NATIONAL INSTITUTE OF OCEANOGRAPHY

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N.I.O. Computer Programs 16

N.I.O. INTERNAL REPORT No. N.16

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N.I.O. COMPUTER PROGRAMS 16

PROGRAMS FOR PHYSICAL OCEANOGRAPHY

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National Institute of Oceanography

N.I.O.PROGRAMS 16

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ERRATA

Subprogram -28

This is a subroutine subprogram written in Fortran IV for the I.B.M.1800 machine

Input G the acceleration due to gravity is in metres/sec^2 and should be calculated as follows:-

$$G = 9.78049 + SJN \times (5.2766 \times 10^{-3} + 1.18 \times 10^{-5} \times SJN)$$

where

$$SJN = (\sin(LD \times 60 + XDM) \times 3.14159/10800)^2$$

LD = Latitude in degrees

XDM = Latitude in minutes

Subprogram -29

This is a subroutine subprogram written in Fortran IV for the I.B.M. 1800 Machine

Subprogram -24

The temperature should be in °C not °K as stated

Queries regarding the use or availability of any of the programs in this volume may be made to :-

The Program Librarian,
Data Processing Group,
National Institute of Oceanography,
Wormley, Godalming, Surrey.

from whom a comprehensive list of all current N.I.O.Programs are available.

All the programs in this volume have been compiled and executed on an I.B.M.1800 Computer having the following configuration:-

1802 Processor-Controller with 16,384 words of core storage

2 2310 Disk Drives Model A

1 2401 Magnetic Tape Drive (30 kc/s)(7 Track)

1442 Model 6 Card Read - Punch

1443 Printer, 240 lines/minute

1816 Keyboard-Printer

Facit Paper Tape Reader, 1000 Characters/second

Facit Paper Tape Punch, 150 Characters/second

The operating system was TSX Version 3

N.I.O.Program 112

Title: Annual Wave Statistics (Version 1)

Name: WAST (consisting of linked programs SETLA, WAST, READW, HSLOT, TPLOT, SPLOT, HPLOT)

Machine: IBM 1800

Language: 1800 Fortran IV

Purpose: To collate the data stored on magnetic tape by N.I.O. Program 136 to produce, on the 1443 printer, seasonal graphs of the percentage exceedance of wave heights, distribution of wave periods, percentage occurrence of spectral width parameter for a year, an annual scatter diagram relating wave height and period, and a graph of the wave height every three hours throughout the year.

Input:

```
                  CC 19
// JOB               X
// XEQ SETLA    FX1
```

followed by two parameter cards:-

1) DATES - The two dates between which the wave recording occurred (Free format in the first 72 columns).
2) YEAR,MAXH - The year in which February occurred for the afore-mentioned period, and 0 if the highest value of IHS (obtainable from N.I.O. 89 output) is ≤ 50ft or 1 if the highest value is > 50ft. (2I4 format)

Method: This program consists of seven linked programs, which will be described in the order in which they are executed.

SETLA: The first link sets a variable LAB equal to 1. This variable is also set in other links in order to return to various labels in WAST.

WAST: This link stores zero in every array before printing the title on the 1443 printer and checking that the first month's data on magnetic tape is January. If it is not the job is aborted. The link then sets various counts before executing READ. The remainder of this link is executed at the end of a month, a season or a year's analysis. The returning point to this link is set in the variable LAB in other links.

READW This link reads one month's data from magnetic tape. As each record is read, the wave period is tested to see if it is "Calm". If it is, 1 is added to the first element of each array and O (the value of IHS) is written to disk before increasing the counts and testing for the end of the season, end of month, end of page and end of day (N.B. the data on magnetic tape is stored in pages - each page containing a heading and five day's data. This is done to speed the execution of N.I.O. 137). If the end of the season has been reached the next link (HSLOT) is executed, if the end of a month has been reached control is returned to WAST. At the end of a page or day, extra blank lines of magnetic tape are read, counts are reset and the next record is read.

If the record is not"calm", the wave period is converted from 2(2A1) format to F5.2 format using the subroutine GET. One is then added to the HS, HMAX (3 hrs), wave period (TZ), Spectral Width Parameter, and Scatter Diagram arrays as follows:-

Let the wave period = A = 4.59
Spectral width parameter = EPSI = 0.371 (read in as 371)
Significant wave height = IHS = 10.6 (read in as 10)
Maximum wave height = IHMAX =14.8 (read in as 14)
Then:-

HS(IHS + 2) and HMAX(IHS + 2) are increased by 1 , and IHS is written to disk.

The wave period is then converted to an integral part (TZAC) and a fractional part(TZAB). If TZAB is ≥0.5, 1 is added to TZ(2,TZAC + 2), otherwise 1 is added to TZ(1,TZAC + 2).

The value of EPSI is tested in intervals of 25. If O ≤ EPSI ≤ 24, SWPA(2) is increased by 1, if 25≤EPSI ≤ 49, SWPA(3) is increased by 1,etc.

The wave period is tested in intervals of 0.50. If O ≤ A ≤ 0.49 then IK = 2, if 0.50 ≤ A ≤0.99 then IK = 3,etc The same process is repeated for IHS in intervals of 1.0 if MAXH = 0 or 2.0 if MAXH = 1, the result being stored in IL. When IK and IL have been calculated for each record then SCAT(IK,IL) is increased by one.

Using the above data and formulae, the following results are obtained:-

HS(12), HMAX(16), TZ(2,6), SWPA(17), SCAT(11,11) if MAXH = 0 or SCAT(11,6) if MAXH = 1 are all increased by 1 .

The link then increases counts and continues as described as above.

HSLOT

This link commences by reversing the elements of the HS and HMAX arrays using the subroutine RVERS. The cumulative percentages of the two arrays are then obtained by expressing each element as a percentage of the number of records in the season and adding the previous total to it.

i.e. AHS(3) = (HS(3)/No.records in season x 100) + AHS(2)
and AHMAX(3) = (AHMAX(3)/No.records in season x 100) + AHMAX(2).

The (integer value/2) is calculated for each element, the results being stored in the arrays JRAY and IRAY respectively. These two arrays, with each element multiplied by 2 to give the true results, are then printed on the 1443 printer.(N.B. These results are halved prior to the graph plotting to form a compact graph).

Each position on the graph forms one record on disk, record one representing the top left hand position on the graph, record 103 representing the left hand end of the second line on the graph etc. JK is set to 2,3,4......10,12,14.......20,25,30,35,40,50........100, and for each value of JK the position along the X-axis is calculated by the formula IK = 0.4343*ALOG(JK)*0.50. The (102 - JK)th element (JJK) of IRAY and JRAY are accessed, if they are equal,the disk record is calculated by (5203 - (IRAY(JJK)*102 + (104 - IK))) and is set to 0 ; if not the record is set to + for a HMAX value. The formula (5203 - (JRAY(JJK)*102 + (104 - IK))) is then applied and the record is set to * for a HS value.

The graph is then plotted with seasonal headings, plotting 102 disk records on every line of the graph.

TPLOT The link commences by storing a space in every element of the output array. Each element of the array TZ is expressed as a percentage of the number of records in the season and stored in the array A. The integer value (IN) of each element is then expressed as a column of IN asterisks in the output array, the position along the X-axis being increased by one interval for each element. The number of calms are stored in A(1) and expressed as a percentage at the bottom of the graph.

The array A is printed before the graph is plotted with seasonal headings.

If the end of the year's analysis has been reached the next link is executed, otherwise control is returned to WAST.

SPLOT The first half of this link collates the values in the array SWPA by the same method as used in the previous link, except that the elements are expressed as a percentage of the number of records analysed in the year. The values are again printed before the annual graph is plotted.

Each element of the array SCAT is tested, if it equals 0 it is set to "space", if it equals 1 it is set to "*", if it equals 2 it is set to "+", otherwise the formula SCAT(I,J) = (SCAT(I,J)*1000/Number of records analysed in the year) is applied to convert to parts per thousand. The Y-axis scale is determined by the value of MAXH - if it is 0 the scale ranges from 0 to 50ft, if it is 1 the scale ranges from 0 to 100ft. Each line of the output graph is converted to A1 format using the subroutine INECB before being plotted.

HPLOT The final link in this suite plots the values of HS which have been stored on disk. Counts of the month and day number in the month are kept so that the month and date can be printed on the left of the graph where necessary. At the end of the graph control is returned to WAST.

Output

The output consists of the following tables and graphs:-
For each season, starting with winter (January to March)-

1) Tables of the percentage exceedance of HS and HMAX in one foot intervals from 102ft downwards, followed by a graph of these two tables. The x-axis is logarithmic and represents wave height from 1 to 100ft while the y-axis represents percentage exceedance from 0 to 100%.
2) Tables of the percentage occurrence of the wave period in half second intervals from calm upwards. A histogram is then plotted, the x-axis representing the wave period in seconds from 0 to 20 seconds, the y-axis representing the percentage occurrence from 0 to 50%.

The percentage of calms in the season is printed after the graph.

At the end of a year's analysis:-

1) Table of the percentage occurrence of the spectral width parameter increasing from calm in tenths. A histogram is then plotted, the x-axis representing the percentage occurrence from 0 to 15%. The percentage of calms in the year is printed after the graph.

2) A scatter diagram relating wave period (calm to 18 seconds along the x-axis) and significant wave height (0 to 100 or 0 to 50ft along the y-axis). One and two occurrences are plotted as * or + respectively, all other occurrences are expressed as parts per thousand.

3) A graph showing the height in feet (represented along the x-axis as 0 to 100ft) of every HS value for the year. The date is shown along the y-axis, there being eight values per day.

Required subroutines GET, RVERS, INECB, NEXTO, STORO

Operating Instructions The system waits prior to printing the final graph. A channel 1 punch carriage control tape must be loaded on the 1443 printer and the system restarted.

Execution Time Approximately 90 minutes.

Notes. This program will shortly be rewritten with output to the 1627 plotter.

Programmer Eileen Page

N.I.O. PROGRAM 114

Title — Error correction of Current Meters (Version 2)

Name — ERC02

Machine — IBM 1800

Language — 1800 Fortran IV

Purpose — To correct current meter data (calibrated) on ½" magnetic tape according to corrections, additions or deletions read from cards. The corrected data is to be written to a second magnetic tape in the next available file.

Input

```
                cc19
//bJOB          200
//b*Job No./Name/Job Title
//bXEQbERC02
*FILES(1,,1),(201,MN,0)
*CCEND
```

where 200, right-justified in cols. 16 - 19 of the job card, is the number of a disk pack containing at least 327, 670 words of non-process working storage, and N is the number of the magnetic tape on which the corrected data is to be written.

The data consists of the following set of cards.

1. IFIL - file no. where the data to be corrected resides, right justified in columns 1 - 7.

2. MN - meter no.
   LFRST - first sequence no.
   LREAD - last sequence no.
   NCORR - no. of correction cards
   NDEL - no. of sets of detection cards required, (i.e. if 2 cards in sequence are to be deleted this is one set of deletions)
   NADD - no. of addition cards

   These six parameters are right justified in columns 1-7, 8-14, 15-21, 22-28, 28-35, 35-42 respectively in FORMAT 6I7.

3. If there are any deletions the following cards are needed

   KDEL, KNUM

   right justified in cols. 1-5, 6-10 respectively where KDEL is the sequence no. for which the next card(s) are to be deleted.

   KNUM is the number of cards to be deleted.

   This card is repeated NDEL times.

4. Addition cards:

   KADD in columns 1-5

   the sequence no. for which the next card is to be added followed by

   JA, AA, BA, CA

   format(I7, 1X, 3(F7·2,1X))

   This is the addition card

   These 2 cards are repeated NADD times.

5. Then follows NCORR correction cards

   Format(I7, 1X, 3(F7·2,1X)) where each card contains reading number, current temperature, direction and speed

e.g. cc. 7 15 23 31
bbbb472bbb14·25bb252·41bbbb9·72

the magnetic tape should be in similar format, as it will be if written by N.I.O. Program 111, Current Meter Analysis.

Output

The new magnetic tape will be in the same format as the old, i.e. first record which is the meter number, I7 format, then records in I7, 1X, 3 (F7·2,1X) format.

On the 1443 printer a monitor of every correction made, preceded by the previous correct or corrected record, will be printed.

Method

The magnetic tape is first wound to the beginning of the required file, IFIL. The complete file from LFRST to LREAD, plus the meter no., is then read to disk. After changing the mag. tape, the data is read back to tape, any deletion records being left out, additions inserted, or correction data being read from cards and substituted when the reading nos. agree. The output will commence at record 1 of the next available unwritten file (NFIL). At the conclusion of the program the following message is printed.

FILE IFIL ON FIRST TAPE HAS BEEN CORRECTED AND COPIED TO FILE NFIL ON SECOND TAPE

K RECORDS WERE WRITTEN

Operation

Load tape, disks and cards in normal way. When all the data has been read from tape the following message will appear on the printer.

CHANGE MAGNETIC TAPE AND PRESS CONSOLE START

Restrictions

No. of records of data <32767 IFILE≤99

If NCORR, NDEL and NADD = O the tape will be copied with no alteration.

The program operates under the N.I.O. Tape Security System and both magnetic tapes in use must have been initialised and used under the system (DPG/P/7).

Execution Time

Approx. (120 x IFIL + K/3) secs. hwere K is the number of records on the file being corrected + time to find both files concerned on mag. tape.

Programmer

R. Howarth (modification of Brian Hinde's program ERC01)

N.I.O.PROGRAM 126

Title Current Meter Analysis

Name CRENO

Language Fortran IV

Purpose To read, calibrate and plot data from Bergen or Plessey current meters. Data is read from cards, two complete sets of readings (i.e.reading number, temperature, direction and speed) being punched on each card. The first number is the reading number, and calibrations of the form ax + b are applied to all the other readings. Provision is made for a dead space on the speed rotor and three graphs are plotted as output. Results are also output to magnetic tape.

Job Description

```
//bJOB
//b*Job No./Name/Title
//bXEQbCRENO
* FILES(201,MK,0) where K is the magnetic tape number
to be used
*CCEND
```

Data The data is in 2 sections immediately following *CCEND

a) four cards, for program control

Card 1

```
            cc 14       22       30      36
A(1)bTObA(4)bX.XXXXXbY.YYYYYbV.VVVVVbW.WWWWW
```

X.XXXXX	a number representing calibration constant	A(1)
Y.YYYYY	" " " "	A(2)
V.VVVVV	" " " "	A(3)
W.WWWWW	" " " "	A(4)

Card 2

```
                  cc 14      22      30      36
B(1)bTObB(4)bX.XXXXXbY.YYYYYbV.VVVVVbW.WWWWW
```

identical to card one with calibration constants B(1) to B(4)

The calibrations are performed with the equation Y = Ax + B where A and B are the calibration constants read in as above and X is the raw data value.

Card 3

```
                cc  18        26        34
RNG(1)bTObRNG(6)bXXXX.XXbYYYY.YYbZZZZ.ZZb
42       50       58
WWWW.WWbUUUU.UUbVVVV.VV
```

where

XXXX.XX the minimum expected value of the temperature calibrated results to be plotted.

YYYY.YY the maximum expected value of the temperature to be plotted.

ZZZZ.ZZ	similar to XXXX.XX for direction
WWWW.WW	" " YYYY.YY " "
UUUU.UU	" " XXXX.XX for speed
VVVV.VV	" " YYYY.YY " "

Card 4

```
      7            20            33      41
IMTNObLLLLLLbISENSb±bbbbbbLSTNObNNNNNNbDII
```

where

LLLLLL	= meter no. right-justified.
±	= direction of meter rotation, right justified.
NNNNNN	= sequence no.of last card,right-justified.
II	= meter dead space
Format	(6X,I6,2(7X,I6),2X,I2)

b) The raw data cards follow card 4 immediately. Each card contains two sets of data-the first in columns one to thirty six and the second in 41 to 76. Each set contains 4 numbers. The first is the sequence No. Second is temperature, third direction and fourth speed.

e.g.
```
1     7                25    31
AAAAAABBBBBBb.........bCCCCCCDDDDDDbbbb

41    47               65    71
EEEEEEFFFFFFb......bGGGGGGHHHHHH
```

format is (2I6,12X,2I6,4X,2I6,12X,2I6)

Output — To Lineprinter

The meter number is written at the head of the page. Following this each set of calibrated results will be printed on the left of the continuous stationery. To the right of the results the graphs will be plotted a different symbol for each variable.

Magnetic Tape

The meter number is read to magnetic tape followed by the three sets of calibrated results. The format is I7,1X, 5(F7.2,1X) until the run is terminated by an end of file marker being written.

Programmers — Howarth/Slade.

N.I.O.Program 141

Title Hydrographic Station Data Analysis

Name HYDR0 (linked to HYDR1, HYDRZ, HYDR2, HYDR3, HYDR4

Machine IBM 1800

Language Fortran IV

Purpose Given a set of values of temperature, salinity and pressure (or depth) to calculate at the given pressures (or depths) the potential temperature, sigma t, sigma theta, specific volume, specific volume anomaly and Brunt - Vaisala frequency.

Also to calculate at standard pressures (or depths) the dynamic height anomaly, potential energy anomaly, sound velocity, sounding velocity and sigma theta.

Control cards

```
//bJOB                16 17
                      F  X
//bXEQbHYDRO
```

followed by data cards.

Data The data consists of the following cards

	1-4	6-8	10-13	15-16	18-19	21,22	24,25
1)	NCO,	NCR,	NSTA,	NDAY,	MON,	NYR,	NHR,

26,27	28,30	31,34	36	38,40	41,44	46	48	50
MIN,	LD,	XDM,	NS,	LLN,	XNM,	NEW,	NTYP,	IFLAG

Format (5X,I3,1X,I4,1X,I2,1X,I2,1X,I2,1X,2I2,1X,I2,F4.1,1X,A1,1X,I3,F4.1,1X,A1,1X,A1,1X,I1)

where NCO = 74DI the Discovery code

NCR = Cruise Number

NSTA = Station Number

NDAY = Day

MON = Month (right justified)

NYR = Last two figures of year

NHR = Hour

MIN = Minutes

(NHR, MIN: Time of release of messenger.)

(NDAY to MIN: Station Time)

LD = Degrees of latitude

XDM = Minutes of latitude

N/S = North or South for Latitude (N or S)
LLN = Degrees of Longitude
XNM = Minutes of Longitude
NEW = East or West for Longitude(E or W)
NTYP = Type of position e.g.decca,satellite,radar etc. punch one letter D,S,R etc.
IFLAG = 1 for pressure input, 2 for depth input.

2) Card Columns 1-10 PCO, 11-20 PCI, 23 INTYP

Format (2F10.4, 2 X, I1)

PCO, PC1 are two pressure constants set in the program to 1.0078 and .00000253
If the user does not wish to change these PCO and PC1 should both be punched as 0.0

INTYP = 1 if interpolated pressures are to be used
= 2 if interpolated depths are to be used
= 3 if no interpolated values required

Then follow the station cards I = 1, N where N is the number of readings on the station.

Card Column	1	21 - 24	3- - 35	41 - 46
	IFL,	PRES(I),	SAL(I),	TEMP(I)

Format (I1, 19 X, F4.0, 5X, F6.3,5X,F6.3)

where IFL = 9 for terminator card
PRES(I) = pressure
SAL(I) = salinity in parts per thousand
TEMP(I) = temperature in degrees centigrade

The terminator card has 9 punched in Column 1 to show all the data points have been read.

The final card contains the steps required for the interpolated values and is omitted if none are required.

The format is 17I4 and is set out as follows

For example take depths 0-500 metres in the steps of 100, 500 - 700 in steps of 50 and 700 - 1000 in steps of 25.

Card Columns

4	678	101112	1516	181920
0	100	5 0 0	50	7 0 0

23-24	25262728	32	36
2 5	1 0 0 0	0	0

In all cases two noughts should be placed after the last range to show no more are required.
The steps required in each range always come between the max. and min. of the range.

Output

The output is to the lineprinter, the first page consisting of headings, general station data and observed values. The second page is interpolated values.

Subroutines called

POTLT, SIGMO, SIGMT, ALPHA', SDVEL, DELV, LAGIN, TLAGR, DSTAF, DATG

The method of calculating the variables and the interpolation can be found in the write-ups of the above subroutines
(N.I.O. -31, -32, -33, -34, -35, -36, -26, -27, -28, -29)

Limits

The program is at present limited to 35 points per station.

Programmer

R. Howarth.

N.I.O. PROGRAM 150

Title Calculate Potential Density and Temperature

Name PTSDI (Lab. system)

Machine IBM 1800

Language 1800 Fortran IV

Purpose To read in temperature periods, salinity periods, and depth. On the lab. system cards input are in a fixed format, on the ship system input is from paper tape in a free format. The potential temperature and potential density are then calculated (using 3 function subprograms) and output to the line printer

Job Description

```
// JOB
// *(Job No./Name/Title)
// XEQ PTSDI
*CCEND
```

followed by data cards or tape.

Input

a) On the lab. system there are five values of

PS = salinity period
PT = temperature period
M = depth (wire out value) in metres

arranged as follows per card.

```
cc.  1   6 7   1213 1617  2223  28 29  32......
PS(1) PT(1) M(1) PS(2) PT(2) M(2) .....
```

(i.e. using the full 80 columns)

The format read is 5(2F6.3,I4)

The last card must contain 999999 in columns 1 - 6 to terminate the program.

b) On the lab. system input data is on paper tape in free format, arranged in the same order as for cards, with a blank between each data value.

Output The following items are listed across the page.

a) PERTEMP - temperature period
b) PERSALY - salinity period
c) DPTH - depth
d) POT.T. - potential temperature
e) SALINITY
f) POT.D - potential density

g) DT/M - temperature change/m
h) DS/M - salinity change/m
i) DD/M - density change/m
j) DAT/M - binomial smoothing of DT/M
k) DAS/M - binomial smoothing of DS/M
l) DAD/M - binomial smoothing of DD/M
m) N - Brunt Värsälä frequency from DD/M
n) ANS - Brunt Värsälä frequency from D5AD
o) D5AD - Binomial smoothings of DD/M when n = 5

Method

Having read the input data, using function POTMT (J. Crease) calculate the potential temperature and similarly calculate sigma 0 and sigma t using SIGMO and SIGMT for the potential density. Calculate the Brunt Värsälä frequency and output all the results.

Programmer

R. Howarth

The program is a modification of a program written by Robin Pingree.

N.I.O. PROGRAM 155

Title Thermometer Corrections

Name TEMP5 (Ship system)

Machine IBM 1800

Language 1800 Fortran IV

Purpose To correct protected and unprotected thermometer readings using Schumachers equations.

Control Cards

//bJOB

//b*(Job No./Name/Title)

//bXEQbTEMP5

*CCEND

followed by the input data cards.

Input Data

Card No.	Name	Function
1	CIN	Correction interval in degrees centigrade

e.g. Col. 1 5

0·090 - this number can extend over 5 columns but the decimal point must be included format F5·0.

Card No.	Name	Function
2	IA, IB	Lower and upper limits of ambient temperature range

e.g. Col. 1 8

010bb050

The format is I3,2X,I3

Card No.	Name	Function
3	NO	Thermometer no. - 6 digits
	NTY	Thermometer type 0 protected, 1 unprotected - 1 digit
	MON	Month of calibration - 2 digits
	NYE	Year of calibration - 4 digits

e.g. Col. 1 17

1234bb0bb01bb1969

Format is I6,2X,I1,2X,I2,2X,I4

Card No.	Name	Function
4	IVO	Volume of mercury in stem below 0 deg. C. i.e. V0 - 3 digits

e.g. Col. 1

169

Format I3

Card No.	Name	Function
5	NPO	No. of main thermometer pts. to follow

e.g. Col. 1

010

Format I3

NPO cards containing

TEMP } main thermometer reading
COR } main thermometer index correction

Format F5·0,2X,F5·0

e.g. Col. 1 12

2·500bb0·100

Each number can be up to 5 digits long but the decimal point must be included.

One card containing

NP1 No. of auxiliary thermometer readings to follow

e.g. Col. 1

010 3 digits

Format I3

NP1 cards containing

AUXT } auxiliary thermometer reading
AUCO } auxiliary thermometer correction

Format F5·0,2X,F5·0

e.g. Col. 1 12

25·00bb0·150

Each number can be up to 5 digits long but a decimal place must be included.

Output

Output is online printer as follows

TEMP - main thermometer temperature followed by

CP - ambient temperature and TAUX correction (there are 5 sets of ambient temps and corrections per line).

Method

The input is read. The range is found for which corrections to the ambient temperature are to be made in increments of CIN. The corrections are calculated using Sverdrup's formulae, and the results output on the lineprinter.

Subroutine LININ - linear interpolation is used for the protected thermometer cases.

Programmer

R. Howarth

based on N.I.O. Program 59 by J. Crease

N.I.O. PROGRAM 158

Title — Generate arbitrary filter

Name — HILOW

Machine — IBM 1800

Language — 1800 Fortran IV

Purpose — To generate a lowpass, bandpass, or highpass filter defined by 3 parameters, with or without its conjugate, punch the multipliers on cards, and list its amplitude response over the full frequency range.

Job Description

```
// JOB
// *Job No./Name/Title
// XEQ HILOW
*CCEND
```

Data

1) One card, containing the following four integers, whose meanings are explained below (see 'Use'):

N L M K Format (4I4)

2) At least n + 1 blank cards if K = 0, or 2(n + 1) blank cards if K = 1, where n is the smallest integer $\geq N/6$

3) If the number of blank cards (2) is exactly correct, further sequences (1), (2) may follow with different parameters. Otherwise, the execution stops when a blank card is read in place of (1).

Use

The program produces the right hand half of a symmetrical filter of half length N. That is, it produces a set of multipliers

F_r , r = 0(1)N

and, if the conjugate is requested by putting K = 1,

G_r , r = 0(1)N

for intended use with a data series x(t) in the forms

$$x_0(t) = F_0 x(0) + \sum_{r=1}^{N} F_r [x(t + r) - x(t - r)]$$

$$\text{or} \quad x_1(t) = 0 + \Sigma \; G_r [x(t + r) - x(t - r)]$$

$x_0(t)$ is a filtered version of $x(t)$, with certain parts of its spectrum suppressed according to the filter characteristics, but no alteration in phase. $x_1(t)$ has approximately the same characteristic, but with all phases reduced by $\frac{1}{2}\pi$.

L and M determine the cut-off frequencies of the filter as follows:

a) If L = 0, a lowpass filter is produced whose characteristic is close to 1 for the frequency range 0 to (M - 1)/N Nyquists*, and close to 0 for the range (M + 2)/N to 1 Nyquists.

b) If M = N, a highpass filter is produced whose characteristic is close to 0 for the frequency range 0 to (L - 1)/N Nyquists*, and close to 1 for the range (L + 2)/N to 1 Nyquists.

c) If 0 < L < M < N, a bandpass filter is produced whose characteristic is close to 0 in the frequency ranges 0 to (L - 1)/N and (M + 2)/N to 1; and close to 1 in the range (L + 2)/N to (M - 1)/N Nyquists.

d) If 0 < L = M < N, the filter is similar to (c) except that the largest value of the characteristic is 0·5 at the frequency M/N.

e) If 0 < L = M - 1; similar to (d), with largest value 0·85 at $(M - \frac{1}{2})/N$.

In the neighbourhood of the cut-off frequencies the characteristics are as follows:

Frequencies (Nyquists)*		Amplitude response
(L-1+m)/N,	(M+1-m)/N, m>2	Between 1± $0{\cdot}5\ m^{-4}$ approx.
(L+1)/N,	(M-1)/N	Exactly 1
L/N,	M/N	0·75
(L-1)/N,	(M+1)/N	0·25
(L-2)/N,	(M+2)/N	Exactly 0
(L-m)/N	(M+m)/N, m>2	Between ± $0{\cdot}5\ m^{-4}$ approx.

If the parameter K = 0, only the real filter F_r is produced and its characteristic listed. K > 0 produces both real and conjugate filters F_r and G_r and their characteristics.

Any value L > 0 will eliminate an artificial mean value and greatly attenuate any slow 'drift' in a time series x(t).

Output

The filters F_r and G_r are punched in Format (2I2, 6F12·8) the 8th decimal place being rounded. The first of the two integers is 0 for the real filter, 1 for the conjugate; the second is a card count, 0(1)n. The first card of each set (card count 0) contains F_0 or G_0 only.

All relevant figures are reproduced on the line printer, with explanatory headings. The characteristics (unrounded) are listed at 0(0·01)1 Nyquists.

* A Nyquist is 1/2δ, where δ is the time interval of the series x(t).

Formulae

The lowpass filter ($L = 0$) is:

$$F_0 = (M + 0\cdot5)/N,$$

$$F_r = \cos^2\tfrac{1}{2}\Omega t.\ \sin(M + \tfrac{1}{2})\Omega t/2N\sin\tfrac{1}{2}\Omega t, \qquad (\Omega = \pi/N)$$

$$G_0 = 0$$

$$G_r = \cos^2\tfrac{1}{2}\Omega t.\ [\cos\tfrac{1}{2}\Omega t - \cos(M + \tfrac{1}{2})\Omega t]/2N\sin\tfrac{1}{2}\Omega t.$$

Note that $F_N = 0 = G_N$

The bandpass and highpass filters have closely related formulae, with $(L - \frac{1}{2})$ in place of $(M + \frac{1}{2})$.

Limitations

The 'Dimension' statement restricts N to ≤ 200. Clearly the greater N, the sharper is the cut off, and the nearer are the characteristics to 0 and 1, but values N ≤ 100 should suit most practical purposes.

Execution time

About 1·5N seconds per filter.

Programmer

D. E. Cartwright

N.I.O. Program 168

Title	Cable Configuration
Name	CABL
Machine	IBM 1800
Language	1800 Fortran IV
Purpose	To compute the equilibrium configuration and tensions of a cable towing a submerged body for faired, unfaired, and discontinuous (lower part only, faired) cables.

Control Cards

```
//bJOB
//b*(Job No./Name/Title)
//bXEQbCABL
*CCEND
```

followed by input data cards.

Input

Card No.	Contents	Function
1	NAME	Column one is a reference digit It must be 3 for a discontinuous cable (part faired, part unfaired) It is normally taken as 1 for Unfaired Cable and 2 for Faired Cable The remaining 39 columns are printed as a title

e.g.

Col. 1 2 ... 40
2ECHO-SOUNDING FISH....U=1.00

FORMAT (40A1)

Card No.	Contents	Function
Card 2	D	Diameter of the cable in inches Cols. 2 - 10. Decimal Point col. 7

e.g.

Col. 2 3 4 5 6 7 8 9 10
0.580

	WT	The weight/unit . length of the cable inlbs/ft. Cols. 11 - 19 Decimal Point col. 16

e.g.

Col. 11 15 19
1.000

	CR	The Drag Coefficient of the cable Cols. 20 - 28 Decimal Point col. 25

e.g.

Col. 20 24 28
0.411

U — Ratio of "Friction Drag"/"Friction Drag and Form Drag"
See Ref. 2 under method section
U = 0·75 recommended for most faired cables
U = 0·02 for unfaired cables

Cols. 29 - 37 d.p. col. 34.

DELO — The weight of the towed body in pounds.

Cols. 38 - 46 d.p. col. 43

FORMAT (A1,5,F9·3) (A1 is character to denote end of data - blank on card 2)

Card 3

ALV2 — Lift (Down)/(velocity)^2 for ddpressors on body. lbs wt/(ft./sec.)^2

Zero for bodies without depressors.

Cols, 2 - 10 d.p. 7

S — Area of Cross-Section Towed Body in sq. ft.

Cols. 11 - 19 d.p. 16

CDO — Drag Coefficient Towed Body

Cols. 20 - 28 d.p. 25

DL — Drag to lift ratio depressor (Put as zero for body without depressor)

Cols. 29 - 37 d.p. 34

VK — Speed of tow in Knots.

Cols. 38 - 46 d.p. 43

FORMAT (1X,5F9·3)

Card 4 — First column see below

SMAX — Value of scope to which computation is wanted in feet.
In the discontinuous case it is the total scope for both sections of cable.

Cols. 2 - 7 Decimal Point col. 6.

H — Step in scope between computed points in feet. See note in method section.

Cols. 8 - 13 Decimal point Col. 12

FORMAT (A1,2F6·1)

Card 5 This card is needed only in the discontinuous case. In this case the values of CR and U read on card 2 are used on the lower position of the cable.

CR2 New drag coefficient
Cols. 2 - 10 d.p. col. 7

U2 New value of U
Cols. 11 - 19 d.p. col. 16

ISS Value of scope at which changeover to these values is made. It must be integral.

Cols. 20 - 23. No decimal point.

FORMAT (A1,2F9·3,I4)

Any number of further groups of four or five cards as above can follow. The last data card in the last group of any run <u>MUST</u> have a slash '/' in column 1. This column should otherwise be blank on cards 2 - 5.

<u>Output</u>

The output on the line printer gives the values of the input data followed by calculated values of

INITIAL ANGLE	The cable angle at the body
CRIT. ANGLE	The cable critical angle } see ref.2
PSIO	ψ_0 } see ref.2
DELTA	The total downwards force on the body (wt. + depressor downthrust)
DRAG	The total drag on the body
INITIAL TENSION	The initial tension of the cable at the body.
NORMAL DRAG	The drag /unit length there would be on the cable if it were normal to the stream. lbs. wt./ft.

Then after a heading (FAIRED CABLE if U>0·1, UNFAIRED CABLE if U≤0·1) there follows a table giving for scopes (measured up from the body) of H, 2H, 3H etc. up to SMAX the values of cable tension, cable inclination phi, total horizontal distance X, and total vertical distance Z.

A final column headed ITN gives the number of times a successive approximation formula is applied. This will vary from point to point with the curvature of the cable. If ITN>3 for the entire length of the cable H should be reduced. If ITN is one for much of the cable H may be increased if the intermediate values are not required. If ITN reaches 10 the program fails and must be repeated with a smaller value of H.

Method

The solution is found for the "Heavy General Cable" law of cable loading as described by Eames (ref. 2).

Note that his μ = U in our notation and that his tables (ref. 1) correspond to the case U = 1·00.

Refs. 1 and 2 make clear the meaning of the various calculated values. The program finds the critical angle for the cable by a bisection method. The main configuration calculation uses the improved Euler method for the first step, followed by a predictor-corrector method as described in ref. 3.

Note that the program takes Density Water $(\text{lbs}/_{\text{ft}^3})$ = $2g$ $\text{ft}/_{\text{sec}^2}$

Ref. 1 Eames, M.C. 1956 The Configuration of a Cable Towing a Heavy Submerged Body from a Surface Vessel.
Naval Research Estab. Canada Report PHx 103
NIO no. N35.2/B/PHx103.

2. Eames, M.C. 1968 Steady State Theory of Towing Cables.
(Quarterly Transactions of the Royal Institute of Naval Architects 110, 185-206).
NIO British Loose Paper 14.11.68.

3. Mihoff, C.M. 1966 Configuration of a Cable Towing a Submerged Body.
Naval Research Estab. Canada Technical Note Math /66/1
NIO no. N35.2/C/Math/66/1.

Execution Time

Approx. 30 secs. for each case computed.

Programmer

Translated into Fortran by Catherine Clayson.

N.I.O. PROGRAM 178

Title	Braincon data reduction
Name	BRCA
Machine	IBM 1800
Language	1800 Fortran IV
Purpose	To convert data in the form of angular positions of the rotor and compass arcs from Braincon type 316 current meters into values of current speed and direction, tilt direction, N-S and E-W current components and displacements (in kilometres) from and arbitrary origin. The data is output to lineprinter and magnetic tape.

Job Description

```
// JOB
// *Job No./Name/Title
// XEQ BRCA
* FILES(201,MX,0)  X is magnetic tape number
*CCEND
```

Input

Card

1)

MN	RW	REFR	PER	V
I7	F4.1	F7.1	F6.1	F6.1

Where MN is the meter number

RW is the width of the rotor spot in degrees

REFR is the distance of the reference spot from the centre

PER is the recording period for each exposure

V is the magnetic variation in degrees (West + ve)

2)

N
I7

N is the number of the last line of data.

3) onwards ....

Data cards punched in following format

I	RA	RB	CA	CB	TM	TD
I6	F7.1	F7.1	F7.1	F7.1	F7.1	F7.1

Where I is the frame number

RA is the angular position of the rotor arc beginning

RB is the angular position of the rotor arc end

CA is the angular position of the compass arc beginning

CB is the angular position of the compass arc end

TM is the separation of the tilt and centre spots (in the same units as REFR).

TD is the direction of the tilt spot.

Use

The data can be read on any machine provided the following rules are observed.

a) The reference spot is vertically downward.

b) The rotor arc progresses clockwise with time.

c) The angular origin is vertically upwards (0/360°)

Output

The data is output to lineprinter with column headings and to magnetic tape without headings. Output format is

I	SPC	DIRT	TAT	CN	CE	DISN	DISE
2X I4	F7·2	F7·1	F7·1	F7·2	F7·2	F11·5	F11·5

Where I is the line number

SPC is the speed (tilt corrected) in cm/sec

DIRT is the true current direction

TAT is the true tilt direction

CN is the northerly current component in cm/sec

CE is the easterly current component in cm/sec

DISN is the northward displacement of an imaginary particle from the origin

DISE is the eastward displacement of an imaginary particle from the origin.

Error messages are output for zero or nagative values of the rotor and compass arc lengths.

Method

Each input card provides one line of output data. The program corrects current speeds for the tilt of the savonius rotor and for values of the recording period different from 19 mins., this correction is also applied in the computation of the progressive vector diagram coordinates.

Execution time

Of the order of 3 mins. per 100 cards (2 mins. for 1 day of record).

Programmer

W. J. Gould.

N.I.O. PROGRAM 181

Title	Current Meter Card Checking
Name	CHECK
Machine	IBM 1800
Language	1800 Fortran IV
Purpose	To check for any sequencing or punching erros in the current meter data cards.
Input	Job and data cards. Last data card having A in column 1.

Job Description	//bJOB
	//b*Job No./Name/Title
	//bXEQbCHECK
	*CCEND

Data Cards	The format of the card's should be: 2I6, 12X, 2I6, 4X, 2I6, 12X, 2I6 Last data card must have 'A' in column 1. This is read in A1 format in the program.
Output	The incorrect cards are listed on the lineprinter.
Method	The program checks first that all the columns contain either blanks or digits 0 - 9. Then it checks that the last digits of all the integers are present. By calling the subroutines RIP and RIM, the sequencing of the cards is checked. The value of the speed is checked - it should be less than 10·23 knots and if the value of speed drops, it should drop by more than 9 knots, indicating that the rev. counter has exceeded 1023 and returned to zero. Error messages are printed if any of the above errors are detected.
Execution time	Approx. 4 mins./100 cards.
Programmer	John Gee

N.I.O. SUBPROGRAM -24

Title	Saturation Vapour Pressure
Name	Function VAPW(T)
Language	1800 Fortran IV
Machine	IBM 1801/02
Purpose	To calculate saturation vapour pressure over water
Input	Temperature in °K
Output	Saturation vapour pressure in millibars e.g. X = VAPW(T) where X is the pressure required.
Method	See Smithsonian tables page 350 equation (1). The function converts the log output of this equation to actual pressure in millibars.
Programmer	R. Howarth

N.I.O.Subprogram -26

Title Three point Lagrangian interpolation of hydrographic data.

Name LAGIN(STAN,PRES,LST,KL)

Purpose When analysing hydrographic data several variables are calculated at standard pressures or depths. For this purpose the variables are interpolated from the known pressures (or depths) to the standard.

Input The input variables are

1) STAN - an array dimensioned as main program of the standard pressures.
2) PRES - an array dimensioned as main program of the given pressures.
3) LST - the number of points in the array PRES.
4) KL - the position of the standard pressure in its array which is currently being used.

Also the input variables to be calculated are passed through common (see output section).

Method The quantities calculated are

a) dynamic height anomaly
b) potential energy anomaly
c) sound velocity
d) sounding velocity
e) sigma theta

The argument is the pressure P.
We have n values of P_i $i = 0 - (n-1)$
and there is a value of the above variables say Y_i for each P_i. Then Y is required for the standard values of P say P_j $j = 0 - (m - 1)$
There are five possible cases.

(1) $P < P_0$
(2) $P_0 \leq P < P_1$
(3) $P_i \leq P < P_{i+1}$ for $i = 1-(n-3)$
(4) $P_{n-2} \leq P \leq P_{n-1}$
(5) $P > P_{n-1}$

In cases (1) and (5) interpolation is impossible. In the other cases two values (Y_1 and Y_2) of Y are computed and Y is taken as the mean of the results. The difference gives an indication of the accuracy.

$$Y = \frac{1}{2}(Y_1 + Y_2)$$

$$e = \frac{1}{2}(Y_1 - Y_2)$$

The general three point Lagrangian Interpolation formula is, using arguments P_{r-1}, P_r and P_{r+1}

$$Y_1 \text{ (or } Y_2) = A_{r-1} Y_{r-1} + A_r Y_r + A_{r+1} Y_{r+1}$$

$$\text{Where } A_{r-1} = \frac{(P - P_r)(P - P_{r+1})}{(P_{r-1} - P_r)(P_{r-1} - P_{r+1})}$$

$$A_r = \frac{(P - P_{r-1})(P - P_{r+1})}{(P_r - P_{r-1})(P_r - P_{r+1})}$$

$$A_{r+1} = \frac{(P - P_{r-1})(P - P_r)}{(P_{r+1} - P_{r-1})(P_{r+1} - P_r)}$$

Near the end of the range linear interpolation is necessary. The formula used in each case works out as

Case 1 Interpolation impossible.

Case 2

$$Y_1 = Y_0 + \frac{Y_1 - Y_0}{P_1 - P_0}(P - P_0)$$

$$Y_2 = A_0 Y_0 + A_1 Y_1 + A_2 Y_2$$

Case 3

$$Y_1 = A_{i-1} Y_{i-1} + A_i Y_i + A_{i+1} Y_{1+1}$$

$$Y_2 = A_i Y_i + A_{i+1} Y_{i+1} + A_{i+2} Y_{i+2}$$

Case 4

$$Y_1 = A_{n-3} Y_{n-3} + A_{n-2} Y_{n-2} + A_{n-1} Y_{n-1}$$

$$Y_2 = Y_{n-2} + \frac{Y_{n-1} - Y_{n-2}}{P_{n-1} - P_{n-2}} (P - P_{n-2})$$

Case 5 Interpolation is impossible.

If the range of standard pressures exceeds the given ones - those outside the range are ignored.

Output The five variables calculated plus the pressure and associated depth are output through common. Common is arranged as follows

dynht, sdvl, sgvl, poten, erdy, erpo, ersg, ersd, dyn, pote, sdv, sgv, dep, erde, sig, ersi, depth, sigth, lint

Where input variables are

dynht (35)	= dynamic height anomaly.
sdvl (35)	= sounding velocity.
sgvl (35)	= sounding velocity.
poten (35)	= potential energy anomaly.
depth (35)	= depth or pressure.
sigth (35)	= sigma theta.

Output variables are

erdy	= dynamic height error.
erpo	= potential energy error.
ersg	= sounding velocity error.
ersd	= sound velocity error.
dyn	= interpolated dynamic height anomaly.
pote	= " potential energy.
sdv	= " sound velocity.
sgv	= " sounding.
dep	= " depth (or pressure)
erde	= depth (pressure) error.
sig	= interpolated sigma theta.
ersi	= sigma theta error.

Subroutines called TLAGR

Programmer R.Howarth. (Taken from N.I.O.Program 58)

N.I.O. Subprogram -27

Title 3 point Lagrangian Interpolation calculation.

Name TLAGR(PNT,P,Y)

Purpose The subroutine is used by LAGIN to calculate a general case of interpolation.

Input There are 3 input variables

1) PNT - value of the standard pressure currently used.
2) P - middle of the three pressures used for interpolation.
3) Y - middle of the three variables used for interpolation.

(For more details see LAGIN,N.I.O. Subprogram -26)

Method The following formula is used

$$TLAGR = A1 \times Y_{i-1} + A2 \times Y_i + A3 \times Y_{i+1}$$

Where

$$A1 = \frac{(PNT - P_i) \times (PNT - P_{i+1})}{(P_{i-1} - P_i) \times (P_{i-1} - P_{i+1})}$$

$$A2 = \frac{(PNT - P_{i-1}) \times (PNT -_{i+1})}{(P_i - P_{i-1}) \times (P_i - P_{i+1})}$$

$$A3 = \frac{(PNT - P_{i-1}) \times (PNT - P_i)}{(P_{i+1} - P_{i-1}) \times (P_{i+1} - P_i)}$$

Output The subprogram is a normal function subprogram e.g.

TLAGR = A1 x Y1 + A2 x Y2 + A3 x Y3

Programmer Ruth Howarth.

N.I.O.Subprogram -28

Title To calculate the Brunt-Vaisala stability frequency

Name DSTAF (G, TEMP, SAL, PRES, NPTS, DV)

Input G = acceleration due to gravity in cm/sec^2

TEMP = temperature array in °C

SAC = salinity array in $^{o}/_{oo}$

PRES = pressure array in decibars

NPTS = no. of points in the above arrays

Method The stability frequency DV, or the Brunt-Varsala frequency, is computed from the relationship derived by Hesselberg and Sverdrup.

$$DV^2 = -{}^{g}/_{\rho}\left(\frac{\partial\rho}{\partial T}\left\{\frac{dT}{dZ} \mp \rho g\Gamma\right\} + \frac{\partial\rho}{\partial S}\ \frac{dS}{dZ}\right)$$

Where ρ is the in situ density in grams per cc

g is the acceleration of gravity in cm/sec^2

T is the in situ temperature in degrees C

Z is the depth in metres increasing downwards

Γ is adiabatic temperature gradient in °C/meter

S is salinity in $^{o}/_{oo}$

ρ = ALPH is calculated by subroutine ALPHA

Γ = GAMMA is cabulated by subroutine DATG

Derivatives are evaluated by forward differencing

In the case of $\frac{\partial\rho}{\partial T}$ its value in the jth.layer is given by

$$\frac{\partial\rho}{2T} = \left\{ \rho\left\{ \bar{T}_j + \Delta T, \bar{S}_j, \bar{P}_j \right\} - \rho\left\{ \bar{T}_j - \Delta T, \bar{S}_j, \bar{P}_j \right\} \right\} \Big/ 2\Delta T$$

when $\bar{T} = \frac{1}{2} (T_j + T_{j+1})$ = mean temp in jth.layer

$\bar{S} = \frac{1}{2} (S_j + S_{j+1})$ = mean salinity in jth. layer

$\bar{P} = \frac{1}{2} (P_j + P_{j+1})$ = mean pressure in jth. layer

$\Delta T = 0.1\ ^{o}C$

similarly for $\frac{\partial \rho}{\partial S}$ with $\Delta S = 0.1\ ^{o}/_{oo}$

If DV^2 is found to be negative i.e. the water is unstable, a negative value for DV is given as a diagnostic.

Subroutines called SIGMO, SIGMT, ALPHA, DATG

Programmer R. Howarth (taken from a Woods Hole program by H. Perkins)

N.I.O.Subprogram -29

Title Adiabatic temperature gradient using Fofonoffs method.

Name DATG(P, T, S, GAMMA)

Input

P - mean value of pressure

T - mean value of temperature in °C

S - mean value of salinity in ‰

(for more details see DSTAF N.I.O. Subprogram - 28)

Method The formula used is as follows:-

$$YA = A1 \times T^4 + A2 \times T^3 + A3 \times T^2 + A4 \times T - A5$$

$$YB = B1 \times T^2 - B2 \times T + B3$$

$$YC = B4 \times T^2 - B5 \times T + B6$$

$$YD = B7 \times T - B8$$

$$YE = C1 \times T - C2$$

$$YF = C3 \times S^2 + YB \times S + YA$$

$$YG = YD \times S + YC$$

$$GAMMA = YE \times P^2 + YG \times P + YF$$

Where

$A1 = -3.32998 \times 10^{-8}$

$A2 = 3.4524 \times 10^{-6}$

$A3 = 1.477539 \times 10^{-4}$

$A4 = 1.119981 \times 10^{-2}$

$A5 = 4.2142 \times 10^{-2}$

$B1 = 9.2455 \times 10^{-8}$

$B2 = 4.954202 \times 10^{-5}$

$B3 = 2.426844 \times 10^{-3}$

$B4 = 7.51888 \times 10^{-9}$

$B5 = 7.62182 \times 10^{-7}$

$B6 = 2.291056 \times 10^{-5}$

B7 = 1.9654×10^{-9}

B8 = 1.058507×10^{-7}

C1 = 1.56162×10^{-11}

C2 = 4.53156×10^{-10}

C3 = -6.47031×10^{-6}

GAMMA (the adiabatic temp gradient) is then output to DSTAF

Programmer R. Howarth (From a Woods Hole Program by J. Webster)

N.I.O. SUBPROGRAM -31

Title Specific Volume of Sea Water

Name Function ALPHA(SIGMT,SIGMO,T,P)

Machine IBM 1800

Language 1800 Fortran IV

Purpose The specific volume is the reciprocal of the density, dependant on salinity, temperature and pressure expressed as α_s, Θ, p.

Input The subprogram is used as an ordinary function, the input variables being SIGMT (see N.I.O. Subprogram -34), temperature and pressure e.g.

ALPH = ALPHA(SIGMT,SIGMO,TEMP,PRES)

Method The formula used is

ALPHO = 1.0/1.0 + SIGMT x 0.001

$$\begin{aligned}
ALPHA = {} & ALPHO\ (\ 1.0 + C1 \times X + C2 \times T \times X + C3 \times T^2 \times X \\
& + C4 \times T^3 \times X + C5 \times X \times SIGMO + C6 \times X \times T \times SIGMO \\
& + C7 \times SIGMO \times X \times T^2 + C8 \times SIGMO^2 \times X + C9 \times SIGMO^2 \times X \times T \\
& + C10 \times X^2 * C11 \times X^2 \times T + C12 \times X^2 \times T^2 + C13 \times SIGMO \times X^2 \\
& + C14 \times SIGMO \times X^2 \times T + C15 \times SIGMO \times X^2 \times T^2 + C16 \times SIGMO^2 \times X^2 \\
& + C17 \times SIGMO^2 \times X^2 \times T + C18 \times X^3 \times T - C20 \times X/(C21 + C22 \times X
\end{aligned}$$

Where
$C1 = -2.2072 \times 10^{-7}$
$C2 = 3.5162 \times 10^{-8}$
$C3 = -6.63 \times 10^{-10}$
$C4 = 4.0 \times 10^{-12}$
$C5 = 1.725 \times 10^{-8}$
$C6 = -2.16 \times 10^{-10}$
$C7 = 4.0 \times 10^{-12}$
$C8 = -4.5 \times 10^{-11}$
$C9 = -1.0 \times 10^{-12}$

$C10 = -6.68 \times 10^{-14}$

$C11 = -1.24064 \times 10^{-12}$

$C12 = 2.14 \times 10^{-14}$

$C13 = -4.248 \times 10^{-13}$

$C14 = 1.206 \times 10^{-14}$

$C15 = -2.0 \times 10^{-16}$

$C16 = 1.8 \times 10^{-15}$

$C17 = -6.0 \times 10^{-17}$

$C18 = 1.5 \times 10^{-17}$

$C20 = 4.886 \times 10^{-6}$

$C21 = 1.0$

$C22 = 1.83 \times 10^{-5}$

Temperature in $^{o}/oo$

Pressure in decibars

Programmers J. Crease and R. Howarth.

N.I.O.Subprogram -32

Title Sound velocity in sea water from Wilson's Ind Formula

Name Function SDVEL (T,S,P)

Purpose The sound velocity is dependant on temperature, salinity and pressure.

Input The subprogram is used as as an ordinary function, the input variables being temperature ($^{\circ}C$), pressure and salinity.

e.g. SOUND = SDVEL(TEMP,SAL,PRES)

Method The formula used is

$$\begin{aligned} SDVEL = \; & CO + C1 \times T + C2 \times T^2 + C3 \times T^3 + C4 \times T^4 \\ & + C5 \times X + C6 \times X^2 + C7 \times X^3 + C8 \times X^4 + C9 \times Z \\ & + C10 \times Z^2 + C11 \times Z \times T + C12 \times X \times Z + C13 \times X^2 \times Z \\ & + C14 \times T \times X \times Z + C15 \times X \times T + C16 \times T^2 \times X \\ & + C17 \times T^3 \times X + C18 \times X^2 \times T + C19 \times X^2 \times T^2 \\ & + C20 \times X^3 \times T \end{aligned}$$

Where Z = Salinity - 35.0 ‰

X = 1.0/9.80655 x pres (conversion from Newton/Sq.Metre to kgf/CM.sq.

$CO = 1.449143 \times 10^{3}$

$C1 = 4.5721$

$C2 = -0.044532$

$C3 = -2.6045 \times 10^{-4}$

$C4 = 7.9851 \times 10^{-6}$

$C5 = 0.1\ 60272$

$C6 = 1.0268 \times 10^{-5}$

$C7 = 3.5216 \times 10^{-9}$

$C8 = -3.3603 \times 10^{-12}$

$C9 = 1.39799$

$C10 = 1.692 \times 10^{-3}$

$C11 = -1.1244 \times 10^{-2}$

$C12 = 7.7016 \times 10^{-5}$

$C13 = 1.2943 \times 10^{-7}$

$C14 = 3.1580 \times 10^{-8}$

$C15 = -1.8607 \times 10^{-4}$

$C16 = 7.4812 \times 10^{-6}$

$C17 = 4.5283 \times 10^{-8}$

$C18 = -2.5294 \times 10^{-7}$

$C19 = 1.8563 \times 10^{-9}$

$C20 = -1.9646 \times 10^{-10}$

Programmers J. Crease and R. Howarth.

N.I.O. Subprogram -33

Title SIGMA T

Name FUNCTION SIGMT(SIGMO,T)

Machine IBM 1800

Language 1800 Fortran IV

Purpose The density of water depends on temperature, salinity and pressure and is defined as $\sigma_{s,\theta,p}$. For practical purposes the symbol σ is used where $\sigma_T = (\rho - 1) \times 1000$

Input The subprogram is used as an ordinary function, the input variables being sigma zero (see N.I.O Subprogram -34) and temperature. For example a call would be:-

SIGT = SIGMT(SIGMO,TEMP)

Method The formula used is:-

$$\sigma_T = (C4 \times T + C5 \times T^2 + C6 \times T^3 + C7 \times T^4) / (C8 + T) + \sigma_o (C9 + C10 \times T + C11 \times T^2 + C12 \times T^3) + \sigma_o \times T (C13 + C14 \times T + C15 \times T^2)$$

Where C4 = 4.531684261

C5 = -0.545939

C6 = -0.00982484022

C7 = $-1.43803586 \times 10^{-7}$

C8 = 67.26

C9 = 1.0

C10 = -0.0047867

C11 = 9.8185×10^{-5}

C12 = -1.0843×10^{-6}

C13 = 1.8030×10^{-5}

C14 = -8.164×10^{-7}

C15 = 1.667×10^{-8}

Programmers J. Crease and R. Howarth.

N.I.O. Subprogram -34

Title	SIGMA ZERO
Name	FUNCTION SIGMO (S)
Machine	1800 IBM
Language	1800 Fortran IV

Purpose

The density of water is defined as $\rho s,\Theta,p$ depending on salinity, temperature and pressure.

For practical purposes the symbol

σ is used where

$\sigma = (\rho - 1) \times 1000$

At atmospheric pressure and temperature $0^{\circ}C$ this becomes σO

Input

The subprogram is used as an ordinary function, the input variable being salinity. For example a call would be

SIGO = SIGMO(SAL)

Method

The basic formula is

$$\sigma O = -0.069 = 1.4708\ CL\ -0.001570CL^2 + 0.0000398CL^3$$

Where CL = chlorinity and

S = 0.030 + 1.8050CL

This reduces to

$$SIGMO = -.0934458632 + 0.814876577 \times S + 0.0004824961402 \times S^2 + 0.000006767861356 \times S^3$$

Where S = Salinity

Programmers

J. Crease and R. Howarth.

N.I.O. Subprogram -35

Title	Potential Temperature Calculation
Name	Function POTLT (S,T,P)
Purpose	The temperature that a water sample would attain if raised adiabetically to the sea surface is the potential temperature, dependant on salinity, temperature and pressure.
Input	The subprogram is used as an ordinary function, the input variables being salinity, temperature and pressure (decibars) e.g. POTT = POTLT(SAL,TEMP,PRES)
Method	The formula used is

$$
\begin{aligned}
POTLT = {} & 10.0 + C0 + C1 \times X + C2 \times X^2 + C3 \times X^3 \\
& + C4 \times X^4 + C5 \times Y + C6 \times X \times Y + C7 \times X^2 \times Y + C8 \\
& \times X^3 \times Y + C9 \times Y^2 + C10 \times Y^2 \times X + C11 \times Y^2 \times X^2 \\
& + C12 \times Y^3 + C13 \times Y^3 \times X + C14 \times Y^4 + C15 \times Z \\
& + C16 \times Z \times X \\
& + C17 \times Z \times X^2 + C18 \times Z \times X^3 + C19 \times Y \times Z + C20 \times \\
& Y \times Z \times X + C21 \times Y \times Z \times X^2 + C22 \times Y^2 \times Z \\
& + C23 \times Y^2 \times Z \times X + C24 \times Y^3 \times Z + C25 \times Z^2 \\
& + C26 \times Z^2 \times X + C27 \times Z^2 \times X^2 + C28 \times Z^2 \times Y \\
& + C29 \times Z^2 \times Y \times X + C30 \times Z^2 \times Y^2 \\
& + C31 \times Z^3 + C32 \times Z^3 \times X + C33 \times Z^3 \times Y + C34 \times Z^4
\end{aligned}
$$

Where $Y = T - 10$

$Z = S - 35$

$X = P - 3000$

and

$C0 = -.398315416$

$C1 = -1.48838184 \times 10^{-4}$

$C2 = -4.97276203 \times 10^{-9}$

$C3 = 1.14787022 \times 10^{-13}$

$C4 = -3.44650095 \times 10^{-18}$

$C5 = 0.980573094$

$C6 = -5.72948486 \times 10^{-6}$

$C7 = 2.31465302 \times 10^{-10}$
$C8 = -6.35886194 \times 10^{-15}$
$C9 = 1.66218502 \times 10^{-4}$
$C10 = 4.73092648 \times 10^{-8}$
$C11 = -3.08648661 \times 10^{-12}$
$C12 = -5.79307228 \times 10^{-6}$
$C13 = -1.87219021 \times 10^{-9}$
$C14 = 1.75294133 \times 10^{-8}$
$C15 = -3.9752447 \times 10^{-3}$
$C16 = -1.17389308 \times 10^{-6}$
$C17 = 4.42058721 \times 10^{-11}$
$C18 = -1.58646788 \times 10^{-15}$
$C19 = 1.27713469 \times 10^{-4}$
$C20 = 3.87625363 \times 10^{-8}$
$C21 = -1.21732442 \times 10^{-12}$
$C22 = -4.05018724 \times 10^{-7}$
$C23 = -1.54641063 \times 10^{-10}$
$C24 = -2.69246776 \times 10^{-10}$
$C25 = 1.39685442 \times 10^{-5}$
$C26 = 5.96101444 \times 10^{-9}$
$C27 = 3.19737957 \times 10^{-13}$
$C28 = -8.84139309 \times 10^{-7}$
$C29 = -2.95408321 \times 10^{-10}$
$C30 = 1.19473357 \times 10^{-8}$
$C31 = 1.18069178 \times 10^{-7}$
$C32 = -7.69559002 \times 10^{-11}$
$C33 = -1.89676587 \times 10^{-10}$
$C34 = 2.50169882 \times 10^{-8}$

Programmers J. Crease and R. Howarth.

P

N.I.O. Program -36

Title	Specific Volume Anomaly
Name	Function DELV(ALPH,PRES)
Language	Fortran IV
Machine	IBM 1800

Purpose

The density of water is a function of pressure, temperature and salinity. (ρ) In practice the reciprocol, the specific volume is used.(alpha) The specific volume anomaly is defined as

δ = alpha (pressure, temperature, salinity) - alpha(pressure,0 $^{\circ}$C,35 $^{\circ}/_{oo}$)
p is in decibars.

Input

The two input variables are
1) alph - specific volume
2) pres - pressure (decibars)

Method

The formula used is

$$DELV = ALPH - C0 + C0 \times P \times C1/(1. + C2 \times P) + P \times C0 \times C3 - C0 \times C4 \times P^2$$

Where

C0 = 0.972643
C1 = 4.886E - 6
C2 = 1.83E - 5
C3 = 2.29E - 7
C4 = 1.059E - 11
P = pressure

The subprogram is used as a normal function subprogram e.g.

SVANOM = DELV(ALPH,PRES)

Programmers

J. Crease and Ruth Howarth.

N.I.O. Subprogram -42

Title	Linear Interpolation
Name	Subroutine LININ (CAUX, TAX)
Machine	IBM 1800
Language	1800 Fortran IV
Purpose	Given a set of auxiliary thermometer readings and their corrections, to linearly interpolate for any given auxiliary thermometer reading.
Input	Data is input through the argument list and via blank common.
Argument	TAX - the auxiliary temperature to be interpolated.
Common	NP1 - no. of points AUXT - array containing auxiliary temperatures AUCO - array containing auxiliary temperature corrections.
Output	CAUX - correction required is passed out through the argument list.
Restrictions	The maximum no. of points to be used is 20. This subroutine is used with the thermometer corrections program 155.
Programmer	R. Howarth