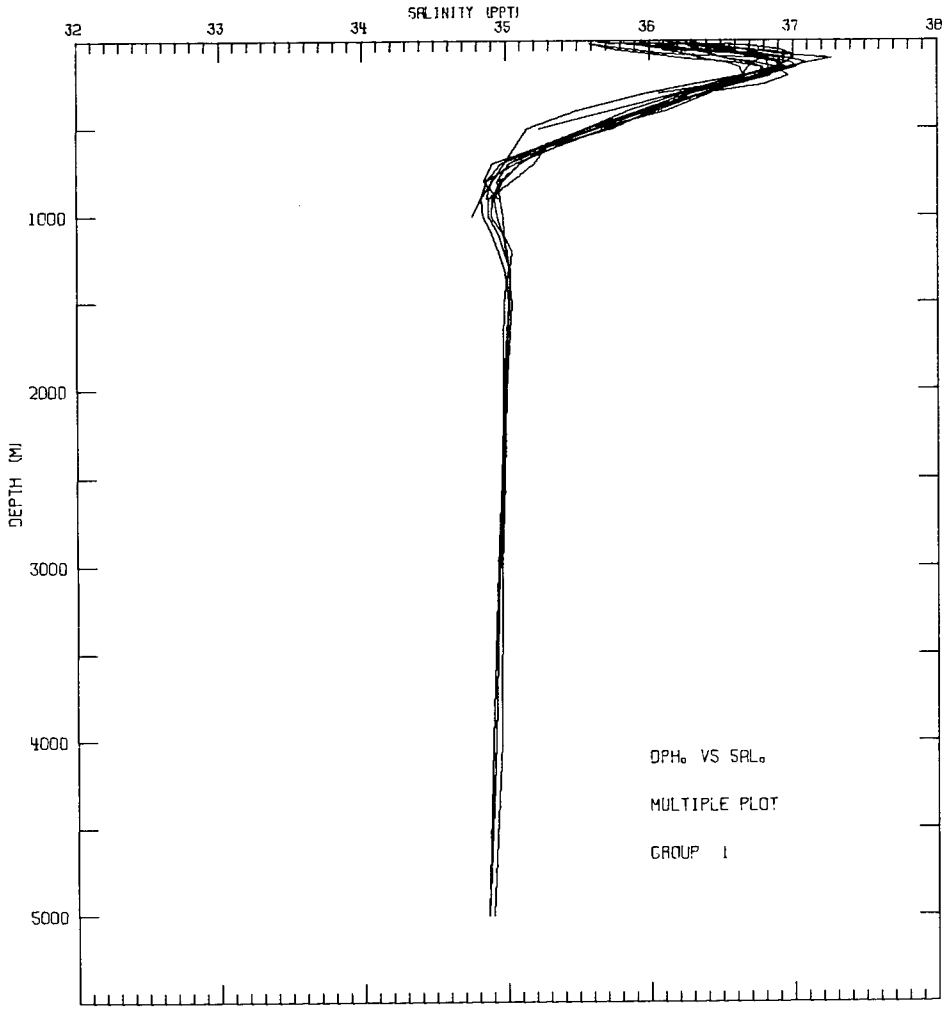

Fig. 12 — Multiple plot, depth (m) vs salinity (ppt)

The legend on bottom right is the same as in item 1 above. All plots are made on a 10-in. plotter.

5. Punched card deck of sound-speed and salinity statistics, referred to as the average salinity deck. Each group produces a set of up to 31 cards of the following format:

Variable	Column	Format	Description
IGP	4-5	I2	Group number
IDH(J)	11-15	I5	standard depth (0 to a maximum of 5000 m)
STLO	19-25	F7.2	mean sound speed minus one standard deviation (m/s)
STHI	29-35	F7.2	mean sound speed plus one standard deviation (m/s)
ASAL	39-45	F7.2	average salinity (ppt)
AMEAN	53-60	F8.2	mean sound speed (m/s)
STDEV	61-70	F10.4	standard deviation (m/s)
STERR	71-80	F10.4	standard error (m/s)

Last card of each group has -1 in column 4-5.

6. Printout having one page per group, shown in Fig. 13. Each column of the printout is noted below.

Column	Description
1	Group number
2	standard depth (m)
3	mean sound speed (m/s)
4	standard deviation (m/s)
5	standard error (m/s)
6	mean sound speed minus one standard deviation (m/s)
7	mean sound speed plus one standard deviation (m/s)

UNCLASSIFIED

Column	Description
8	sum of the sound speeds in the group (m/s)
9	square of the sum of the sound speeds in the group (m^2/s^2)
10	number of sound speeds in each sum

VELOCITY STATISTICS

GROUP	DEPTH	MEAN VAL.	ST. DEV.	ST. ERROR	VALUE 1	VALUE 2	SUM X	SUM X**2	N
1	0	1539.73	1.4347	0.3704	1538.30	1541.17	23096.00	35561709.88	15
1	10	1539.71	1.4429	0.3725	1538.26	1541.15	23095.60	35560478.44	15
1	20	1539.41	1.6681	0.4307	1537.75	1541.08	23091.20	35546940.12	15
1	30	1539.15	1.5501	0.4002	1537.60	1540.70	23087.20	35534620.56	15
1	50	1538.59	1.3405	0.3461	1537.25	1539.93	23078.80	35508759.12	15
1	75	1537.77	1.3563	0.3502	1536.41	1539.12	23066.50	35470920.57	15
1	100	1536.27	1.6816	0.4342	1534.59	1537.95	23044.10	35402075.91	15
1	125	1534.09	2.0331	0.5434	1532.05	1536.12	21477.20	32947919.44	14
1	150	1531.59	2.0481	0.5474	1529.54	1533.64	21442.30	32840928.05	14
1	200	1526.45	2.1707	0.5801	1524.28	1528.62	21370.30	32620755.69	14
1	250	1522.49	2.1610	0.5776	1520.33	1524.65	21314.90	32451843.71	14
1	300	1518.96	2.8392	0.7588	1516.13	1521.80	21265.50	32301639.81	14
1	400	1512.99	4.0264	1.2733	1508.96	1517.02	15129.90	22891533.31	10
1	500	1506.28	4.1667	1.3176	1502.11	1510.45	15062.80	22688950.64	10
1	600	1501.20	2.3696	0.7899	1498.83	1503.57	13510.80	20282457.88	9
1	700	1495.96	2.6843	0.8948	1493.27	1498.64	13463.60	20141004.86	9
1	800	1492.84	2.5530	0.8510	1490.29	1495.40	13435.60	20057312.96	9
1	900	1491.68	1.7285	0.6111	1489.95	1493.40	11933.40	17800775.36	8
1	1000	1491.53	1.7951	0.7329	1489.74	1493.33	8949.20	13348046.22	6
1	1100	1491.62	1.5786	0.7060	1490.04	1493.20	7458.10	11124661.09	5
1	1200	1491.92	1.3387	0.5987	1490.58	1493.26	7459.60	11129133.60	5
1	1300	1492.24	1.1971	0.5354	1491.04	1493.44	7461.20	11133906.82	5
1	1400	1492.72	0.9176	0.4103	1491.80	1493.64	7463.60	11141068.36	5
1	1500	1493.30	0.6929	0.3099	1492.61	1493.99	7466.50	11149726.37	5
1	1750	1495.70	0.4898	0.2191	1495.21	1496.19	7478.50	11185593.41	5
1	2000	1498.46	0.3579	0.1601	1498.10	1498.82	7492.30	11226912.37	5
1	2500	1504.88	0.1923	0.0860	1504.69	1505.07	7524.40	11323319.22	5
1	3000	1511.94	0.3437	0.1537	1511.60	1512.28	7559.70	11429813.29	5
1	4000	1527.60	0.1000	0.0578	1527.50	1527.70	4582.80	7000685.30	3
1	5000	1544.37	0.3215	0.1856	1544.05	1544.69	4633.10	7155205.41	3

Fig. 13 — Printout of velocity statistics produced by Program VDTSMUPT

2.5 Sound Speed Calculation and Plot (SSCPDN)

Each temperature profile should now be examined using the depth vs temperature multiple plot from Sec. 2.4.4(3) and the chart produced in Sec. 2.2. The character of the profile and its relationship to the positions of the grouped Nansen casts should be considered in order to assign to each profile one of the group numbers (Sec. 2.3.1). This is the number that should appear on Card 2 (title card), columns 77-78, of the temperature profile deck of Sec. 1.2.

Program SSCPDN calculates sound speed for each value of the temperature deck using the first three terms of Leroy's second formula. The value of salinity at any given depth is found by linearly interpolating the salinity vs depth data. A printout and/or punched card deck is produced as well as a depth vs sound-speed plot. The plot consists of the

calculated sound speeds denoted by an octagon symbol. Two additional plots are created by adding and subtracting the archival standard deviation from the mean sound speed. These two traces can be used to extend the calculated sound speeds to the ocean bottom. Any of the three output options — printout, punched cards, and plots — may be suppressed, but if the printout is omitted the punch card deck will also be omitted.

2.5.1 *Leroy's Second Formula* — The second formula of Leory is

$$V(\text{sound speed m/s}) = V0 + VA + VB + VC + VD,$$

where

$$V0 = 1493.0 + 3(T-10.0) - 6\times10^{-3}\,(T-10.0)^2 - 4\times10^{-2}\,(T-18.0)^2 + 1.2(S-35.0) - 10^{-2}\,(T-18.0)\,(S-35.0) + Z/61.0$$

$$VA = 10^{-1}\delta^2 + 2\times10^{-4}\delta^2\,(T-18.0)^2 + 10^{-1}\delta\phi/90.0$$

$$VB = 2.6\times10^{-4}\,T(T-S)\,(T-25.0)$$

$$VC = 10^{-3}\delta^2\,(\delta-4.0)\,(\delta-8.0)$$

$$VD = 1.5\times10^{-3}\,(S-35.0)^2\,(1.0-\phi) + 3.0\times10^{-6}T^2\,(T-30.0)\,(S-35.0),$$

in which

T = temperature (C)

S = salinity (ppt)

Z = depth (m)

δ = depth (km) = $Z/1000.0$

ϕ = latitude in degrees and fractions of a degree.

The first three terms (V0, VA, VB) are accurate to ±0.3 m/s as compared to Wilson's second equation for temperature -2 to 30°C, salinities 30 to 42ppt, and depths 0 to 7200 m. Because these conditions cover most of the world's oceans, the program was limited to the first three terms, but it can easily be modified to include all five terms if necessary.

2.5.2 *Depth vs Salinity* — Many programs which calculate sound speed use the temperature vs salinity profile for obtaining a value of salinity. Because of this, program SSCPDN provides for using such input profiles. Unfortunately, there are large areas of the ocean where currents such as the Gulf Stream cause so much mixing that a particular temperature value can have more than one value of salinity. Handling such multivalued functions leads to serious problems. The single-valued salinity as a function of depth seemed a simple solution, and with this in mind the punched card deck described in Sec. 2.4.4 (5) was produced as primary input to this program.

UNCLASSIFIED

2.5.3 *Program Control Cards*

$^{7}_{9}$JOB,....

$^{7}_{9}$EQUIP,10=**,WO,LO,DA (plot tape)

$^{7}_{9}$FTN,L,X,R

Fortran source deck

Scope

$^{7}_{9}$LOAD

$^{7}_{9}$RUN,.....

2.5.4 *Input Control and Data Cards*

Card 1: control card

Variable	Column	Format	Description
IGP	1-3	I3	=0; depth vs salinity input profiles =1; temperature vs salinity input profiles
NGP	4-6	I3	less than or equal to 10 highest Group number (for example, if we have assigned Group numbers 1, 4, 8, then NGP = 8)
IPSK	7-9	I3	=-1; no printout or punched cards =0; printout, punched card deck, and plot for no punched card deck, see IPUS =1; no plots
IYR	10-12	I3	year profile was taken (example IYR=74) used on the plots
IPUS	13-15	I3	=1 and IPSK=0; no punched card depth vs sound-speed deck =1 and IPSK=-1; no punched cards no matter what the value of IPUS =0 and IPSK=0; punched card deck produced
IPRP	16-18	I3	number of points to skip between the plotting of the symbol on the plot of the calculated sound speeds, all points are connected by a straight line

Variable	Column	Format	Description
			=0; every calculated point will have a symbol
IAVV	19-21	I3	=1; the statistical limits of the sound speed will not be plotted; this will be the case if the temperature vs salinity input deck option is chosen or if the extra plotting is to be omitted from the depth vs salinity input option. =0; limits will be plotted

EOF card will terminate the program.

Card 2 to N: IGP=0 option, depth-salinity deck from Sec. 2.4.4(5)

Variable	Column	Format	Description
IG	4-5	I2	Group number
IDH	11-15	I5	standard depth (m)
SPA	19-25	F7.2	mean sound speed minus standard deviation (m/s)
SPB	29-35	F7.2	mean sound speed plus standard deviation (m/s)
ASAL	39-45	F7.2	average salinity (ppt)

CAUTION: Up to ten groups of 31 cards may be read in with the depth increasing. Each group is terminated when IG =-1 is read, and the entire set of groups is terminated when IG =NGP. The deepest depth of any group must exceed the maximum depth of any input temperature profile.

Card 2 to N: IGP=1 option, temperature vs salinity deck

Variable	Column	Format	Description
IG	4-5	I2	Group number
TEMP	11-20	F10.2	temperature (C)
ASAL	21-30	F10.2	average salinity (ppt)

UNCLASSIFIED

CAUTION: Up to ten groups of 30 temperature-salinity pairs may be read in. Each group is terminated when IG=-1, and the entire set of groups is terminated when IG = NGP. The order must decrease from the highest temperature. The range of temperatures must exceed all temperature profile values of a given group.

Card N+1 to M: IGP=1 and IAVV=1 option, sound-speed limits deck

Variable	Column	Format	Description
IG	4-5	I2	Group number
IDH	11-15	I5	standard depth (m)
SPA	19-25	F7.2	lower limit of the sound speed (m/s)
SPB	29-35	F7.2	upper limit of the sound speed (m/s)

CAUTION: This deck is needed when, even though a temperature vs salinity profile approach was used, a plot having the statistical limits of the sound speed is desired. The number of groups should correspond to those of option IGP=1. Each group is terminated when IG=-1, and the entire set is terminated when IG = NGP.

Cards M to K: temperature profile deck

This is the deck described in Sec. 1.2.

Procedure:

The temperature deck will be read in and each profile processed using the appropriate salinity group until an EOF card is encountered; then the program will loop back to Card 1 (control card) to repeat the whole process on a new set of average salinity and temperature profile cards. When an EOF card is encountered when Card 1 is read, the program will terminate.

The running time of this program depends on the length and number of temperature profiles. It is approximately 5s per profile. For most cases the total run will not exceed 5 min.

2.5.5 *Program SSCPDN Fortran Source Listing*

```
      PROGRAM SSCPDN
C     PROGRAM CALCULATES SOUND SPEED FROM XBT PROFILE USING DEPTH-SAL,
C     OR TEMP-SAL, PROFILES, USING LEROYS SECOND EQUATION THE FIRST
C     THREE TERMS
      DIMENSION IDT(450),TT(450),VEL(450),DV(450),PLTARRAY(254),PD(450),
     1PV(450)
      COMMON/GDS/GD(10,30),GVA(10,30),GVB(10,30),GS(10,30)
      COMMON/GTS/GT(10,30),GST(10,30)
      CALL PLOTS(PLTARRAY,254,10)
    1 READ 2,IGP,NGP,IPSK,IYR,IPUS,IPRP,IAVV
    2 FORMAT(7I3)
C     CONTROL CARD  IGP= ,LE. 0 THEN DEPTH-SAL PROFILES
C                     = ,GT. 0 THEN TEMP- SAL PROFILES
C                  NGP= NO, OF LARGEST GROUP  ,LE. 10
C                 IPSK= ,LT. 0 NO PRINTOUT JUST PLOTS
C                       ,EQ. 0 BOTH PRINTOUT AND PLOTS
C                       ,GT. 0 NO PLOTS JUST PRINTOUT
C                  IYR= YEAR OF PROFILES
C                 IPUS= ,GT. 0 NO DEPTH-VEL CARDS PUNCHED
C                       ,LE. 0 PUNCHES CARDS
C                 IPRP= NO, OF POINTS TO SKIP BETWEEN PLOT SYMBOL
C                 IAVV= ,GT.0 NO VEL LIMITS DECK ONLY T-S DECK
C                             OR SKIP  PLOTTING VEL LIMITS
      IF(EOF,60)100,3
C     IGP=0 - READ IN GROUP, DEPTH, LOWER VEL, UPPER VEL, AVE, SAL DECK
    3 IF(IGP.LE,0) CALL DPSAL(NGP)
C     IGP=1 - READ IN TEMPERATURE , SALINITY DECK
C     IF  VEL LIMITS DESIRED  DECK WITH FORMAT OF DEPTH SAL DECK MUST BE
C     INSERTED  AFTER  T-S DECK
      IF(IGP.GT,0) CALL TEMPSAL(NGP)
      IF(IAVV,GT,0)GO TO 62
      IF(IGP.GT,0) CALL DPSAL(NGP)
   62 IF(IPRP,LE,0)IPRP=1
    4 READ 5,IAA
    5 FORMAT(I4)
    6 READ 7,NUM,JD,IMO,IDA,IHR,IMN,NPB,TMF,LA,LAM,NLA,LO,LOM,NLO,NPP,MS
     $Q,MDSQ,IGS,ICOF
    7 FORMAT(1X,I3,1X,I3,1X,I2,1X,I2,1X,I2,1X,I2,1X,A2,1X,F4.1,1X,I2,1X,
     $I2,A1,1X,I3,1X,I2,A1,1X,A2,3X,I3,7X,I2,15X,I2,1X,I1)
C     XBT TITLE CARD FORMAT
      IF(EOF,60)1,8
    8 READ 5,IAA
    9 N=1
   10 NN=N+5
C     READ  DEPTH-TEMP MUST HAVE MORE THAN ONE CARD
   11 READ 12,NOM,(IDT(I),TT(I),I=N,NN)
   12 FORMAT(1X,I3,6(I5,F6.2))
      N=NN+1
      IF(NOM.EQ,NUM)GO TO 10
      NN=NN-6
      N=NN-5
      DO 13 JJJ=N,NN
      IF(TT(JJJ),LE,0,0)GO TO 14
      JJ=JJJ
   13 CONTINUE
C
```

UNCLASSIFIED

```
C
   14 J=1
      M=1
   15 DPH=IDT(J)
      TEP=TT(J)
      IF(IGP.LE.0) CALL SALDPH(DPH,SALIN,IGS)
      IF(IGP.GT.0) CALL SALTEM(TEP,SALIN,IGS)
      D=DPH/1000.0
      ALA=FLOAT(LA)*(FLOAT(LAM)/60.0)
      VO=1493.0+3.0*(TT(J)-10.0)+6.0*10.0**(-3)*(TT(J)-10.0)**2-4.0*10.0
     1**(-2)*(TT(J)-18.0)**2+1.2*(SALIN-35.0)-10.0**(-2)*(TT(J)-18.0)*(S
     2ALIN-35.0)+DPH/61.0
      VA=10.0**(-1)*D*D+2.0*10.0**(-4)*D*D*(TT(J)-18.0)**2+10.0**(-1)*D*
     1ALA/90.0
      VB=2.6*10.0**(-4)*TT(J)*(TT(J)-5.0)*(TT(J)-25.0)
      DV(M)=DPH
      VEL(M)=VO+VA+VB
      M=M+1
      J=J+1
      IF(J.EQ.JJ+1)GO TO 16
      GO TO 15
   16 IF(IPSK.LT.0)GO TO 50
      PRINT 7,NUM,JD,IMO,IDA,IHR,IMN,NPB,TMF,LA,LAM,NLA,LO,LOM,NLO,NPP,M
     $SG,MDSQ,IGS,ICOF
      M=M-1
C     M= NO. OF DPH-VEL VALUES
      PRINT 18
   18 FORMAT(2H  /)
      PRINT 200
  200 FORMAT(80H DPH(M)  S. SPD  DPH(M)  S. SPD  DPH(M)  S. SPD  DPH(M)
     $ S. SPD  DPH(M)  S. SPD )
      IF(IPUS.GT.0)GO TO 61
      PUNCH 7,NUM,JD,IMO,IDA,IHR,IMN,NPB,TMF,LA,LAM,NLA,LO,LOM,NLO,NPP,M
     $SG,MDSQ,IGS,ICOF
C     DV(I)=DEPTH, VEL(I)=VELOCITY
   61 PRINT 19,(DV(I),VEL(I),I=1,M)
      IF(IPUS.GT.0)GO TO 60
      PUNCH 19,(DV(I),VEL(I),I=1,M)
   19 FORMAT(5(F8.2,F8.2))
   60 PRINT 20
   20 FORMAT(2H  ///)
   50 IF(IPSK.GT.0)GO TO 6
C     CONSTRUCT GRID
      YY=0.909090909
      GXX=0.2
      GYYY=0.2
      CALL PLOT(0.0,0.0,3)
      CALL PLOT(0.0,0.2)
      GX=0.0
      GY=0.0
      XXX=1.0
      DO 21 K=1,11
      GX=GX+XXX
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GYYY,1)
      CALL PLOT(GX,GY,1)
```

```
   21 CONTINUE
      GMAX=GX+4.0
      CALL AX(GX,GY,YY)
      KLM=1550
      CALL NUMBER(10.8,10.1,.12,KLM,0.0,2HI4)
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      GYYYY=GY-GYYY
      DO 22 K=1,11
      GX=GX+XXX
      CALL PLOT(GX,GY,1)
      CALL PLOT(GX,GYYYY,1)
      CALL PLOT(GX,GY,1)
   22 CONTINUE
      KLM=1440
      CALL NUMBER(*.2,10.1,.12,KLM,0.0,2HI4)
      CALL SYMBOL(4.2,10.1,.12,14HVELOCITY (M/S),0.0,14)
      CALL PLOT(GX,GY,3)
      CALL PLOT(GX,GY,2)
      CALL AXX(GX,GY,YY,GXX)
      CALL SYMBOL(*.6,5.0,.12,9HDEPTH (M),90.0,9)
      CALL SYMBOL(.5,2.5,.12,15HDPH, VS S, SPD.,0.0,15)
      CALL SYMBOL(.5,2.0,.12,11HPROFILE NO.,0.0,11)
      CALL NUMBER(1.73,2.0,.12,NLM,0.0,2HI3)
      CALL NUMBER(.5,1.5,.12,IMO,0.0,2HI2)
      CALL SYMBOL(.76,1.5,.12,1H/,0.0,1)
      CALL NUMBER(.91,1.5,.12,IDA,0.0,2HI2)
      CALL SYMBOL(1.17,1.5,.12,1H/,0.0,1)
      CALL NUMBER(1.32,1.5,.12,IYR,0.0,2HI2)
      ITM=(IHR*100)+IMN
      CALL NUMBER(1.8,1.5,.12,ITM,0.0,2HI4)
      CALL SYMBOL(2.26,1.5,.12,1HZ,0.0,1)
C     PLOT PROFILE
      DFAC=0.00181818
      DO 23 I=1,M
      PV(I)=(VEL(I)-1440.0)*.1
      PD(I)=(5500.0-DV(I))*DFAC
      IF(PV(I).LT.0.0)PV(I)=0.0
      IF(PV(I).GT.11.0)PV(I)=11.0
      IF(PD(I).LT.0.0)PD(I)=0.0
      IF(PD(I).GT.10.0)PD(I)=10.0
   23 CONTINUE
      CALL LINE(PV,PD,M,1,1,.04,IPRP)
      CALL PLOT(0.0,0.0,-3)
      CALL SPACE00
C     PLOT LOWER AVE. SOUND SPEED
      IF(IAVV.GT.0)GO TO 6
      DO 24 I=1,30
      IF(GVA(IGS,I).LT.0.0)GO TO 25
      PV(I)=(GVA(IGS,I)-1440.0)*.1
      PD(I)=(5500.0-GD(IGS,I))*DFAC
      IF(PV(I).LT.0.0)PV(I)=0.0
      IF(PV(I).GT.11.0)PV(I)=11.0
      IF(PD(I).LT.0.0)PD(I)=0.0
      IF(PD(I).GT.10.0)PD(I)=10.0
      J=I
```

UNCLASSIFIED

```
   24 CONTINUE
   25 CALL LINE(PV,PD,J,1,-1,.01,1)
C     PLOT UPPER AVE. SOUND SPEED
      DO 26 I=1,J
      PV(I)=(GVB(IGS,I)-1440.0)*.1
      IF(PV(I).LT.0.0)PV(I)=0.0
      IF(PV(I).GT.11.0)PV(I)=11.0
   26 CONTINUE
      CALL LINE(PV,PD,J,1,-1,.01,1)
      CALL PLOT(GMAX,0.0,-3)
      CALL SPACEOO
      GO TO 6
  100 CALL SPACEOO
      CALL STOPPLOT
      END
```

```
      SUBROUTINE DPSAL(NGP)
C     READS IN DEPTH,VEL,AVE. SALINITY PROFILES
      COMMON/GDS/GD(10,30),GVA(10,30),GVB(10,30),GS(10,30)
      DO 1 J=1,10
      DO 2 JJ=1,30
      GD(J,JJ)=-99.0
      GVA(J,JJ)=-99.0
      GVB(J,JJ)=-99.0
      GS(J,JJ)=-99.0
    2 CONTINUE
    1 CONTINUE
    3 N=1
    4 READ 5,IG,IDH,SPA,SPB,ASAL
    5 FORMAT(1X,I4,5X,I5,3X,F7.2,3X,F7.2,3X,F7.2)
      IF(IG.LE.0)GO TO 10
      GD(IG,N)=IDH
      GVA(IG,N)=SPA
      GVB(IG,N)=SPB
      GS(IG,N)=ASAL
      N=N+1
      IGG=IG
      GO TO 4
   10 IF(IGG.GE.NGP)GO TO 20
      GO TO 3
   20 RETURN
      END
```

```
      SUBROUTINE TEMPSAL(NGP)
      COMMON/GTS/GT(10,30),GST(10,30)
C     READS IN TEMP-SAL PROFILES
      DO 1 J=1,10
      DO 2 JJ=1,30
      GT(J,JJ)=-99.0
      GST(J,JJ)=-99.0
```

```
    2 CONTINUE
    1 CONTINUE
    3 N=1
    4 READ 5,IG,TEMP,ASAL
    5 FORMAT(1X,I4,5X,2F10.0)
      IF(IG.LE.0)GO TO 10
      GT(IG,N)=TEMP
      GST(IG,N)=ASAL
      IGG=IG
      N=N+1
      GO TO 4
   10 IF(IGG.GE.NGP)GO TO 20
      GO TO 3
   20 RETURN
      END
```

```
      SUBROUTINE SALDPH(DPH,SALIN,IGS)
      COMMON/GDS/GD(10,30),GVA(10,30),GVB(10,30),GS(10,30)
C     CALCULATE SALINITY FROM DPH-SAL
    1 J=2
    2 IF(GD(IGS,J).GE.DPH)GO TO 3
      J=J+1
      GO TO 2
    3 SALIN=(GS(IGS,J))-((GD(IGS,J)-DPH)/(GD(IGS,J)-GD(IGS,J-1))*(GS(IGS
     1,J)-GS(IGS,J-1)))
      RETURN
      END
```

```
      SUBROUTINE SALTEM(TEP,SALIN,IGS)
C     CALCULATES SALINITY FROM TEMP-SAL
      COMMON/GTS/GT(10,30),GST(10,30)
    1 J=2
    2 IF(GT(IGS,J).LE.TEP)GO TO 3
      J=J+1
      GO TO 2
    3 SALIN=(GST(IGS,J))-((GT(IGS,J)-TEP)/(GT(IGS,J)-GT(IGS,J-1))*(GST(I
     1GS,J)-GST(IGS,J-1)))
      RETURN
      END
```

```
      SUBROUTINE AX(GX,GY,YY)
      GGX=GX-0.2
      DO 1 J=1,11
      GY=GY+YY
      CALL PLOT(GX,GY,1)
      CALL PLOT(GGX,GY,1)
      CALL PLOT(GX,GY,1)
```

UNCLASSIFIED

```
1 CONTINUE
  RETURN
  END
```

```
  SUBROUTINE AXX(GX,GY,YY,GXX)
  NUM=1000
  GNY=8.121818181
  GNX=-0.5
  DO 1 J=1,5
  GY=GY-YY
  CALL PLOT(GX,GY,1)
  CALL PLOT(GXX,GY,1)
  CALL PLOT(GX,GY,1)
  GY=GY-YY
  CALL PLOT(GX,GY,1)
  CALL PLOT(GXX,GY,1)
  CALL PLOT(GX,GY,1)
  CALL NUMBER(GNX,GNY,.12,NUM,0.0,2H14)
  CALL PLOT(GX,GY,3)
  CALL PLOT(GX,GY,2)
  NUM=NUM+1000
  GNY=GY-1.878181818
1 CONTINUE
  GY=GY-YY
  CALL PLOT(GX,GY,1)
  RETURN
  END
```

2.5.6 *Sample Output* — Program SSCPDN produces the following outputs:

1. Plot of sound speed (1440 to 1550 m) on a 27.9-cm abscissa vs depth (0 to 5000 m) on a 25.4-cm ordinate, shown in Fig. 14. Each calculated sound speed is denoted by an octagon symbol. The values obtained by adding and subtracting one standard deviation from the mean sound speed are connected by straight lines. Plots are made on a 10-in. plotter.

Legend on bottom left:

Title

PROFILE NO. ***

Date and time (example: 5/9/74 2230Z)

2. Punched card deck consisting of a title card followed by pairs of depth (m), and sound-speed (m/s) values, five sets of values to a card. This deck, called the sound-speed deck, has the following format:

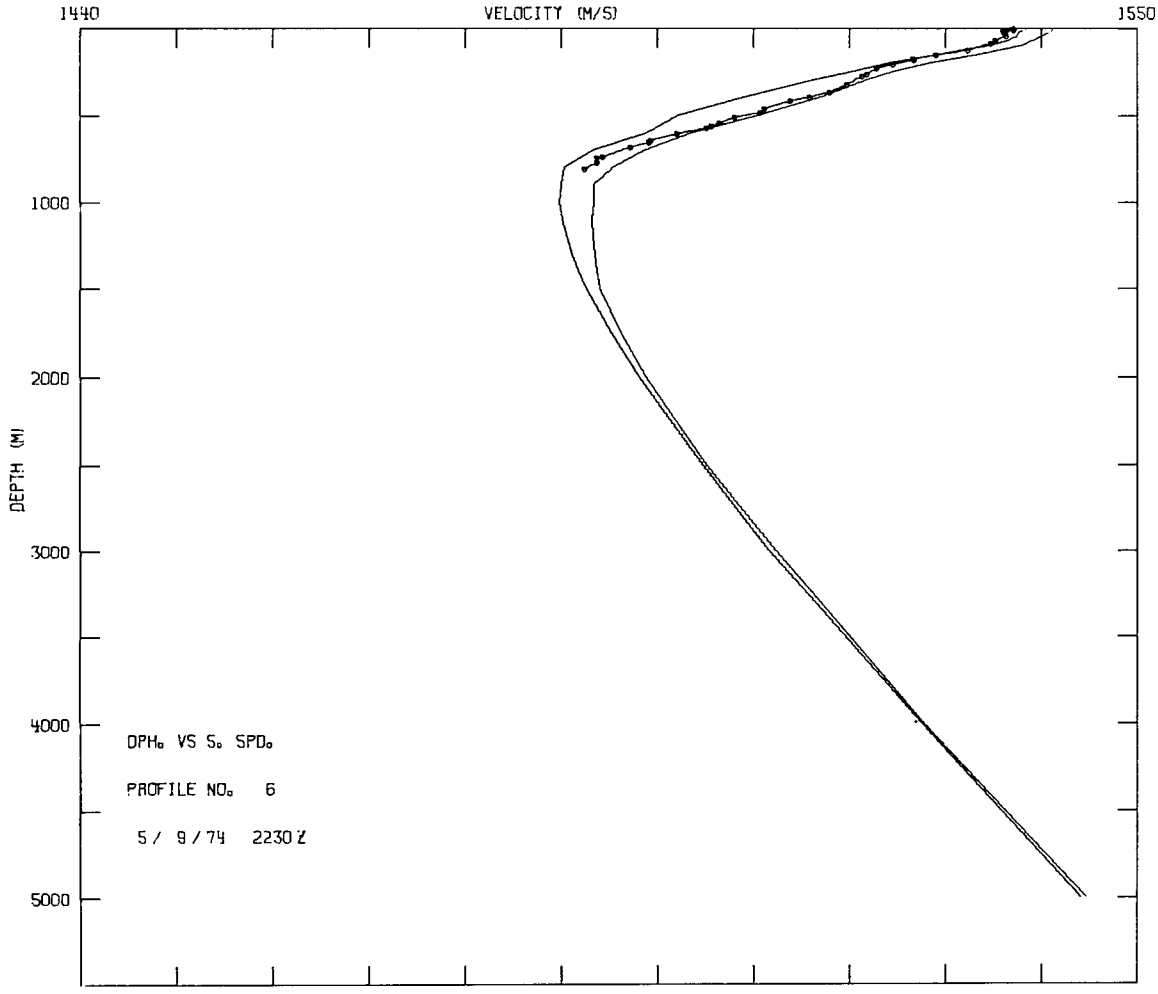

Fig. 14 — Calcomp plot of calculated sound speed (square symbols). Solid line, plot of one standard deviation above and below archival grouped average sound speeds.

Card 1: Title Card

Column	Format	Description
3-4	I2	Profile number same as temperature profile number
6-8	I3	Julian day
10-11	I2	number of the month
13-14	I2	day of the month
16-17	I2	hour (Zulu)

UNCLASSIFIED

Column	Format	Description
19-20	I2	minute
22-23	A2	type of XBT probe used (if given)
25-28	F4.2	surface temperature (if given)
30-31	I2	latitude degrees
33-34	I2	latitude minutes
35	A1	N or S
37-39	I3	longitude degrees
41-42	I2	longitude minutes
43	A1	E or W
45-46	A2	type of XBT paper used (if given)
50-52	I3	Marsden square (if given)
60-61	I2	1° degree square (if given)
77-78	I2	salinity group number
80	I1	profile confidence indicator, =1; profile good =0; profile doubtful

Card 2 to N: sound-speed data deck

Column	Format	Description
1-8	F8.2	depth (m)
9-16	F8.2	sound speed (m/s)
17-24	F8.2	depth (m)
etc.		pairs of values repeated five to a card, until all values punched

Each temperature profile produces a sound-speed profile deck having the above format.

3. Printout of title and sound-speed profiles having the same format as the punched cards, shown in Fig. 15.

```
  1 129  5  9 10 30 T5 25,6 19 40N  60 38W T5     43        90                  1 1

DPH(M)  S. SPD  DPH(M)  S. SPD  DPH(M)  S. SPD  DPH(M)  S. SPD  DPH(M)  S. SPD
   0.00 1537,47   13,00 1537,29   21,00 1537,53   25,00 1536,93   29,00 1537,27
  43.00 1536,20   61,00 1535,68   65,00 1535,30   73,00 1535,49   79,00 1535,15
  82.00 1535,47   91,00 1534,96   96,00 1535,57  101,00 1535,69  137,00 1534,40
 144.00 1533,77  150,00 1533,87  179,00 1531,17  209,00 1527,82  222,00 1526,05
 237.00 1525,11  253,00 1523,59  285,00 1521,92  346,00 1520,28  388,00 1519,28
 460.00 1514,56  505,00 1511,89  531,00 1511,25  616,00 1506,66  685,00 1501,27
 804.00 1494,51  826,00 1493,71  847,00 1492,90  867,00 1492,83  880,00 1492,27
 884.00 1491,55  982,00 1491,19 1046,00 1491,51 1247,00 1492,98 1446,00 1494,30
1641.00 1496,34 1848,00 1499,41


  2 129  5  9 12 30 T7 25,6 19 55N  60 34W T5     43        90                  1 1

DPH(M)  S. SPD  DPH(M)  S. SPD  DPH(M)  S. SPD  DPH(M)  S. SPD  DPH(M)  S. SPD
   0.00 1537,00    6,00 1537,12    9,00 1536,94   13,00 1536,82   15,00 1536,64
  18.00 1536,26   23,00 1536,16   29,00 1536,08   38,00 1536,07   47,00 1536,30
  52.00 1535,95   56,00 1536,04   66,00 1535,81   94,00 1535,77  113,00 1535,69
 128.00 1535,73  138,00 1535,66  147,00 1535,57  150,00 1535,62  153,00 1535,41
 159.00 1534,99  166,00 1534,84  171,00 1534,40  177,00 1533,47  182,00 1532,76
 185.00 1532,03  190,00 1531,58  195,00 1530,33  202,00 1529,89  213,00 1527,59
 220.00 1526,30  226,00 1526,92  239,00 1525,69  245,00 1525,48  283,00 1521,90
 330.00 1519,79  385,00 1517,42  423,00 1515,07  450,00 1513,17  478,00 1510,58
 538.00 1506,99  564,00 1505,97  580,00 1503,75  597,00 1502,92  671,00 1498,90
 729.00 1494,89  800,00 1492,52  832,00 1492,65


  5 129  5  9 18 30 T5 26,1 20 24N  60 22W T5     79         0                  1 1

DPH(M)  S. SPD  DPH(M)  S. SPD  DPH(M)  S. SPD  DPH(M)  S. SPD  DPH(M)  S. SPD
   0.00 1537,00    6,00 1537,12    9,00 1536,94   11,00 1536,52   16,00 1536,44
  26.00 1535,76   46,00 1535,55   49,00 1534,90   61,00 1534,71   85,00 1534,31
 104.00 1535,75  111,00 1535,89  117,00 1535,52  147,00 1535,82  166,00 1534,59
 179.00 1531,95  193,00 1528,97  205,00 1528,85  225,00 1527,19  243,00 1525,46
 263.00 1523,41  293,00 1522,00  343,00 1520,83  400,00 1517,60  448,00 1516,00
 465.00 1513,99  511,00 1511,31  556,00 1509,59  592,00 1507,02  641,00 1503,87
 678.00 1501,89  697,00 1501,43  742,00 1499,56  792,00 1496,22  842,00 1494,74
 893.00 1493,26 1042,00 1492,63 1143,00 1493,61 1292,00 1494,15 1491,00 1495,06
1642.00 1496,77 1792,00 1498,88 1874,00 1500,67 1990,00 1501,81
```

Fig. 15 — Printout of calculated sound-speed profile

2.6 Report Plots (XREPDN and SSDSDN)

This final set of two programs plots the temperature profile, sound-speed, and archival average salinity decks in a condensed format suitable for reproduction in a report. Six temperature and sound speed profiles and three average salinity profiles are produced on a page-sized plot.

Program XREPDN plots the temperature deck, while Program SSDSDN plots the sound-speed and average salinity decks. All the sound-speed profiles of a set are plotted, followed by the salinity profiles that were used in their calculation. Program XREPDN will be discussed first, then program SSDSDN.

UNCLASSIFIED

1. Program XREPDN

2.6.1 *Program Control Cards (XREPDN)* — Same as Section 2.5.4.

2.6.2 *Data Cards*

Card 1 to N: temperature deck (described in Section 1.2). An EOF card at the end of the deck will terminate the program.

2.6.3 *Program XREPDN Fortran Source Listing*

```
      PROGRAM XREPDN
C     PROGRAM PLOTS XBT DIGITIZED DATA FOR DATA REPORT
C     SIX PLOTS TO A PAGE - D. NUTILE
C     DIMENSION ID(100),TP(100),X(100),Y(100),PLTARRAY(254)
      DIMENSION ID(900),TP(900),X(900),Y(900),PLTARRAY(254)
      CALL PLOTS(PLTARRAY,254,10)
      XAX=2.5
      YAX=3.0
      TMAX=30.
      DMAX=2000.0
      IDMAX=2000
      ITMAX=30
      MNU=0
      TFAC=XAX/TMAX
      DFAC=YAX/DMAX
    1 READ 2,IA
    2 FORMAT(I2)
    3 NP=1
      CALL PLOT(0.0,5.0,-3)
    4 READ 5,NOM,JD,IHR,MIN,ICOF
    5 FORMAT(1X,I3,I4,7X,I2,1X,I2,59X,I1)
      IF(EOF,60)100,6
    6 READ 2,IA
    7 N=1
    8 NN=N+5
      READ 9,NUM,(ID(I),TP(I),I=N,NN)
    9 FORMAT(1X,I3,6(I5,F6.2))
      N=NN+1
      IF(NUM.EQ.NOM)GO TO 8
      NN=NN-6
      N=NN-5
      IF(N.LT.0)GO TO 4
      DO 10 JJJ=N,NN
      IF(TP(JJJ).LE.0.0)GO TO 11
      JJ=JJJ
   10 CONTINUE
   11 CALL PLOT(0.0,0.0,0.2)
      CALL PLOT(XAX,0.0,1)
      CALL PLOT(XAX,YAX,1)
      CALL PLOT(0.0,YAX,1)
      CALL PLOT(0.0,0.0,1)
```

```
      IF(NP.GT.1)GO TO 12
      CALL NUMBER(*,5,-.06,.12,IDMAX,0.0,2HI4)
      CALL SYMBOL(*,18,1.05,.12,6HDEPTH (M),90.0,9)
      CALL NUMBER(*,19,2.94,.12,MAL,0.0,2HI1)
      CALL NUMBER(*,03,3.12,.12,MAL,0.0,2HI1)
      CALL SYMBOL(.86,3.12,.12,8HTEMP (C),0.0,8)
      CALL NUMBER(2.4,3.12,.12,ITMAX,0.0,2HI2)
   12 DO 13 J=1,JJ
      IF(ID(J).GT.IDMAX)GO TO 14
      X(J)=TP(J)*TFAC
      Y(J)=(DMAX-FLOAT(ID(J)))*DFAC
      NN=J
   13 CONTINUE
   14 CALL LINE(X,Y,NN,1,-1,.01,0)
      ITME=(IHR*100)+MIN
      CALL NUMBER(.2,.1,.12,JD,0.0,2HI3)
      CALL NUMBER(.69,.1,.12,ITME,0.0,2HI4)
      CALL SYMBOL(1.10,.1,.12,1HZ,0.0,1)
      IF(ICOF.LT.1)CALL SYMBOL(2.4,.1,.12,11,0.0,-1)
      IF(NP.EQ.3)GO TO 20
      IF(NP.EQ.6)GO TO 21
      NP=NP+1
      IF(NP.LE.3)CALL PLOT(XAX,5.0,-3)
      IF(NP.GT.3)CALL PLOT(XAX,2.0,-3)
      GO TO 4
   20 XX=2.0*XAX
      NP=NP+1
      CALL PLOT(-XX,2.0,-3)
      GO TO 4
   21 XX=XAX+4.0
      CALL PLOT(XX,0.0,-3)
      CALL SPACE00
      GO TO 3
  100 CALL SPACE00
      CALL STOPPLOT
      STOP
      END
```

2.6.4 *Sample Output* — Program XREPDN produces six plots of depth (0 to 2000 m) (ordinate) vs temperature (0 to 30°C) (abscissa), on a 10-in. plotter, as shown in Fig. 16. Each plot is 6.35 cm (2.5 in.) by 7.62 cm (3 in.), with an overall dimension of 19.05 cm (7.5 in.) by 15.24 cm (6 in.). Only the first plot on the top left side of the page is labeled. The plots are ordered left to right, top to bottom. If a profile was marked as doubtful, an asterisk (*) is plotted in the lower right corner of the plot.

Legend on bottom left:

Julian day and time Z (example: 129 1030Z)

UNCLASSIFIED

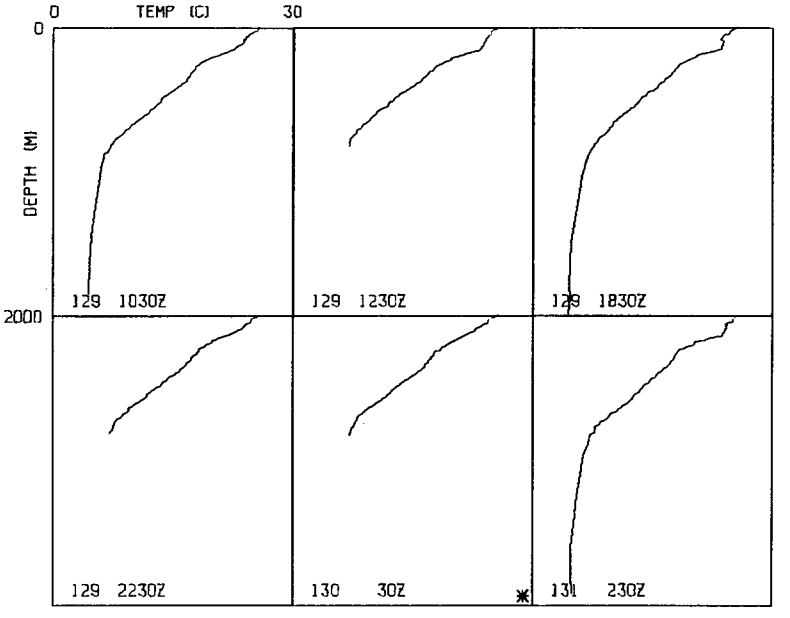

Fig. 16 — Calcomp plots of six temperature profiles. Asterisk denotes a profile noted as doubtful.

2. Program SSDSDN

2.6.5 *Program Control Cards (SSDSDN)* — Same as Sec. 2.5.3.

2.6.6 *Input Control and Data Cards*

Card 1: control card

Variable	Column	Format	Description
IDSS	2	I1	=1; sound-speed plots =0; no sound-speed plots
IDSL	3	I1	=1; archival average salinity plot =0; no salinity plot
NGP	4-5	I2	Group number (largest) of the last average salinity group
NPL	7-8	I2	number of points to skip between plotting symbol (same as IPRP of Sec. 2.5.4)
VMIN	11-20	F10.2	minimum sound-speed limit of plot (m/s)
VMAX	21-30	F10.2	maximum sound-speed limit of plot (m/s)

Variable	Column	Format	Description
DMAX	31-40	F10.2	maximum depth of sound-speed plot (m)
DSMAX	41-50	F10.2	maximum depth of average salinity plot (m)
SMIN	51-60	F10.2	minimum value of salinity plot (ppt)
SMAX	61-70	F10.2	maximum value of salinity plot (ppt)
XAX	71-75	F5.2	length of X (sound speed or salinity) axis in inches
YAX	76-80	F5.2	length of Y (depth) axis in inches

CAUTION: The dimensions of the average salinity plots will be XAX by 2 YAX inches.

Card 2 to N: IDSL = 1 option

Average salinity deck as described in Sec. 2.4.4(5) or Sec. 2.5.4.

Card N+1 to M: IDSS = 1 option

Depth vs sound-speed deck (including title cards) as described in Sec. 2.5.6(2). Insert blank cards as described in procedures below.

Procedures:

A blank card must be inserted after the last depth vs sound speed card and before the next title card of each profile. Do not place a blank card before the first title card of a set. An EOF card ends a set and the program goes to Card 1 (control card) for a new set of average salinities and sound speeds. When an EOF card is read in the Card 1 position the program terminates. Both input decks (average salinity and sound speed) are required for the sound-speed plots, but for plotting only salinities (IDSS = 0), the sound speed deck may be omitted.

2.6.7 *Program SSDSDN Fortran Source Listing*

```
      PROGRAM SSDSDN
C     PROGRAM TO PLOT EITHER DEPTH VS. SOUND SPEED OR DEPTH VS.
C     AVE. SALINITY OR BOTH. FOR REPORT, SIX SOUND SPEED AND THREE
C     SALINITY PLOTS TO A PAGE. WRITTEN FOR OP. 74 - D. NUTILE
      DIMENSION DPT(900),SS(900),DPH(10,30),SAL(10,30),SSA(10,30),SSB(10
     1,30),X(900),Y(900),PLTARRAY(254)
```

UNCLASSIFIED

```
      CALL PLOTS(PLTARRAY,254,10)
    1 READ 2,IDSS,IDSL,NGP,NPL,VMIN,VMAX,DMAX,DSMAX,SMIN,SMAX,XAX,YAX
C     IDSS .LE. 0 THEN NO SOUND SPEED PLOTS
C     IDSL .LE. 0 THEN NO DEPTH SALINITY PLOTS
C     NGP = NO. OF LAST GROUP
C     VMIN = MIN. S. SPEED            VMAX = MAX. S. SPEED
C     DMAX = MAX. DEPTH D-SS PLOT  DSMAX = MAX. DEPTH D-SAL PLOT
C     SMIN = MIN. SAL.                SMAX = MAX. SAL.
C     XAX = LENGTH OF X-AXIS INCHS YAX = LENGTH OF Y-AXIS INCHES
    2 FORMAT(1X,2I1,I2,1X,I2,2X,6F10.2,2F5.2)
      IF(EOF,60)100,3
    3 VFAC=XAX/(VMAX-VMIN)
      DFAC=YAX/DMAX
      SFAC=XAX/(SMAX-SMIN)
      DSFAC=(2.0*YAX)/DSMAX
      IDZ=0
      IDMAX=DMAX
      IDSMAX=DSMAX
      IVMIN=VMIN
      IVMAX=VMAX
      ISMIN=SMIN
      ISMAX=SMAX
      TYAX=2.0*YAX
      ACOF=XAX-0.1
      DO 4 J=1,10
      DO 5 JJ=1,30
      DPH(J,JJ)=-99.0
    5 CONTINUE
    4 CONTINUE
    6 N=1
    7 READ 8,IG,IDH,SPA,SPB,ASAL
    8 FORMAT(1X,I4,5X,I5,3X,F7.2,3X,F7.2,3X,F7.2)
      IF(IG.LE.0)GO TO 9
      DPH(IG,N)=IDH
      SSA(IG,N)=SPA
      SSB(IG,N)=SPB
      SAL(IG,N)=ASAL
      N=N+1
      IGG=IG
      GO TO 7
    9 IF(IGG.GE.NGP)GO TO 10
      GO TO 6
   10 IF(IDSS.LE.0)GO TO 50
   11 CALL PLOT(0.0,5.0,-3)
      NP=1
   12 READ 13,NOM,JD,IHR,MIN,IGS,ICOF
   13 FORMAT(1X,I3,I4,7X,I2,1X,I2,56X,I2,1X,I1)
      IF(EOF,60)45,14
   14 N=1
   15 NN=N+4
   16 READ 17,(DPT(I),SS(I),I=N,NN)
   17 FORMAT(5(2F8.2))
      IF(SS(N).LE.0.0)GO TO 18
      N=NN+5
      GO TO 15
```

```
18 NN=N-1
   N=NN-4
   DO 19 JJJ=N,NN
   IF(SS(JJJ).LE.0.0)GO TO 20
   JJ=JJJ
19 CONTINUE
20 CALL PLOT(0.0,0.0,2)
   CALL PLOT(XAX,0.0,1)
   CALL PLOT(XAX,YAX,1)
   CALL PLOT(0.0,YAX,1)
   CALL PLOT(0.0,0.0,1)
   IF(NP.GT.1)GO TO 21
   CALL NUMBER(-.5,-.06,.12,IDMAX,0.0,2HI4)
   ALAB=(YAX/2.0)-.45
   CALL SYMBOL(-.18,ALAB,.12,9HDEPTH (M),90.0,9)
   ALAB=YAX-.06
   CALL NUMBER(-.19,ALAB,.12,IDZ,0.0,2HI1)
   ALAB=YAX+.12
   CALL NUMBER(-.19,ALAB,.12,IVMIN,0.0,2HI4)
   ALAB=(XAX/2.0)-.86
   BLAB=YAX+.17
   CALL SYMBOL(ALAB,BLAB,.12,17HSOUND SPEED (M/S),0.0,17)
   ALAB=XAX-.19
   CALL NUMBER(ALAB,BLAB,.12,IVMAX,0.0,2HI4)
21 DO 22 J=1,JJ
   IF(DPH(J).GT.DMAX)GO TO 23
   X(J)=(SS(J)-VMIN)*VFAC
   Y(J)=(DMAX-DPT(J))*DFAC
   NN=J
22 CONTINUE
23 CALL LINE(X,Y,NN,1,1,.03,NPL)
   ITME=(IHR*100)+MIN
   CALL NUMBER(.2,.1,.12,JD,0.0,2HI3)
   CALL NUMBER(.69,.1,.12,ITME,0.0,2HI4)
   CALL SYMBOL(1.10,.1,.12,1HZ,0.0,1)
   IF(ICOF.LT.1)CALL SYMBOL(ACOF,.1,.12,11,0.0,-1)
   J=0
   NN=0
24 J=J+1
   IF(DPH(IGS,J).GT.DMAX)GO TO 25
   X(J)=(SSA(IGS,J)-VMIN)*VFAC
   Y(J)=(DMAX-DPH(IGS,J))*DFAC
   NN=J
   GO TO 24
25 CALL LINE(X,Y,NN,1,-1,.01,1)
   DO 26 J=1,NN
   X(J)=(SSB(IGS,J)-VMIN)*VFAC
   Y(J)=(DMAX-DPH(IGS,J))*DFAC
26 CONTINUE
   CALL LINE(X,Y,NN,1,-1,.01,1)
   IF(NP.EQ.3)GO TO 27
   IF(NP.EQ.6)GO TO 28
   NP=NP+1
   IF(NP.LE.3)CALL PLOT(XAX,5.0,-3)
   IF(NP.GT.3)CALL PLOT(XAX,2.0,-3)
   GO TO 12
```

UNCLASSIFIED

```
27 XX=2.0*XAX
   NP=NP+1
   CALL PLOT(-XX,2.0,-3)
   GO TO 12
28 XX=XAX+4.0
   CALL PLOT(XX,0.0,-3)
   CALL SPACE00
   GO TO 11
45 IF(NP.LT.4)XEND=(XAX*(4.0-FLOAT(NP)))+4.0
   IF(NP.GE.4)XEND=(XAX*(7.0-FLOAT(NP)))+4.0
   CALL PLOT(XEND,0.0,-3)
   CALL SPACE00
50 IF(IDSL.LE.0)GO TO 1
   NS=1
51 NP=1
52 CALL PLOT(0.0,2.0,-3)
53 CALL PLOT(XAX,0.0,2)
   CALL PLOT(XAX,TYAX,1)
   CALL PLOT(0.0,TYAX,1)
   CALL PLOT(0.0,0.0,1)
   IF(NP.GT.1)GO TO 54
   CALL NUMBER(-.5,-.06,.12,IDSMAX,0.0,2HI4)
   ALAB=(TYAX/2.0)-.45
   CALL SYMBOL(-.18,ALAB,.12,9HDEPTH (M),90.0,9)
   ALAB=TYAX-.06
   CALL NUMBER(-.19,ALAB,.12,IDZ,0.0,2HI1)
   ALAB=TYAX+.12
   CALL NUMBER(-.09,ALAB,.12,ISMIN,0.0,2HI2)
   ALAB=(XAX/2.0)-.96
   BLAB=TYAX+.17
   CALL SYMBOL(ALAB,BLAB,.12,19HAVE. SALINITY (PPT),0.0,19)
   ALAB=XAX-.09
   BLAB=TYAX+.12
   CALL NUMBER(ALAB,BLAB,.12,ISMAX,0.0,2HI2)
54 IF(DPH(NS,1).LT.0.0)GO TO 55
   GO TO 56
55 NS=NS+1
   IF(NS.LE.NGP)GO TO 54
   GO TO 75
56 NN=1
57 IF(DPH(NS,NN).LT.0.0)GO TO 58
   IF(DPH(NS,NN).GT.DSMAX)GO TO 58
   X(NN)=(SAL(NS,NN)-SMIN)*SFAC
   Y(NN)=(DSMAX-DPH(NS,NN))*DSFAC
   NN=NN+1
   GO TO 57
58 NN=NN-1
   CALL LINE(X,Y,NN,1,-1,.01,0)
   CALL SYMBOL(.2,.1,.12,9HGROUP NO.,0.0,9)
   CALL NUMBER(1.23,.1,.12,NS,0.0,2HI1)
   NP=NP+1
   NS=NS+1
   CALL PLOT(XAX,0.0,-3)
   IF(NS.GT.NGP)GO TO 75
   IF(NP.GT.3)GO TO 59
   GO TO 52
```

```
 59 CALL PLOT(4.0,0.0,-3)
    CALL SPACE00
    GO TO 51
 75 XEND=(XAX*(4.0-FLOAT(NP)))+4.0
    CALL PLOT(XEND,0.0,-3)
    CALL SPACE00
    GO TO 1
100 CALL SPACE00
    CALL STOPPLOT
    END
```

2.6.8 *Sample Output* — Program SSDSDN has the following outputs.

1. Plots of depth (ordinate) vs sound speed (abscissa); six plots to a page, shown in Fig. 17. The size of the plot is determined by the input parameters (Sec. 2.6.6); each plot has three separate traces, the calculated sound speed (m/s) denoted with a symbol, and the upper and lower standard deviation from the mean archival sound speed. Only the first plot on the top left is labeled. Plots run top left to right, then bottom left to right. Any plot designated as questionable will be marked with an asterisk on the bottom right side.

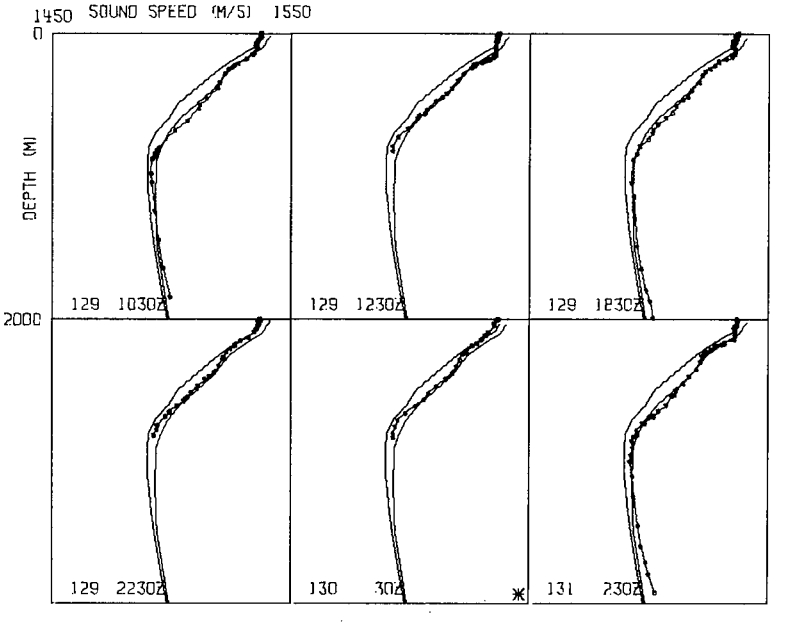

Fig. 17 — Calcomp plots of six sound-speed profiles. Asterisk denotes a profile produced from doubtful temperature profile.

Legend on bottom left of each plot:

Julian day and time Z (example: 129 1030Z)

UNCLASSIFIED

2. Plots of depth (ordinate) vs average archival salinity (abscissa); three plots to a page, shown in Fig. 18. The dimensions of the plot are determined by the input parameters (Sec. 2.6.6), (XAX by 2 YAX). Only the leftmost plot is labeled.

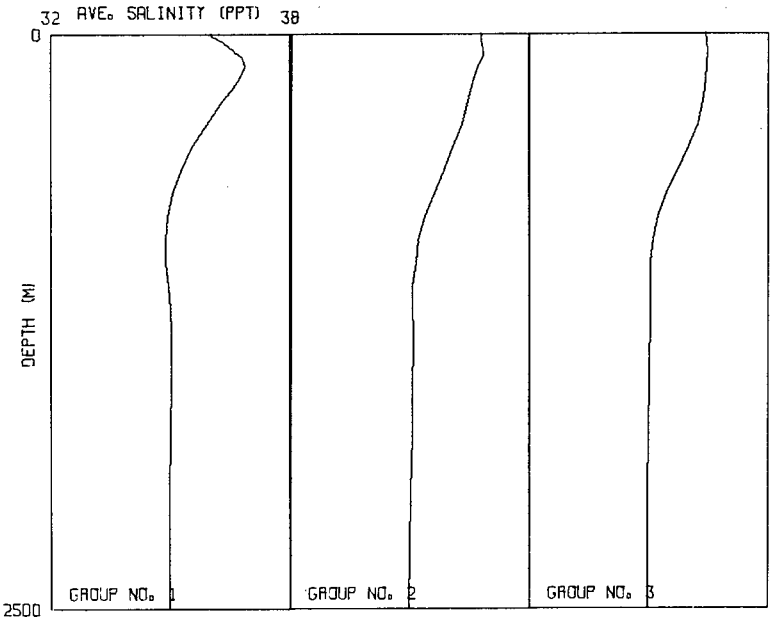

Fig. 18 — Calcomp plot of three salinity profiles

Legend on bottom left of each plot:

GROUP NO. ** (salinity group number)

All plots are made on a 10-in. plotter.

3.0 CONCLUSION

It has been the intent of this report to present a series of programs and procedures that process depth vs temperature data. These programs are organized into a data flow system with advantages of speed, accuracy, and flexibility. The programs were planned to run concurrently with an experiment from the planning phase, where the archival data and charts can be used, to the reduction of temperature data to sound speeds for use in acoustic predictions and calculations. This system, now being used by the Naval Research Laboratory, gives consistently good results.

4.0 REFERENCES

1. B.G. Roberts, Jr., "Retrieval Program for Archival Nansen-Cast Data," NRL Report 7633, Oct. 25, 1973.

2. Morris Schulkin, "Basic Acoustic Oceanography," Naval Oceanographic Office Reference Publication 1, April 1975.

3. H.U. Sverdrup, M.W. Johnson, and R.H. Fleming, *The Oceans — Their Physics, Chemistry and General Biology*, Prentice Hall, New York, 1942.

4. C.C. Leroy, "Development of Simple Equations for Accurate and More Realistic Calculation of the Speed of Sound in Seawater," J. Acoust. Soc. Amer. 46, 216-226 (1969).