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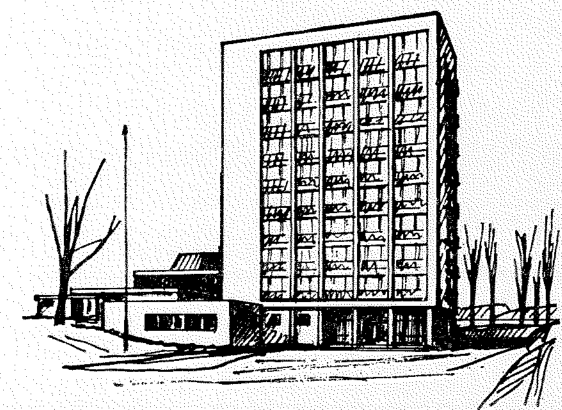

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THE DATA LOGGING SYSTEM OF R.V. "G.O.SARS"
DESCRIPTION OF SOFTWARE

by

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INTRODUCTION

When the Institute of Marine Research planned it's research vessel "G.O.Sars", it was decided to include a computer centered data acquisition system in the equipment of the ship. The intention with the system was to obtain automatic and accurate data collection from various instruments which should be connected on-line to the computer. A need for this was particularly felt in the use of echo sounders which had developed requirements for data acquisition at rates which were impossible by more convential methods. The computer should also perform data reduction and necessary processing in real time. Reduced data and real-time products should be stored on paper tape for further management onboard or ashore.

The contract for planning the system, including choise of computer with peripherals and construction of interface units for the instruments to be logged, was placed with the Central Institute for Industrial Research, Oslo. The software of the system was made by this institute and the Institute of Marine Research in cooperation. The hardware, and also parts of the software, of the system is earlier presented by JAHR et al. 1970 and a paper on the use of the system is earlier presented by BLINDHEIM and EIDE 1971.

Since the system became operational and experience in practical use has been gained, several modifications have been made. This report describes the modified software of the system and summarizes briefly its hardware configuration.

SYSTEM CONFIGURATION, HARDWARE

The data logging system is built around a NORD-1 computer which has paper tape input/output (I/O) units. A block diagram of the system is shown in Fig.1 and specifications for the different peripheral devices are entered in Table 1. As indicated in Fig.1, the system is collecting data from a wide variety of instruments within the fields of oceanography, meteorology, hydroacoustics and navigation. Many of the instruments give analog inputs and are connected to the computer wia a multiplexer and an analog to digital converter (ADC). Other instruments produce digital outputs. These are given device numbers and connected directly to the I/O channelse of the computer.

The data acquisition from these sources is governed by interrupts generated by the real-time clock and the ship's log. From the log an interrupt is given every tenth of a nautical mile outsailed distance and the interrupts from the real-time clock occur at a rate of one Hz. More details about the sampling which is performed on log interrupt is entered in Table 2,and in Table 3 is the sampling activities occurring on each clock interrupt summarized.

In some case it is necessary to sample the echo sounders at rates up to 50 kHz. For this reason the echo sounders can be connected to the computer wia an acoustic interface unit (Simrad Computer Interface Unit) and a fast ADC. The interface unit gives interrupt to the computer when sampling shall start and stop, the interrupt occurring when the echoes are received from the upper and lower limits of the depth interval to be sampled. In the interface unit the timing of the interrupts is controlled by an adjustable electronic counter. The greatest possible depth to the upper limit is 400 m and the magnitude of the depth interval itself can not exceed 200 m. This corresponds to a time interval of approximately 0,3 sec. In order to avoid loss of interrupt from the lower priority real-time clock during these periods, the low interrupt rate of one Hz has been chosen for the clock.

One of the teleprinters which is involved in the system serves as operators keyboard terminal in the acoustic instrument room. The rest of the system is placed in one room where the computer, the papertape I/O units and the interface electronics occupy three instrument racks. Both these rooms are on the bridge deck level adjacent to the Operations Centre from where the research activities of the ship are currently coordinated.

DESCRIPTION OF THE SOFTWARE

The standard software of the NORD-1 comprises the programming languages MAC Assembly and debugging system, FORTRAN II, FORTRAN IV and BASIC. Considering the requirements it was evident that assembly coding had to be applied for the programming of the system. During its further design two characteristic features had to be considered: Firstly that the hardware configuration made it necessary that most of the system software should be core resident, and secondly that some of the data collection should be done at a speed which required the ful capacity of the computer. During the programming phase it was, therefore, thought more of compactness and speed than of generality. One of the means for obtaining this was to utilize the effecient priority interrupt system of the computer so that time shearing could be applied for the different data acquisition programs and processing routines which accordingly were plased on the different priority interrupt levels. Here the priority of the data collection and processing were given priority according to sampling rate and necessary speed. Slower procedures as for instance output were given low priority. Further a compact operation system was incorporated and reentrant I/O routines were made specially for the system.

Since the system is supposed to be working constantly when the ship is at sea, it was considered important to have also the possibility to apply more casual programs when the system is working. This is achieved by placing the MAC assembler on Level 1. In retaliation some programs belonging to the system, but not in regular use, are read into the memory by means of the assembler only when they are needed. This is done in order to reserve a sufficient part of the core store for general use.

A listing of the system software is entered in Appendix 1 and a short description of the programming on each level is compiled in the following.

LEVEL 15

Start: Interrupts from the acoustic interface unit.

Operations: Identification of interrupts for start or stop of data collection from the echo sounder. Reading of counter indicating depth of acoustic sampling.

Products: Interrupts to Level 14.

Description: The fast data collection from the echo sounders which requires the ful speed capacity of the computer, is given the highest priority. The acoustic interface unit gives interrupt on Level 15 to start or stop the sampling. These interrupts are identified and interrupts are given to Level 14 accordingly. Further is an electronic counter in the acoustic interface unit read when the interrupts are given. According to the interrupt these readings give the depth to, and the magnitude of the interval to be sampled. The maximum possible depth to the upper limit of the interval is 400 m and the magnitude of the interval can not exceed 200 m.

LEVEL 14

Start: Interrupt from Level 15.

Operations: Reading of echo signals from echo sounder wia 10-bit ADC. Reduction and processing of the collected data.

Products: Characteristic parameters of echoes from single targets. Interrupt to Level 5 for output when adequate.

Description: The intention with the fast sampling of the echo signals which is done on this level is classification of echo traces based on reflection patterns of single targets. For this reason a procedure is applied which utilizes all echoes received from a single fish when it passes through the acoustic beam from the echo sounder. The method is described by MIDTTUN and NAKKEN 1971 and here shall only be summarized what is done in the computer. The processing of the echo signals is splitted into three phases. About 20 micro seconds between each sample is utilized for the first phase. Here the program keeps record of when the fish comes into and fades out of the acoustic beam. Before the sample is considered valid and stored in memory, tests on treshold and pulse length are also performed. The sampling may go on up to about 0,3 seconds on each transmission (when the interval to be sampled is 200 m) and the rest of the time before the next pulse transmission is more than sufficient for the second phase of processing and data reduction. During this phase the maximum amplitude of the current echo signal is recorded, the echo integral and the pulse length at 50 % of maximum amplitude is computed. This is done for each ping when the target passes through the acoustic beam. After the target has faded out of the beam the depth to the target is worked out and also the reflection angle of the target given by

$$\theta = 2 \arctan \frac{v(n+1)}{2\ DP}$$

where v is the speed of the ship in cm/sec., n is the number of echoes received from the target, D is the depth to the target in cm and P is the repetition rate of the echo sounder in number of transmission per sec. The echo strength of each echo is computed by

$$Es = k+20 \log \alpha D$$

where k is constant, α is the voltage sampled from the echo sounder and D is the depth to the target.

A program which optionally can be combined with the classification program plots the envelope curve of the echo signals on the drum plotter. An example of this is shown in Fig. 2.

On Level 14 there is also an option for getting the specter of echo strengths received from the sampled interval in a chosen number of transmission. In that case the computer observes the peak values in all echoes received. Every signal exceeding the noice treshold is then considered as an echo.

An option for processing of bottom back scattering data is also included. It has, however, not been much applied as yet.

LEVEL 13

Start: Interrupt from the real-time clock.

Operations: Data acquisition from gyro compass, ships log, meteorological instruments, digital depth recorder, echo integrators and STD system.

Products: Position (updated by dead reckoning), N-S and E-W components of the ships speed, wind speed and direction, date and time. Interrupts to Level 12, Level 5, Level 4 and Level 3 for Decca position, punching of STD data, routine output and listing of STD data respectively.

Description: The signals from the gyro compass are digitized in the interface (coding disc.). Decoding of the digitized input is done by software and correction for the ship's speed and latitide is done by

$$\theta = \arctan \left(\frac{v \cdot \sin C}{900 \cos \phi \sin C}\right)$$

where θ is the correction of the course in radians, C is the uncorrected course of the ship obtained from the gyro compass and v is the ship's speed and ϕ is the latitude.

From the course and speed of the ship N-S and E-W components of its velocity are worked out. These are used in the updating of the ship's position by dead reckoning and further when working out true wind speed and direction from the relative wind observed on the moving ship.

The interrupts from the real-time clock are also used for updating the time every second and the date when adequate.

The STD-data are received in the form of frequencies proportional to salinity, temperature and depth. These are fed into the computer wia frequency counters and the parameters are derived by linear interpolation within the frequency interval defined for each parameter. Instrument calibration constants are supplied to the computer by the operator and are applied in the program. Computations of σ_t (Density of the sea water), $\Delta\alpha$ (specific volume anomaly) and ΔD (dynamic depth anomaly) are done in real time and can be printed out according to program, normally every 5 second. An example of STD-listing with depth, temperature and σ_t is shown in Fig.6. The computation of σ_t is done as given by KNUDSEN (1901) and rearranged by SÆLEN 1958.

$$\sigma_t = D+(C+0,1324)(1-AT+BT(C-0,1324)$$

where

$$D = -\frac{(t-3,98)^2(t+283)}{503,57(t+67,26)}$$

$$C = 28.1263+0.806(S-35)+(S-35)^2\cdot 0.23\cdot 10^{-3}+(S-35)^3 0.68\cdot 10^{-5}$$

$$AT = (4.7867\cdot t-0.098185\ t^2+0.0010843\ t^3)\cdot 10^{-3}$$

$$BT = (18.03\ t-0.8164\ t^2+0.01667\ t^3)\cdot 10^{-6}$$

t is the temperature in $^{\circ}C$ and S is the salinity.

The computation of $\Delta\alpha$ is done as given by BJERKNES (1910) and SVERDRUP (1933).

$$10^5\Delta\alpha = (\alpha(s,t)-0.972643)\cdot 10^5\cdot(1-4.66\cdot 10^{-6}\cdot P)+\alpha(s,t)\cdot$$

$$P\cdot 10^{-4}(G(t,P)+\frac{C-28}{10}\cdot H(t,P)-1.85+P\cdot 4.0^{-5})$$

where

$$\alpha(s,t) = \frac{1}{1+\sigma_t\cdot 10^{-3}}$$

and

$$G(t,P) = 28.33\ t-0.551\ t^2+0.004\cdot t^3-10^{-4}P(9.5-0.158\ t)+$$

$$1.5\cdot 10^{-8}\cdot P^2$$

$$H(t,P) = 147.3-2.72\ t+0.04\ t^2-10^{-4}P(32.4-0.87\ t+0.02\ t^2)$$

C is the same as in the computation of σ_t, t is temperature, S is salinity and P is the pressure in d bar.
$10^4\ \Delta D$ is worked out by integration of $\Delta\alpha$.

$$10^4\ \Delta D = 10^5\int_{P=0}^{P=P_1}\Delta\alpha\ dp$$

Here P is simply exchanged by the depth in metres which introduces only a minor error.

LEVEL 12

Start: Interrupt from Level 13.

Operations: Data acquisition from DECCA navigator.

Products: DECCA position.

Description: The signals from the DECCA navigator are read every second and the position is computed in degrees and minutes of latitude and longitude. The applied geometry is explained more in detail by J.CASPERSEN in a note which is entered in Appendix 2 (in Norwegian). When initiating this program the operator has to feed the current DECCA coordinates into the computer together with identification number of the DECCA chain to be applied as explained more in detail in Appendix 3 . Fixed constants for the various chains must be kept in program.

LEVEL 11.

Start: Interrupt from teleprinter, paper tape reader or the ship's log.

Operations: Identification of interrupts.

Products: Interrupt to Level 10 on interrupt from the log and interrupt to Level 9 on interrupt from paper tape reader or teleprinters.

Description: When input shall come from any of the teleprinters or from the paper tape reader, an interrupt is wired in hardware to occur on this level. The ship's log also give an interrupt on this level for every tenth of a nautical mile outsailed distance.

The programming identifies the interrupts and gives interrupt to other levels accordingly. The activities which are governed by interrupts from the log are placed on Level 10, and Level 9 is activated if input from the other devices generates interrupt.

LEVEL 10

Start: Interrupt from Level 11.

Operations: Data acquisition of sea surface temperature, sea surface salinity and transparency of the sea water.

Products: Average of the ship's speed, temperature, salinity and transparency in the surface layer of the sea for each nautical mile outsailed distance. Echo abundance per nautical mile. Interrupt to Level 4 and Level 3 for output when adequate.

Description: Activities governed by interrupts from the ship's log are placed on Level 10. The log gives an interrupt every tenth of a nautical mile outsailed distance and initiates data collection routines for the parameters to be observed in the surface layer of the sea. Associated data reduction and averaging, for instance per nautical mile, is further done according to program. The program also give interrupt to Level 4 for routine output on paper tape and teleprinter, normally for every nautical mile outsailed distance.

Also the echo abundance value is accumulated over an adequate distance, normally 5 nautical miles, which can be set in program by the operator. Interrupt is given to Level 3 for output.

LEVEL 9

Start: Interrupt from teleprinter keyboard.

Operations: Initiation and termination of programs as adequate. Printout of current value of any parameter on request.

Description: The programming for the operation of the system occupies Level 9. This comprises initiation of the different data acquisition programs including incertion of initial values of some parameters which are used in associated processing. In some of the routines it is also allowed for correction of current values when necessary. This is for instance the case in the routine for the dead reckoning position.

More details about this operation system are entered in Appendix 3.

LEVEL 8

This Level is not used.

LEVEL 7

Start: Interrupt from teleprinters or paper tape punches.

Operations: Identifications of interrupts.

Products: Interrupts to the level on which the interrupting device was triggered.

Description: If output is performed when the interrupt system is on, the output devices are programmed to give interrupt to Level 7 when each output instruction is executed. The program on Level 7 identifies the interrupting device and gives interrupt to the level where the device is working.

LEVEL 6

This Level is not used.

LEVEL 5

Start: Interrupt from Level 14 or Level 13.

Operations: Output of acoustic data and STD-data.

Products: The programming on this level comprises routines for printout of echo classification data and echo strength data, and further for output of STD-data on paper tape. For the acoustic data only data lists are produced, and examples of these are shown in Figs. 3 and 4.

The output rate of the STD-data on paper tape is one set of parameters per second.

LEVEL 4

Start: Interrupt from Level 13 or Level 10.

Operations: Output on punch and teleprinter every nautical mile and every hour.

Products: Data record on paper tape and lists. Interrupt to Level 3 for output of echo abundance.

Description: This level holds the programs for output on teleprinter and punch every whole nautical mile outsailed distance and every whole hour, triggered by interrupt from the ship's log and the real-time clock respectively. An example of such routine listings are shown in Fig. 5.

The data are simultaneously punched on paper tape together with identification characters for each parameter.

LEVEL 3

Start: Interrupt from Level 13 of Level 3.

Operations: Output on teleprinter.

Products: Data lists for STD-data and echo abundance.

Description: This level holds output program for the echo abundance data obtained from the echo integrators. These data are produced only on data lists since the next step in their management has to be done manually.

The program is triggered by interrupts originally coming from the ship's log and the distance travelled between each printout may be set by program, normally a distance of 5 nautical miles is chosen.

The program for listing of STD-data is also placed on this level. It is governed by the real-time clock and the printout rate may be chosen by program.

The printout of the three derived parameters, σ_t, $\Delta\alpha$ and ΔD is optional. The maximal printout rate allowed by the capacity of the teleprinter is one set of parameters every fifth to seventh second depending on the parameters printed. An example of an STD-listing is shown in Fig.6.

LEVEL 2

This Level is not used.

LEVEL 1

Start: Interrupt from the operation system on Level 9.

Operations: Application of assembler when the system is running.

Description: The MAC-assembler, the assembly language of the computer, is placed on Level 1. This facilitates the application of the system by enabeling programs to be assembled and executed in time shearing with the rest of the system. Further the operating procedures become more flexible since it gives access to all debugging facilities in the assembler. It also offers posibility of leaving out of the system programs that only occasionally are used in real time. This is for instance done with the voluminous routines for the drum plotter.

LEVEL 0

Start: When priority allows.

Operations: Waiting mode or operations according to background program.

Products: According to background program, normally none.

Description: When no program on higher priority interrupt levels is busy, the control is given to Level 0. When the computer is working on Level 0 it is consequently in a waiting mode, but it may still be executing an application program. In this system Level 0 has been much utilized to hold programs for updating the numerical display which may be displaying any parameter as for instance the current position of the ship.

DISCUSSION

Introductorily the intentions with the system was outlined and it appears from this that the two main tasks for the system is firstly data acquisition and secondly storing of reduced and preliminary processed data on paper tape.

The data storage on paper tape has offered some problems. During the planning phase of the system paper tape was considered as a reliable data storage medium. The amount of data which is produced by the system described above is, however, somewhat too large for storage on paper tape. The resulting quantities of tape are very clumsy to handle and easily broken. This makes the further data management onboard rather time consuming and is to some degree a limiting factor.

It has also been difficult to keep the paper tape punches working satisfactorily over periods like a research cruise of about a month. The punches which originally belonged to the equipment were very problematic and had to be exchanged. The substitutes are far better, but even with these it occurs that erroneous characters are punched, particularly just after the start of the punch.

As to the data logging from the different instruments the system has worked quite satisfactorily. Particularly in connection with data collection from the STD-system, and also from the acoustic instruments, it has proved a valuable tool. The advantage here is that the computer presents digital data in real time (as far as the STD-system concerns also derivatives) where the instruments precent only an analog paper record. To digitize these data would otherwise be a cumbersome and lengthy job, and it would not be possible to obtain the accuracy of the computer.

In the present and previous use of the system it's flexibility has been sufficient. In particular has the possibility of using the assembler on Level 1 been useful as well in the use of external programs as in on-line control of the system.

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Table 1. Specifications of the computer and peripheral devices connected to it.

UNIT	SPECIFICATIONS
PAPER TAPE PUNCH (two units)	Type: FACIT 6040
PAPER TAPE READER	Type: Elliot TRM 250 Speed: 250 characters/S Rack mountered
KEYBOARD TERMINAL (tree units)	Type: Data Dynamics ASR - 33 teletypes Speed: 10 characters/S
DRUM PLOTTER	Type: Calcomp 563 Speed: 300 steps/S Resolution: 0,1 mm Plotting width 30 inches
MULTIPLEXER AND A/D CONVERTER	Type: Raytheon Miniverter Number of channels: 24 (extendable to 64) Number of bits: 12 Through-put rate: 35 kHz Input voltage: $\pm$ 10 Volts
A/D CONVERTER	Type: Raytheon Miniverter Number of bits: 10 Through-put rate: 50 kHz Input voltage: $\pm$ 10 Volts
NUMERIC DISPLAY	Type: LED display made at Central Institute for Industrial Research. 12 digits in four groups.
NUMERIC INPUT	Type: Thumbwheel switch input made at Central Institute for Industrial Research. 12 digits in four groups.
BOUY DATA RECORDER	Type: TANDBERG 1600x, modified by Chr. Michelsens institute. For input from magnetic data tapes produced in oceanographic bouy instruments.

Table 1 continued

UNIT	SPECIFICATIONS
COMPUTER, NORD-1	CORE STORE: 16 K (extendable up to 64 K) WORDSIZE: 16 bits CYCLE TIME: 1,7 μs CPU: Hardware floating point arithmetic, 7 programmable registers, control flip-flops and ful parallel operation. INTERRUPT SYSTEM: 16 priority interrupt levels with multiprogramming system. OPTIONS: Two direct memory access channels with a total transfer rate of 588 K words/s. Two I/O channels with capacity of up to 256 device numbers in four groups. Real time clock. Memory protect system.

Table 2. Sampling activities on log interrupt every tenth of a nautical mile. Real time processing on log interrupt.

Instrument	Parameter	Type of input	Data processing and reduction in real time.
Thermosa-linograph	SST	Analog	Mean sea surface temperature per n. mile.
	SSS	Analog	Mean sea surface salinity per n. mile.
Transpa-rencymeter	Trans-parency	Analog	Mean transparency per n. mile.
Echo-integrators	Echo-abundan-ce	Analog	Echo abundance integrated over latest n. mile.
Real-time clock	Mean speed		Mean speed through latest n. mile.

Table 3. Sampling activities and real-time processing every second on interrupt from the real-time clock.

Instrument	Parameters	Type of input	Pocessing and data reduction in real time.
Gyro	Course	Digital	N-S and E-W components from course and speed. Dead reckoning position.
Ships log	Speed	Analog	
Decca navigator	Red, green and purple lane	Analog	Decca position
STD-system	Salinity Temperature Depth	Digital " "	Values obtained from instrument frequencies and adjusted according to instrument calibrations, products computed (σ_t, $\Delta\alpha$ and ΔD).
Depth indicator	Echo depth	Digital	
Echo integrator (6 channels)	Echo abundance	Analog	Accumulation
Air-thermometer	Air temp.	Analog	Mean for last ten minutes
Psyckrometer	Dew point temperature	Analog	Mean for last ten minutes
Barometer	Air pressure	Analog	Mean for last ten minutes
Anemometer	Wind speed	Analog	Mean for last ten minutes
Wind wane	Wind direction	Analog	Mean for last ten minutes

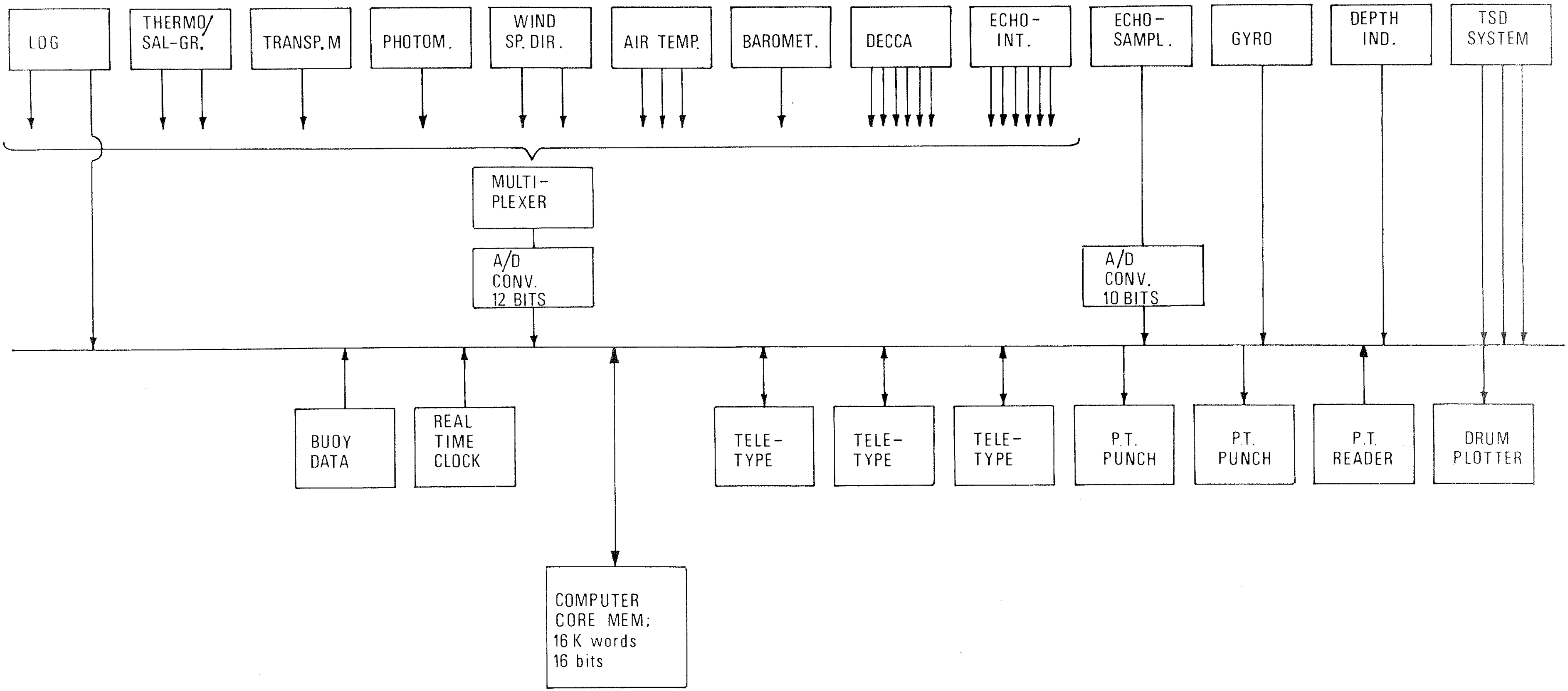

Fig. 1. Block diagram of the data logging system on R.V. "G.O.Sars".

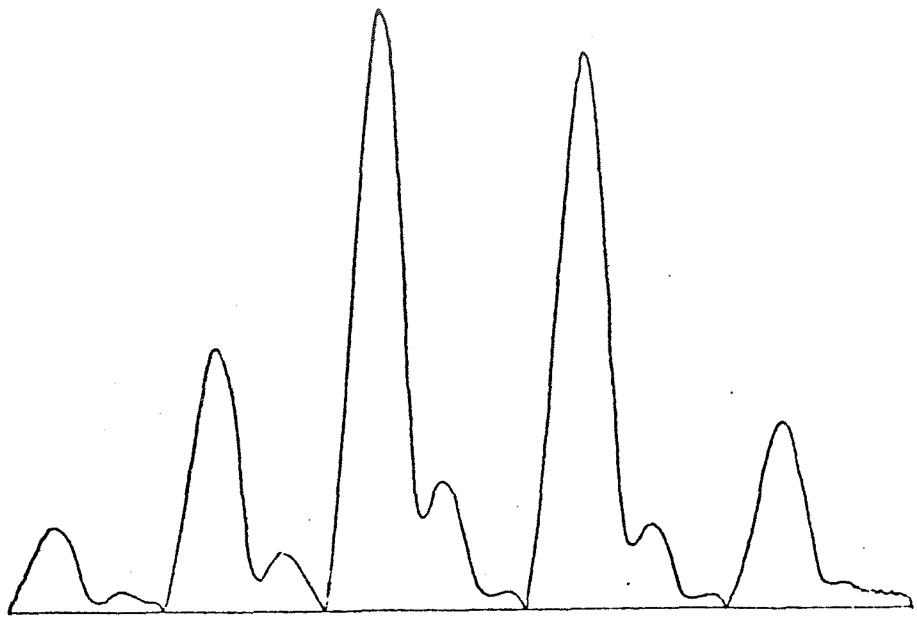

Fig. 2. Plot of the envelope of five echoes from a single fish as it passed through the acoustic beam. The echo sounder was sampled at a rate close to 50 kHz.

```
YES?
BG
GAIN -30
RATE 96
TOTAL 200
FRAME 6
INTEGR. 0
MAX DB -20

DATE 71 03 25
TIME     LAT          LONG      LOG      SPD     STMP    SSAL    THSF    LPI   CH
23 59   68  1.1     13 38.0    48.0     7.3     0.0     0.0     30.5     91   845

 TYP   DV   C   MAX   D1   DB
  69   22 *99  -30   97  -36-34-33-32-33-31-31-30-31-31-35-37
  67    3 642  -39   50  -39
  70    2 <01  -37   67  -37
  73    1 450  -39   36  -39
  71    3 C51  -33   85  -33-36
  71    2 519  -39   42  -39
  72    3 I47  -36   77  -36-37
  69    2 <94  -37   73  -37
  56    3 978  -38   57  -38
  66    4 189  -37   75  -38-37
  52    4 P41  -34   95  -34
  60    8 A72  -35   79  -35-35-37
  55    7 E77  -37   71  -38-37
  70    3 363  -39   32  -39
```

Fig. 3. Print out from the echo classification program.

```
YES?
BG
GAIN -82
RATE 48
TOTAL 200
FRAME 0
INTEGR. -1
MAX DB -20

DATE 71 05 07
TIME     LAT        LONG     LOG     SPD   STMP   SSAL   TRSP   DPT   CRS
22 38   61  5.6    -7 21.7   325.5   2.2   9.5    32.3   66.2   691   311
      1   -34
      2   -35
      4   -36
      6   -37
     14   -38
     57   -39
     60   -40
     65   -41
     85   -42
    105   -43
     92   -44
    112   -45
     96   -46
     97   -47
    123   -48
    116   -49
     90   -50
    102   -51
     23   -52
      6   -53
      2   -54
      3   -58
     18   -59
     58   -60
     46   -61
     31   -62
     24   -63
     13   -64
     61   -65
      8   -66
      3   -67
```

Fig. 4. Printout of the echo strength distribution.

```
YES?
BG
GAIN -82
RATE 48
TOTAL 200
FRAME 0
INTEGR. -1
MAX DB -20

DATE 71 05 07
TIME     LAT        LONG      LOG     SPD    STMP   SSAL   TRSP   DPT   CRS
22 38   61  5.6    -7 21.7   325.5    2.2    9.5    32.3   66.2   691   311
      1    -34
      2    -35
      4    -36
      6    -37
     14    -38
     57    -39
     60    -40
     65    -41
     85    -42
    105    -43
     92    -44
    112    -45
     96    -46
     97    -47
    123    -48
    116    -49
     90    -50
    102    -51
     23    -52
      6    -53
      2    -54
      3    -58
     18    -59
     58    -60
     46    -61
     31    -62
     24    -63
     13    -64
     61    -65
      8    -66
      3    -67
```

Fig. 4. Printout of the echo strength distribution.

```
DATE 73 05 04
TIME     LAT         LONG     LOG     SPD    STMP   SSAL   TRSP   DPT   CRS
17 27   59 22.0    3 35.6   747.0    3.7    2.8   13.8   20.3   242   358
17 33   59 23.1    3 35.5   748.0   10.2    7.1   34.4   40.9   241   356
17 39   59 24.1    3 35.4   749.0    9.8    7.1   34.5   41.6   242   358
17 46   59 25.2    3 35.2   750.0    8.8    7.1   34.5   41.1   243   356
17 51   59 26.2    3 35.1   751.0   10.7    7.0   34.4   40.8   244   359

TIME     LAT         LONG     LOG     PRES     AIRT   DEWP LUXM    WF    WDIR
18 00   59 26.3    3 35.2   751.01010.6    7.3    6.0    0.0    16     72

TIME     LAT         LONG     LOG     SPD    STMP   SSAL   TRSP   DPT   CRS
18 20   59 27.3    3 35.0   752.0    2.1    6.9   34.2   40.3   242   356
18 26   59 28.3    3 34.9   753.0    9.9    6.9   34.2   39.7   242   357
18 33   59 29.4    3 34.8   754.0    8.7    6.9   34.1   39.6   241   356

TIME     LAT         LONG     LOG     PRES     AIRT   DEWP LUXM    WF    WDIR
19 00   59 30.2    3 34.8   754.81010.3    7.7    5.0    0.0    13     84
```

Fig. 5. Routine printout on interrupt from the real-time clock and from the ship's log.

```
ST NO 431
OBSERVATIONS: 6
KORREKSJON FOR DYP:   0.0   TEMPERATUR:   0.00   SALTHOLDIGHET: -0.060

DATE 73 05 27
TIME     LAT        LONG     LOG     SPD    STMP   SSAL   TRSP   DPT   CRS
14 45   76 47.0   14 13.0   653.2   11.5   -0.7   34.1   31.8    79   235

DEPTH    TEMP.    SAL.   SIGMA-T   D-ALFA   DELTA-D
    4    -0.71    34.10   27.44    65.32  5160.90
    4    -0.71    34.11   27.44    64.79  5160.90
    4    -0.75    34.11   27.45    64.40  5160.90
    8    -0.73    34.09   27.43    66.03  5186.05
   13    -0.76    34.06   27.40    68.51  5223.85
   19    -0.82    34.10   27.43    65.39  5261.45
   23    -0.84    34.10   27.44    65.31  5286.48
   29    -0.84    34.10   27.44    65.03  5323.84
   36    -0.85    34.16   27.48    60.72  5372.19
   42    -0.80    34.24   27.55    54.06  5404.26
   48    -0.75    34.31   27.61    48.99  5433.77
   53    -0.16    34.45   27.69    41.31  5456.05
   61     1.51    34.76   27.84    27.15  5469.92
   65     2.07    34.91   27.91    20.61  5479.31
   69     2.64    35.02   27.95    16.73  5486.00

YES?
CD
```

Fig. 6. Listing of STD-data. Sigma-t, D-alfa and Delta-D are computed simultaneously with the lowering of the probe.

APPENDIX 1

PROGRAM LISTING

```
% COMMON AREA

% POINTERS TO SUB-ROUTINES

EXP,EXP1                  % EXPONENTIAL FUNCTION
SQR,ROT1                  % SQUARE ROOT
SIN,SIN1                  % SINE FUNCTION ( RADIANS)
COS,COS1                  % CO-SINE FUNCTION ( RADIANS)
TAN,TAN1                  % TANGENT FUNCTION (RADIANS)
ATAN,ATAN1                % ARCUS TANGENT (RADIANS)
ALOG,ALOG1                % NATURAL LOGARITHM FUNCTION

ASCI,ASCI1                % TWO DIGIT NUMBER OUTPUT
AV1,AV1F                  % DATA REDUCTION, AVERAGING
CLF,CLF1                  % CR/LF OUTPUT
DATE,DATE1                % DATE OUTPUT
DORTE,DORTE1              % FLOATING OUTPUT
FLIN,FLINT                % FLOATING INPUT
HTI,PRI                   % INTEGER INPUT
HTO,HELTA*                % INTEGER OUTPUT
INP2,DINP                 % TWO CHARACTERS INPUT
KONV,KONV1                % POSITION OUTPUT (DEGREES AND MINUTES)
MPX,MPX1                  % READING MULTIPLEXER
ORIGO,PLOTS               % CALCOMP PLOTTER, SETTING ORIGO
PLFLT,NUMBR               %  "   "     "  "   FLOATING OUTPUT
PLTXT,SYMBL               %  "   "     "  "   TEXT OUTPUT
PNPOS,WHERE               %  "   "     "  "   PEN POSITION
RIO,WRA                   % INPUT OUTPUT ROUTINE
SCALE,FACT                % CALCOMP PLOTTER, SCALING ROUTINE
TIME.TIME1                % TIME OUTPUT
TPAR,PARCH                % PARITY CHECK
TXT,TXT1                  % TEXT OUTPUT
TRACE,PLOT                % CALCOMP PLOTTER, LINE OUTPUT


% CONSTANTS

DS,#                      % TWO SPACES, ASCII CODE
QAD,<102.3                % FROM BITS TO VOLTAGE, FAST MULTIPLEXER CH.
MPF,<204.7                % FROM BITS TO VOLTAGE, SLOW MULTIPLEXER CH.
BLOGE,<0.434294483        % LOGARITHM (BASE 10) OF E
DTR,<0.0174532925         % DEGREES TO RADIANS
PI,<3.14159265            % PI
TPI,<6.2831853            % 2*PI
PI2,<1.57079633           % PI/2
EX1,<0.996659151          % EARTH EXCENTRICITY
EX2,<0.00672267           % (1-EX2)
```

```
ER,<6378388.              % EARTH RADIUS
ERL,<6378388.             % LOCAL EARTH RADIUS
RR,<0.002                 % TEMPORARY STORAGE, DECCA PROGRAM

% FLOATING POINT NUMBERS

FL0,<0                    % 0.
FL1,<1.                   % 1.
FL2,<2.                   % 2.
FL3,<3.                   % 3.
FL4,<4.                   % 4.
FL5,<5.                   % 5.
FL6,<6.                   % 6.
FL7,<90.                  % 90.
FL8,<180.                 % 180.
FL9,<360.                 % 360.
FL10,<10.                 % 10.
FL20,<20.                 % 20.
FLTUS,<1000.              % 1000.
MINOS,<-0.5               % -0.5

% INTEGERS

ND3,3                     % 3
HT2,0264                  % 180
HT5,012                   % 10
HT6,0144                  % 100

% INTERRUPT CONTROLS, INPUT-OUTPUT DEVICES

DV3,0                     % TELETYPE 1, OUTPUT
DV7,0                     % PAPER TAPE PUNCH 1
DV11,0                    % TELETYPE 3, OUTPUT
DV5,0                     % TELETYPE 2, OUTPUT
DV17,0                    % PAPER TAPE PUNCH 2
DV22,0                    % PAPER TAPE READER

K,0                       % BASE ADRESS, USUALLY HOLD IN B-REG.

SKD,<0                    % CORR. FACTOR, DEPTH S-T-D
SKT,<0                    % CORR. FACTOR, TEMPERATURE S-T-D
SKS,<0                    % CORR. FACTOR, SALINITY S-T-D

C131,0                    % TEMPORARY STORAGE, LEVEL 13
0                         %  "     "     "     "    "
0                         %  "     "     "     "    "
C101,<0                   %  "     "     "     "    "   10
C102,<0                   %  "     "     "     "    "   10
```

```
C103,<0          %  "  "  "  "  "  10
C91,<0           %  "  "  "  "  "   9
C41,0            %  "  "  "  "  "   4
0                %  "  "  "  "  "   4
0                %  "  "  "  "  "   4
C42,0            %  "  "  "  "  "   4
0                %  "  "  "  "  "   4
0                %  "  "  "  "  "   4

% CONSTANTS COMPUTED AND USED BY DECCA PROGRAM

GRF,<0
FA,<0
FB,<0
FC,<0
FD,<0
STG,<0
GA,<0
GB,<0
GC,<0

CH1,0
CH2,0
0
CH3,0
0

T1,0             % FLAG-WORD, INDICATING WHETHER DECCA IS RUNNING
T3,0
T4,0
T5,0             % FLAG-WORD. ONE BIT FOR EACH ROUTINE
S2,0
S3,0
S6,0

TETA,<0
R1,<0
R2,<0
K1,<0
K2,<0
K3,<0
K4,<0
K5,<0
K6,<0
```



```
% FLOATING OUTPUT. THIS ROUTINE PERFORMS OUTPUT OF FLOATING ACCUMULATOR.
% THE OUTPUT IS RIGHT HAND ORIENTATED. DEVICE NUMBER 3,5,7,11 OR 17 CAN
% BE USED. THE ROUTINE IS RE-ENTRANT. X-REGISTER WILL BE SAVED AND THE
% BASE-ADRESS (K) WILL BE LOADED INTO B-REGISTER BEFORE RETURN.

DORTE1,COPY SA DB
TRA  STS
SHA  4
SHA  ZIN SHR 014     % CURRENT INTERRUPT-LEVEL
MPY  TRE
SWAP SA DX           % INDEX FOR SAVING X-REG.
STA  I SAVEX ,X      % SAVE X-REG.
COPY SB DX
COPY AD1 SL DB       % POINTER TO NUMBER OF DIGITS BEFORE DECIMAL POINT
COPY AD1 SB DL       % POINTER TO NUMBER OF DIGITS AFTER DECIMAL POINT
BLDA 0170 DT         % SIGN TO K (ONE BIT ACCUMULATOR)
BSET ZRO 0170 DT     % ABS. VALUE OF FLOATING ACCUMULATOR
SAA  3
MPY  1 ,B            % NUMBER OF DIGITS AFTER DECIMAL POINT
ADD  SIFF -1
SWAP SA DX           % POINTER TO "SIFF"-TABLE
RINC DT
FAD  033 ,X          % ROUNDING OF LAST DIGIT TO BE PRINTED
RDCR DT
COPY SA DX
SAA  -3
MPY  ,B              % NUMBER OF DIGITS TO BE PRINTED BEFORE DEC. POINT
ADD  SIFF -2
BSKP ONE SSK         % NEG. SIGN ?
AAA  -3              % NO. ONE MORE DIGIT (SPACE) BEFORE DEC. POINT
SWAP CLD SA DB       % POINTER TO "SIFF"-TABLE

SPACE,AAB  S
LDA  SIFF -2
SKP  IF DA UEQ SB    % ONLY ONE DIGIT BEFORE DEC. POINT ?
JMP  * 012           % YES. THIS DIGIT CAN NEVER BE SPACE
COPY ST DA
SUB  ,B
JAF  * 6
COPY SX DA
SUB  1 ,B
JAF  * 3
COPY SD DA
SUB  2 ,B
JAN  BACK -011       % RIGHT HAND ORIENTATED. JUMP IF SPACE
RCLR DA
BSTA 00 DA
```

```
JAF  BACK -2          % NEG. SIGN TO BE PRINTED OUT
BSKP ZRO 0160 DT      % FLOATING ACCUMULATOR LESS THEN ONE ?
JMP  FORBI 1          % NO. COMPUTE DIGIT
JMP  BACK             % YES. PRINT OUT ZERO
SWAP SL DB
LDA  I -2 ,B          % DEVICE NUMBER
SWAP SL DB
BSET ZRO 030 DA
AAA  -7
JAZ  SPACE            % SKIP OUTPUT OF SPACE ON FAST PUNCH
SAA  0164             % ENTRY FOR MAKING ASCII-CODE FOR SPACE
AAA  -2               % ENTRY FOR MAKING ASCII-CODE FOR NEG. SIGN
AAA  -2               % ENTRY FOR MAKING ASCII-CODE FOR DEC. POINT

BACK,AAA  060         % ENTRY FOR MAKING ASCII-CODE FOR ZERO
SWAP SA DB
TRR  MPR              % USING MPR-REG. FOR TEMPORARY STORAGE OF B-REG
SWAP SB DL
LDA  I -2 ,B          % DEVICE-NUMBER
AAA  -017
JAZ  * 2
AAA  016
SWAP SA DL
RADD SL DP            % JUMP TO CORRECT OUTPUT-INSTRUCTION
IOT  ACT PIN 017      % OUTPUT ON FAST PUNCH II
JMP  * 010
IOT  ACT PIN 03       % OUTPUT ON TELETYPE I
JMP  * 6
IOT  ACT PIN 05       % OUTPUT ON TELETYPE II
JMP  * 4
IOT  ACT PIN 07       % OUTPUT ON FAST PUNCH I
JMP  * 2
IOT  ACT PIN 011      % OUTPUT ON TELETYPE III
WAIT                  % GIVE UP PRIORITY. WAIT FOR INTERRUPT FROM DEVICE
COPY SA DL
SWAP SL DB
TRA  MPR
SWAP SA DB
AAA  -055
JAZ  SPACE 020        % JUMP IF OUTPUT WAS NEG. SIGN
AAA  -1
JAZ  FORBI            % JUMP IF OUTPUT WAS DEC. POINT
AAA  -0162
JAZ  SPACE            % JUMP IF OUTPUT WAS SPACE
SAA  3
SWAP SX DL
MPY  ,X               % NUMBER OF DIGITS AFTER DEC. POINT
SWAP SX DL
```

```
ADD  SIFF -2
SKP  IF DA UEQ SB     % OUTPUT FINISHED ?
JMP  UT               % YES
LDA  SIFF -2
RSUB SB DA
JAZ  BACK -1          % TIME FOR DEC. POINT ?

FORBI,AAB  3          % START COMPUTING NEXT DIGIT
SWAP CLD SX DA
FSB  ,B
BSKP ONE 0170 DT
JPC  * -2             % COUNT THE SUBTRACTION LOOP
FAD  ,B
SWAP SA DX
BLDA 00 DA
BSKP BAC 010 DA
BSET BCM 070 DA
BLDA 020 DA
BSKP BAC 030 DA
BSET BCM 070 DA       % CORRECT SETTING OF PARITY BIT
JMP  BACK

TRE,3
SAVEX,BLOK1           % ADRESS TO STORAGE BLOCK. 3 LOC. FOR EACH INT. LEV.

UT,TRA  STS
SHA  4
SHA  ZIN SHR 014      % CURRENT INTERUPT-LEVEL
MPY  TRE
COPY SA DX
LDA  I SAVEX ,X       % UNSAVE THE X -REG.
COPY SA DX
LDA  BASE1
SWAP CLD SA DB        % BASE-ADRESS TO B-REG.
COPY AD1 SL DP        % EXIT

EN
SIFF
SIFF,<1000000000.
<100000000.
<10000000.
<1000000.
<100000.
<10000.
<1000.
<100.
<10.
EN,<1.
```

```
<0.1
<0.01
<0.001
<0.0001
<0.00001
<0.000001
<0.0000001
<0.00000001
<0.000000001
<0.0000000001
BASE1,K              % BASE-ADRESS, COMMON AREA

)KILL DORTE1 SPACE BACK FORBI UT TRE SAVEX SIFF

% FLOATING INPUT. THIS ROUTINE PERFORMS INPUT OF DECIMAL NUMBERS INTO
% FLOATING ACCUMULATOR FROM DEVICE NUMBER 2,4,10 OR 22. THE ROUTINE IS
% RE-ENTRANT. X-REGISTER WILL BE SAVED AND THE BASE-ADRESS (K) WILL BE
% LOADED INTO B-REGISTER BEFORE RETURN.


FLINT,TRA  STS
SHA  4
SHA  ZIN SHR 014     % CURRENT INTERRUPT-LEVEL
MPY  NB3-K ,B
SWAP SA DX           % INDEX FOR TEMPORARY STORAGE
TRR  MPR             % USING MPR-REG. FOR TEMPORARY STORAGE OF A-REG.
LDF  FLO-K ,B
STF  I RES1 ,X
STF  I RES2 ,X
COPY AD1 SL DB       % RETURN ADRESS
RCLR DL
JMP  RUT

CIFER,BSET ONE 0160 DB
NLZ  020             % DIGIT JUST READ
FAD  I RES2,X        % ADD EARLIER READINGS
FMU  EN-3            % GIVE PLACE FOR NEXT DIGIT
STF  I RES2,X
BSKP ZRO 0170 DX     % AFTER DECIMAL POINT ?
RDCR DL              % YES. COUNT DECIMALS

RUT,COPY SL DT
JPL  I WRI           % READ ONE CHARACTER
COPY ST DL
AAA  -072
JAF  DELMT           % JUMP IF LAST CHARACTER WAS DELIMETER
AAA  012
JAF  CIFER           % JUMP IF LAST CHARACTER WAS A DIGIT
AAA  2
JAF  * 3             % DECIMAL POINT ?
AAX  -060            % YES. X-REG. WILL BECOME NEGATIV
JMP  RUT
AAA  1
JAF  * 2             % NEGATIV SIGN ?
BSET ONE 0170 DB     % YES. SET TEST-BIT

DELMT,BSKP ONE 0160 DB  % DECIMAL NUMBER HAS BEEN READ ?
JMP  RUT             % NO. IGNORE DELIMETER
BSKP ZRO 0170 DX
AAX  060             % RESET INDEX
LDF  EN
FMU  EN 3            % MULTIPLY WITH 0.1 FOR EACH DIGIT AFTER DEC. POINT
RINC DL
SKP  IF DL GRE 0
JMP  * -3
FMU  I RES1 ,X       % SECOND PART OF DECIMAL NUMBER. AFTER DEC. POINT
FAD  I RES2 ,X       % FIRST PART OF DECIMAL NUMBER. BEFORE DEC. POINT
FMU  EN 3
BLDA 0170 DB
BSTA 0170 DT         % SIGN
COPY SA DL
TRA  MPR
COPY SA DX           % UNSAVE X-REG.
SWAP SL DB
LDA  BASE1
SWAP SA DB           % BASE-ADRESS TO B-REG.
BSET ZRO 0170 DL     % RESET TEST-BIT
BSET ZRO 0160 DL     % RESET TEST-BIT
EXIT


% INTEGER INPUT. THIS ROUTINE HANDLES INPUT OF INTEGER NUMBERS INTO
% A-REGISTER FROM DEVICE-NUMBER 2,4,10 OR 22. THE ROUTINE IS RE-ENTRANT.
% X-REG. WILL BE SAVED AND THE BASE-ADRESS WILL BE LOADED INTO B REG.
% BEFORE RETURN.


PRI, COPY AD1 SL DB % RETURN ADRESS
RCLR DT
BSET ONE 0170 DT     % NUMBER HAS NOT BEEN READ
JPL  I WRI           % READ ONE CHARACTER
AAA  -072
JAF  UTP             % JUMP IF DELIMETER
AAA  012
```

```
JAN  NEGP              % JUMP IF DELIMETER OR NEG. SIGN
BSET ZRO 0170 DT       % NUMBER HAS BEEN READ
SWAP SA DT
MPY  SIFF 3            % MULTIPLY EARLIER READINGS WITH TEN
RADD SA DT             % ADD TO LAST DIGIT
JMP  PRI 3

NEGP,AAA 3
JAF  UTP               % NEG. SIGN ?
BSET ONE 0170 DB       % YES. SET TEST-BIT

UTP, BSKP ZRO 0170 DT  % NUMBER HAS BEEN READ ?
JMP  PRI 3             % NO. IGNORE DELIMETER
COPY ST DL
BSKP ZRO 0170 DB       % NEG. SIGN ?
COPY CM2 SL DL         % YES. MAKE TWO'S COMPLEMENT
JMP  PRI-6             % BASE-ADRESS TO B-REG. RESET TEST-BIT AND EXIT


% INTEGER_OUTPUT. THIS ROUTINE GIVES A RIGHT HAND ORIENTATED DECIMAL
% OUTPUT OF AN INTEGER NUMBER IN A-REGISTER TO DEVICE NUMBER 3,5,7,11 OR
% 17. THE ROUTINE IS RE-ENTRANT. X-REG. WILL BE SAVED AND THE BASE-
% ADRESS WILL BE LOADED INTO B-REG. BEFORE RETURN.


HELTA,BLDA 0170 DA     % SIGN-BIT TO K (ONE BIT ACCUMULATOR)
BSKP ZRO 0170 DA
COPY CM2 SA DA         % ABS. VALUE OF A-REG.
BSTA 0170 DL
COPY AD1 SL DB         % POINTER TO NUMBER OF DIGITS IN OUTPUT
COPY SX DT
LDX  ,B                % NUMBER OF DIGITS IN OUTPUT
COPY CM2 SX DX         % INDEX FOR ADRESSING THE "SIFF"-TABLE
TRR  MPR               % MPR-REG. USED FOR TEMPORARY STORAGE OF A-REG

LUP1,TRA MPR
SUB  I SIFF-2,X
BLDC 0170 DA           % SSK=1 WHEN TIME FOR PRINTING SIGN
BSET BAC 0160 DB
BAND 0170 DB           % SSK=1 WHEN TIME FOR PRINTING NEG. SIGN
LDA  I -1,B            % DEVICE NUMBER
BSET ZRO 030 DA
AAA  -7
BSKP ONE SSK           % TIME FOR PRINTING NEG. SIGN ?
JAZ  * 5               % NO. SKIP OUTPUT OF SPACE ON FAST PUNCH
SAA  040               % ASCII-CODE FOR SPACE
BSKP ZRO SSK
AAA  015               % CHANGE TO ASCII-CODE FOR NEG. SIGN
JPL I WRI              % PRINT OUT SPACE OR NEG. SIGN
BSKP ONE 0160 DB       % TIME FOR PRINTING DIGIT ?
JNC  LUP1              % NO

LUP2,COPY CM1 DD
TRA  MPR
JPC  * 7               % LAST DIGIT TO BE PRINTED OUT ?
SUB  I SIFF-1,X        % NO
RINC DD                % COUNT THE SUBTRACTION LOOP
JAP  * -2
ADD  I SIFF-1,X
TRR  MPR               % MPR-REG. USED AS TEMPORARY STORAGE OF A-REG.
COPY SD DA
AAA  060               % MAKING ASCII-CODE
JPL  I WRI             % PRINT OUT ONE DIGIT
JXN  LUP2              % JUMP IF NOT LAST DIGIT
COPY ST DX
COPY AD1 SB DL         % RETURN ADRESS
JMP  PRI-5             % EXIT
RES1,BLOK1             % ADRESS TO STORAGE BLOCK. 3 LOC. FOR EACH INT. LEV.
RES2,BLOK2             %    "     "     "     "     "  "    "    "    "    "
SIFF 5
SIFF 4
SIFF,023420            % "SIFF"-TABLE FOR HELTA
001750
000144
000012
000000


)KILL EN FLINT RUT CIFER DELMT PRI NEGP UTP HELTA LUP1 LUP2 SIFF
)KILL WRI RES1 RES2 BASE1

% DATE OUTPUT. THIS ROUTINE GIVES OUTPUT OF DATE ON DEVICE NUMBER 3,5,7,
% 11 OR 17. THE ROUTINE IS RE-ENTRANT. X-REG. WILL BE SAVED AND THE
% BASE-ADRESS WILL BE LOADED INTO B-REG. BEFORE RETURN.


DATE1,COPY SX DA
TRR  MPR               % MPR-REG. USED FOR SAVING X-REG.
LDA  I DATO1           % DATE
SWAP CLD SA DD
SAD  6                 % A-REG. BIT 0-5  YEAR
SHD  ROT 4
```

```
BSET ZRO SSM
SHD  LIN 012
COPY SD DT            % T-REG. BIT 012-017  MONTH, BIT 4-011  DAY
AAA  0100
SAX  -3               % OUTPUT LOOP TO BE EXECUTED THREE TIMES
JMP  BACKT-1


% TIME OUTPUT. THIS ROUTINE GIVES OUTPUT OF TIME ON DEVICE NUMBER 3,5,7,
% 11 OR 17. THE ROUTINE IS RE-ENTRANT. X-REG. WILL BE SAVED AND THE
% BASE-ADRESS WILL BE LOADED INTO B-REG. BEFORE RETURN.


TIME1,COPY SX DA
TRR  MPR              % MPR-REG. USED FOR SAVING X-REG.
LDD  I DATO1          % DATE TO A-REG. TIME TO D-REG.
BLDA  00 DA
RCLR DA
SAD  4                % A-REG. BIT 0-5  HOURS
COPY SD DT            % T-REG. BIT 012-017  MINUTES, BIT 04-011 SECONDS
BSKP ZRO SSK          % P.M. OR A.M. ?
AAA  014              % A.M. ADD TWELVE TO HOURS
SAX  -2               % OUTPUT OF HOURS AND MINUTES ONLY

COPY AD1 SL DB        % RETURN ADRESS

BACKT,JPL ASCI2       % MAKING ASCII-CODE OF A-REG. ONLY TWO DIGITS
JPL WRA 7             % PRINT OUT A-REG. TWO DIGITS.
SAA  040
JPL  WRA 7            % PRINT OUT SPACE
SHT  ROT 6
SAA  077
RAND ST DA            % NEXT INFORMATION IN A-REG.
JNC  BACKT            % JMP IF OUTPUT OF DATE OR TIME IS NOT FINISHED

TRA  MPR
COPY SA DX            % UNSAVE X-REG.
JMP  WRA 2            % EXIT


% TEXT OUTPUT. THIS ROUTINE PRINTS OUT TEXT FROM MEMORY ON DEVICE NUMBER
% 3,5,7,11 OR 17. WHEN ENTERING THE ROUTINE T-REG. MUST CONTAIN THE
% ADRESS TO THE TWO FIRST CHARACTERS TO BE PRINTED. PRINTING WILL
% CONTINUE UNTIL A " ' " IS FOUND IN BIT 0-7 IN A-REG. (LAY-OUT BY
% ASSEMBLER ) THE ROUTINE IS RE-ENTRANT. X-REG. WILL BE SAVED AND THE
% BASE-ADRESS WILL BE LOADED INTO B-REG. BEFORE RETURN


TXT1,COPY AD1 SL DB % RETURN ADRESS
SWAP ST DB
LDA  ,B               % TWO CHARACTERS INTO A-REG.
SWAP ST DB
COPY SA DD
SAA  0177
RAND SD DA            % ONE CHARACTER TO A-REG.
JAZ WRA 2             % A-REG. EMPTY. EXIT
AAA  -047
JAZ  * 5              % TEST FOR END OF TEXT.
COPY SD DA
JPL  WRA 7            % PRINT OUT CHARACTERS IN A-REG.
RINC DT               % ADRESS TO NEXT TWO CHARACTERS
JMP  * -014
COPY SD DA
SHA  ZIN SHR 010      % LAST CHARACTER
JAZ  WRA 2            % A-REG. EMPTY. EXIT
JMP  WRA 1            % PRINT LAST CHARACTER


% NUMBER OUTPUT. ROUTINE FOR MAKING ASCII-CODE AND PRINT OUT A NUMBER
% IN A-REG. (LESS THEN 100) ON DEVICE NUMBER 3,5,7,11 OR 17.
% THERE WILL ALWAYS BE TO DIGIT IN OUTPUT (EKS: 1 OUTPUT: 01 ). THE
% ROUTINE IS RE-ENTRANT. ONLY A- AND D-REG. WILL BE LOST.


ASCI1,COPY AD1 SL DB % RETURN ADRESS
JPL  ASCI2            % MAKING ASCII-CODE OF THE NUMBER IN A-REG.
JMP  WRA 1            % PRINT OUT A-REG.


% ASCII-CODE. THIS ROUTINE CHANGE THE A-REG. FROM A NUMBER TO
%  ASCII-CODE FOR THE SAME NUMBER. THE NUMBER MUST BE LESS THEN 100 AND
% POSITIV. THE ROUTINE IS RE-ENTRANT. ONLY A- AND D-REG. WILL BE CHANGED


ASCI2,COPY CM1 DD
AAA  -012
RINC DD               % COUNTING LOOP FOR THE TENS
JAP  * -2
```

```
AAA  072            % MAKING ASCII-CODE OF THE ONES
SHA  010
AAA  060            % MAKING ASCII-CODE OF THE TENS
RADD SD DA          % ADD TENS
SHA  ROT 010        % PUT THE TENS BEFORE THE ONES
EXIT


% CR/LF OUTPUT. THIS ROUTINE PRINT OUT CARRIAGE RETURN, LINE FEED ON
% DEVICE NUMBER 3,5,7,11 OR 17. ONLY A- AND D-REG. WILL BE LOST.


CLF1,LDA  CL        % LOAD CR/LF INTO A-REG. CONTINUE WITH NEXT ROUTINE


% SINGLE INPUT-OUTPUT. THIS ROUTINE READ ONE CHARACTER INTO A-REG. OR
% PRINT OUT A-REG. (ONE OR TWO CHARACTERS ). A- AND D-REG. WILL BE LOST


WRA,COPY AD1 SL DB  % RETURN ADRESS
JPL  WRA 7          % INPUT-OUTPUT OF A-REG.
COPY SB DL
COPY SA DB
LDA  BASE
SWAP SA DB          % BASE-ADRESS TO B-REG.
EXIT


% INPUT-OUTPUT. THIS IS THE BASIC INPUT-OUTPUT ROUTINE AND ALL INPUT-
% OUTPUT, ECCEPT FLOATING OUTPUT, GOES THROUGH THIS ROUTINE. DEPENDING
% ON DEVICE NUMBER THIS ROUTINE HANDLES INPUT OF ONE CHARACTER TO A-
% REG. FROM DEVICE NUMBER 2,4,10 OR 22, OR GIVES OUTPUT FROM A-REG.,
% ONE OR TWO CHARACTERS, TO DEVICE NUMBER 3,5,7,11 OR 17. THE ROUTINE
% IS RE-ENTRANT AND ONLY A- AND D-REG. AND THE ONE BIT ACCUMULATOR
% WILL BE LOST


INOUT,COPY SA DD
JAZ  * 015
SHD  ROT 010        % PLACE THE FIRST CHARACTER IN POSITION FOR OUTPUT
SAA  177
BSET ONE 070 DA
```

```
RAND SD DA
JAZ  *-4            % JUMP IF NO CHARACTER IN THIS POSITION
BSET ONE 070 DA     % TEST-BIT FOR END OF PARITY-LOOP
BSET ZRO SSK
SHA  1
BSKP ZRO 070 DA
BSET BCM SSK        % COMPLEMENT SSK FOR EACH ONE-BIT
JAP  *-3            % JUMP IF PARITY-LOOP NOT FINISHED
BSET BAC 070 DD     % SET CORRECT PARITY-BIT

ENTRI,SAA  2        % CAN BE USED AS ENTRY POINT FOR INPUT ROUTINES
MPY  I -1 ,B        % MULTIPLY WITH DEVICE-NUMBER
AAA  -4
BLDA 050 DA
BSKP BCM 010 DA     % IS DEVICE NUMBER 2,4 OR 10 ?
WAIT                % YES. WAIT FOR INTERUPT
SWAP SA DD
RADD SD DP          % JUMP TO CORRECT INPUT-OUTPUT INSTRUCTION
IOT  ACT PIN 02     % INPUT FROM TELETYPE I
JMP  PARCH
IOT  ACT PIN 03     % OUTPUT TO TELETYPE I
JMP  TEST
IOT  ACT PIN 04     % INPUT FROM TELETYPE II
JMP  PARCH
IOT  ACT PIN 05     % OUTPUT TO TELETYPE II
JMP  TEST
CL,06412            % ASCII-CODE FOR CARRIAGE RETURN, LINE FEED
BASE,K              % BASE-ADRESS, COMMON AREA
IOT  ACT PIN 07     % OUTPUT TO FAST-PUNCH I
JMP  TEST
IOT  ACT PIN 010    % INPUT FROM TELETYPE III
JMP  PARCH
IOT  ACT PIN 011    % OUTPUT TO TELETYPE III
JMP  TEST
DATO1,DATO          % DATE


% DOUBLE INPUT. THIS ROUTINE HANDLES INPUT OF TWO CHARACTERS IN A-REG.
% FROM DEVICE NUMBER 2,4,10 OR 22. THE ROUTINE IS RE-ENTRANT. X- AND
%  T-REG. WILL BE SAVED AND THE BASE-ADRESS WILL BE LOADED INTO B-REG.
% BEFORE RETURN


DINP,COPY AD1 SL DB % RETURN ADRESS
JPL  WRA 7          % READ FIRST CHARACTER
```

```
SHA  010
JPL  WRA 7           % READ NEXT CHARACTER
COPY SA DD
TRA  MPR
RADD SD DA           % BOTH CHARACTERS IN A-REG.
JMP  WRA 2           % EXIT



% INPUT-OUTPUT CONTINUE


IOT  ACT PIN 017     % OUTPUT TO FAST-PUNCH II
TEST, WAIT           % WAIT FOR INTERUPT
SHA  ZIN SHR 010
JAF  WRA 7           % JUMP IF ONE MORE CHARACTER TO BE PRINTED
EXIT
D3, DV3              % TEST-WORD FOR TELETYPE I
IOT  ACT PIN 022     % INPUT FROM PAPER TAPE READER
WAIT                 % WAIT FOR INTERUPT.


% PARITY CHECK.  THIS ROUTINE TEST FOR CORRECT PARITY AND REMOVE PARITY-
% BIT .  IF CORRECT PARITY ONLY THE ONE BIT ACCUMULATOR IS DISTURBED,
% ALWAYS ZERO WHEN LEAVING THE ROUTINE.  IF NOT CORRECT PARITY A-REG.
% AND D-REG. WILL BE LOST AND THE MESSAGE "IC" WILL BE PRINTED OUT ON
% TELETYPE I.  THE ROUTINE IS RE-ENTRANT


PARCH, BLDA 070 DA   % TAKE CARE OF PARITY-BIT
BSET ONE 070 DA      % FOR END OF TESTING LOOP
SHA  1
BSKP ZRO 070 DA
BSET BCM SSK         % COMPLEMENT SSK FOR EACH ONE-BIT
JAP  * -3            % JUMP IF NOT END OF TESTING LOOP
SHA  ZIN SHR 010     % REPLACE THE CHARACTER
BSET ZRO 070 DA      % REMOVE PARITY-BIT
BSKP ONE SSK         % EVEN PARITY ?
EXIT                 % YES
TRA  STS
SHA  4
SHA  ZIN SHR 014     % CURRENT INTERUPT LEVEL
RCLR DD
BSET ONE SSM
```

```
RDCR DA
SHD  LIN 1
JAP *-2
COPY SA DD           % A ONE-BIT IN POSITION FOR CURRENT INT. LEVEL
ORA  I D3
STA  I D3            % SET BIT IN TESTWORD FOR TELETYPE I
SAA  -067            % ASCII-CODE FOR "I"
IOT  ACT PIN 03      % PRINT OUT "I"
WAIT
AAA  -6              % MAKING ASCII-CODE FOR "C"
IOT  ACT PIN 03      % PRINT OUT "C"
WAIT
COPY CM1 SD DA
AND  I D3
STA  I D3            % RESET BIT IN TESTWORD FOR TELETYPE I
JMP ENTRI

)KILL DATE1 TIME1 BACKT TXT1 ASCI1 ASCI2 CLF1 WRA INOUT ENTRI CL BASE
)KILL DATO1 DINP TEST D3 PARCH

% TEMPORARY STORAGE FOR FLOATING POINT NUMBERS
% TWO FOR EACH INTERRUPT LEVEL


BLOK1, <0
<0
<0
<0
<0
<0
<0
<0
<0
<0
<0
<0
<0
<0
<0
BLOK2, <0
<0
<0
<0
<0
<0
<0
<0
```

```
<O
<O
<O
<O
<O
<O
<O
<O
```

% ROUTINE FOR POSITION OUTPUT (DEGREES AND MINUTES)

```
124375              % JMP *-3
KONV1,LDF ,X
BLDA 0170 DT
BSET ZRO 0170 DT
DNZ -020
SWAP SL DB
LDT 2,B
BSKP ZRO 0170 DT
JMP * 6
LDT KONV1-1
STT 2,B
SWAP SL DB
LDT HTO-K,B
COPY AD1 ST DP
SAT 1
STT 2,B
SWAP SL DB
NLZ 020
BSTA 0170 DT
FSB ,X
FMU FL6-K,B
FMU FL10-K,B
BSET ZRO 0170 DT
JMP I DORTE-K,B
```

% ROUTINE FOR READING MULTIPLEXER

```
MPX1,LDA 4,X
SHA ZIN SHR 010
COPY SA DD
IOT ACT SKA 050
JMP *-1
COPY SD DA
IOT ACT SKA 050
JMP *-1
SHA 4
SHA SHR 4
NLZ 020
FDV MPF-K,B
FMU 013,X
FAD 016,X
STF 5,X
FAD 010,X
STF 010,X
EXIT
```

% ROUTINE FOR DATA REDUCTION, AVERAGING

```
AV1F,LDA 4,X
SHA 010
SHA ZIN SHR 010
NLZ 020
STF 1,X
LDF 010,X
FDV 1,X
STF 1,X
LDF FL0-K,B
STF 010,X
EXIT
```

% EXPONENTIAL FUNCTION

```
EXP1,SWAP SA DX
BLDA 0170 DT
BSET ZRO 0170 DT
TRR MPR
TRA STS
SHA 4
SHA ZIN SHR 014
MPY NB3-K,B
ADD A1 020
COPY SA DB
COPY SX DA
FDV A1
STF ,B
LDX A1 021
RSUB ST DX
RCLR DD
JPC * 3
SAD ROT 1
JNC *-1
COPY SD DA
```

```
CUPY SA DX
NLZ 020
BSET BCM 0170 DT
FAD ,B
FMU A1
STF ,B
FMU ,B
FAD A1 3
STF 060,B
LDF A1 6
FDV 060,B
FAD A1 011
FMU ,B
FMU ,B
FAD A1 014
FSB ,B
STF 060,B
FAD ,B
FAD ,B
FDV 060,B
RADD SX DT
LDX A1 017
SWAP SX DB
BSKP ONE SSK
JMP * 4
STF ,X
LDF FL1-K,B
FDV ,X
COPY SA DX
TRA MPR
SWAP SA DX
EXIT
A1,<0.69314718
<42.
<4.9
<0.05
<2.
KK1,K
ARG1,BLOK1
37777
)KILL EXP1 A1
```

% NATURAL LOGARITHM FUNCTION

```
ALOG1,JAZ  UTAL
SWAP SX DA
TRR  MPR
TRA  STS
SHA  4
SHA  ZIN SHR 014
MPY  NB3-K ,B
ADD ARG1
COPY SA DB
SWAP CLD SX DA

BSET ZRO 0170 DT
LDX  LN2
RADD CM2 SX DT
SWAP SX DT
STF  ,B
FAD  AK1
STF  060 ,B
LDF  ,B
FSB  AK1
FDV  060 ,B
STF  ,B
FMU  ,B
FAD  D
STF  060 ,B
LDF  C
FDV  060 ,B
FAD  B
FMU  ,B
FMU  ,B
FAD  AA
FMU  ,B
FAD  AK2
STF  060 ,B
TRA  MPR
SWAP SA DX
NLZ  020
FMU  LN2
FAD  060 ,B
SWAP SA DB
LDA  KK1
SWAP SA DB
EXIT

UTAL,LDF  NEG
JMP  * -2
```

```
LN2, 040000
130562
013767

AK1, 040000
132404
171465

AK2, 137777
130562
013767

AA, 040001
177777
177775

B, 037775
157544
140333

C, 140000
143376
006345

D, 140001
131160
135007

NEG, 143000
177777
177777

)KILL AK1 AK2 AA B C D NEG KK1 ARG1


% SINE FUNCTION (RADIANS)

SIN1, RCLR DB
BLDA 0170 DT
JMP  * 3

% CO-SINE FUNCTION (RADIANS)

COS1, RCLR AD1 DB
BSET ZRO SSK
BSET ZRO 0170 DT
FSB  PIT
RINC DB
SKP  IF DT LST 0
JMP  * -3
BSKP ZRO 010 DB
BSET BCM SSK
BSKP ZRO 00 DB
FAD  PIT

COPY SA DB
COPY SX DA
TRR  MPR
TRA  STS
SHA  4
SHA  ZIN SHR 014
MPY  TALL3
ADD  ARG
SWAP SA DB
STF  060 ,B
FMU  060 ,B
STF  ,B
SAX  -025
LDF  I KONST ,X
FMU  ,B
AAX  3
FAD  I KONST ,X
JXN  * -3
FMU  060 ,B

BSKP ZRO SSK
BSET BCM 0170 DT
COPY SA DX
LDA  KK
COPY SA DB
TRA  MPR
SWAP SA DX
EXIT

TALL3, 3
KONST, KADR
PIT, 40001, 144417, 155242
137730, 153477, 117470
037740, 130222, 030234
137747, 153462, 025477
037756, 134360, 016460
137764, 150015, 000317
037772, 104210, 104211
137776, 125252, 125253
KADR, 040001, 100000, 000000
```

```
ARG, BLOK1

% TANGENT FUNCTION (RADIANS)

TAN1, COPY SL DX
BLDC 0170 DT
BSET ZRO 0170 DT
FSB  PIT
BSET BCM SSK
BSKP ONE 0170 DT
JMP  * -3
FAD  PIT
BSTA 0170 DX
JPL  SIN1
COPY SX DL
BLDA 0170 DL
BSET ZRO 0170 DL
COPY SA DX
TRA  STS
SHA  4
SHA  ZIN SHR 014
MPY  NB3-K ,B
ADD  ARG
SWAP SA DX
STF  ,X
FMU  ,X
STF  ,X
BSET ONE 0170 DT
JAZ  UTAN
STF  060 ,X
LDF  ,X
FDV  060 ,X
COPY SL DX
JPL  ROT1
COPY SX DL
JMP  * 2

UTAN, LDF  BIG
BSTA 0170 DT
EXIT

BIG, 077777
177777
177777

% ARCUS TANGENT (RADIANS)

ATAN1, SWAP SA DX
TRR  MPR
TRA  STS
SHA  4
SHA  ZIN SHR 014
MPY  NB3-K ,B
ADD  ARG
SWAP SA DX

BLDA 0170 DT
BSET ZRO 0170 DT
FSB  FL1-K ,B
SKP  IF DT LST 0
JMP  * 4
FAD  FL1-K ,B
JMP  * 6
FAD  FL2-K ,B
STF  ,X
FSB  FL2-K ,B
FDV  ,X
BSET ONE 0170 DL
STF  060 ,X
FMU  060 ,X
STF  ,X
COPY SX DB
SAX  -017
LDF  I KOEFF ,X
FMU  ,B
AAX  3
FAD  I KOEFF ,X
JXN  * -3
FMU  060 ,B
BSKP ZRO 0170 DL
FAD  PI4
BSET ZRO 0170 DL
BSKP ZRO SSK
BSET BCM 0170 DT
COPY SA DX
LDA  KK
COPY SA DB
TRA  MPR
SWAP SA DX
EXIT

KOEFF, KOADR
KK, K
PI4, <0. 78539816
<-0. 01172120
< 0. 05265332
```

```
<-0. 11643287
< 0. 19354346
<-0. 33262347
KOADR,< 0. 99997726
```

```
% SQUARE ROOT

ROT1,JAZ UTRO
SWAP SA DX
TRR  MPR
TRA  STS
SHA  4
SHA  ZIN SHR 014
MPY  NB3-K ,B
ADD  ARG
COPY SA DB
SWAP CLD SX DA

BSET ZRO 0170 DT
BSET ONE 0160 DX
BSKP ZRO 00 DT
RINC DX
SHT  SHR 1
SWAP ST DX
STF  060 ,B
RDCR DT
FAD  KOFF
STF  ,B
LDF  060 ,B
FDV  ,B
FAD  ,B
RDCR DT
STF  ,B
LDF  060 ,B
FDV  ,B
FAD  ,B
RDCR DT
STF  ,B
LDF  060 ,B
FDV  ,B
FAD  ,B
RDCR DT
RADD SX DT
```

```
LDX  KK
SWAP CLD SX DB
BSET ONE 0150 DX
RSUB SX DT
COPY SA DX
TRA  MPR
SWAP SA DX
UTRO,EXIT

KOFF,<0. 4648

)KILL..KK KOFF KOEFF KOADR PI4

)PCL K6
```

```
% INITIALIZATION OF INTERRUPT SYSTEM

INIT,IOF
SAA -1
MCL PID
MCL PIE
ION GRP1 GRP2
WAIT
LDA (LEV15
STA I (0270
LDA (LEV14
STA I (0257
LDA (LEV13
STA I (0246
LDA (LEV12
STA I (0235
LDA (LEV11
STA I (0224
LDA (LEV10
STA I (0213
LDA (LEV9
STA I (0202
LDA (LEV8
STA I (0171
LDA (LEV7
STA I (0160
LDA (LEV6
STA I (0147
LDA (LEV5
STA I (0136
LDA (LEV4
```

```
STA I (0125
LDA (LEV3
STA I (0114
LDA (LEV2
STA I (0103
LDA (LEV1
STA I (072
LDA (LEV0
STA I (061

LDA (K
STA I (0277
STA I (0266
STA I (0255
STA I (0244
STA I (0233
STA I (0222
STA I (0211
STA I (0200
STA I (0167
STA I (0145
STA I (0134
STA I (0123
STA I (0112
STA I (070

IOT PIN 2
IOT PIN 4
IOT PIN 010
IOT PIN 0123
IOT PIN 0122
IOT PIN 0121

LDA (057277
MST PIE
JMP I *

)FILL

)KILL_INIT

% PROGRAM ON LEVEL 15

% IDENTIFICATION OF INTERRUPTS FROM ACOUSTIC INTERFACE UNIT


LEV15,IOT  SNI 0121
JMP  * 4             % INTERRUPT INDICATING UPPER LIMIT
IOT  SNI 0122
JMP  * 012           % INTERRUPT INDICATING LOWER LIMIT
JMP  * 015
IOT  PIN 0121        % PREPARE NEW INTERRUPT
IOT  ACT 0130        % READ DEPTH COUNTER
SHA  ZIN SHR 1
STA  UPL
RCLR DA
BSET ONE 0160 DA
MST  PID             % INTERRUPT TO LEVEL 14
JMP  * 5
IOT  PIN 0122
IOT  ACT 0130        % READ INTERVAL COUNTER
SHA  ZIN SHR 1
STA  UPL 2
WAIT                 % EXIT
JMP  LEV15


% PROGRAM ON LEVEL 14

% PROGRAM FOR ECHO STRENGTH SPECTER

TARG,WAIT
IOT  ACT 052         % DUMMY READING
LDX UPL 2
COPY CM2 SX DX
LDT RASK
SWAP CLD ST DD
RCLR DB
JXZ  LEV14
JXZ  LEV14
JMP * 1

IOT ACT 52           % READING LOOP
SKP IF DA LST SD
JMP * 020
SKP IF DT EQL 0
SKP IF DL LST 0
JMP * 7
STT ,B
STX 1,B
AAB 2
RCLR DL
JNC *-012
JMP * 022
SAT -0144
```

```
SWAP CLD ST DL
BSET ONE 0150 DB
JMP * 1
JMP * 1
JMP * -7

SKP IF DD EQL 0
SKP IF DB UEQ 0
JMP * 6
SKP IF DA GRE ST
SKP IF DA LST ST
COPY SA DT
RINC DL
JMP *-011
JMP * 1
JMP * 1
JMP * -3

BSET ONE 0150 DX        % ECHO STRENGTH,COMPUTATION AND SORTING
RSUB SB DX
JXN * 2
JMP * 035
LDA UPL 2
ADD 1,B,X
ADD UPL
NLZ 020
FMU I (MPS
STF I (FDYP
LDA ,B,X
LDT (K
SWAP SB DT
STT TB14
NLZ 020
FDV QAD-K,B
FMU I (FDYP
JPL I ALOG-K,B
FMU BLOGE-K,B
FMU FL20-K,B
DNZ -020
ADD I (F
RCLR DB
BSET ONE 0150 DB
BSET ONE 0120 DB
COPY CM2 SA DA
RADD SA DB
MIN ,B
LDT TB14
COPY ST DB
```

```
AAX 1
JNC *-033
MIN I (ANTAL
JMP LEV14
SAA 040
MST PID                 % INTERRUPT TO LEVEL 5 FOR OUTPUT
JMP LEV14

TB14,0                  % TEMPORARY STORAGE
LOGG                    % FLAG DECIDING WHICH ROUTINE TO BE OPERATED
APING,PING 5            % POINTER END OF BUFFER, TABLES
BPING,PING 6            % POINTER END OF BUFFER, TABLES

)FILL

UPL,0                   % UPPER LIMIT
0                       % OLD UPPER LIMIT
0                       % CURRENT INTERVAL
0                       % OLD INTERVAL
RASK,2                  % TRESHOLD FOR AMPLITUDE
TELL1,-1                % NUMBER OF SAMPLES IN INTERVAL
DELAY,-1                % WAITING LOOP WHEN FISH IS FOUND
DLAY1,-1                % TEMPORARY SAVING OF DELAY
BOT,TOM                 % POINTER TO BOTTOM BACKSC. ROUTINE


LEV14,LDA I TB14 1
JAP * 4                 % JUMP TO ECHO CLASSIF. PROGRAM
BSKP ZRO 00 DA
JMP TARG                % JUMP TO ECHO STRENGTH PROGRAM
JMP I BOT               % JUMP TO BOTTOM BACK SCATTERING PROGRAM
LDA  I TB14 3
STA  I TB14 2
RCLR DL
SAA  -2
COPY SA DD
LDX  TELL1
SAA  -1
STA  DELAY

START,LDA UPL 2
LDT  UPL 3
STA  UPL 3
COPY CM2 SA DA
STA  TELL1
RADD ST DA
JAP  * 2
COPY CM2 SA DA
```

```
AAA  -020
JAP  LEV14          % INTERVAL CHANGED
LDA  UPL
LDT  UPL 1
STA  UPL 1
RSUB ST DA
JAP  * 2
COPY CM2 SA DA
AAA  -020
JAP  LEV14          % UPPER LIMIT CHANGED
WAIT

IOT  ACT 052        % DUMMY READING
JXZ  LEV14
JXZ  LEV14
LDT  RASK
RCLR DB
BSET ONE 070 DB
MIN  DELAY
JMP  * -7
BLDC 0120 DX

INLES, IOT  ACT 052   % READING LOOP
SKP  IF DA LST ST
JMP  EKKO
BSKP BAC 0120 DX
JMP  * 4
BSET BCM SSK
SHD  1
JMP  * 4
BSKP ZRO 00 DD
JMP  * 3
JMP  * 1
JMP  * 3
BSKP ONE 0170 DD
JMP  FISK
RCLR DB
BSET ONE 0150 DB
JMP  EKKO 010
BSKP ZRO 00 DD
BSKP ONE 00 DD
JMP  EKKO 4
BSET ONE 0170 DD
JXZ  LEV14
JMP  EKKO 010

EKKO, BSKP ZRO 070 DB
JMP  EKKO -6
```

```
STA  ,B
RINC DB
RSUB ST DA
SKP  IF DA GRE ST
SKP  IF DA LST ST
BSET ONE 00 DD
JNC  INLES
SKP IF DL UEQ 0
JMP  LIMIT
BSKP ONE 00 DD
JMP  ENDOF
JMP  LEV14

LIMIT, RCLR DT
BSET ONE 0120 DT
SAX  -020
LDA  TELL1
RADD ST DA
RINC DX
JAN  * -2
SHD  1
JNC  * -1
JMP  START-3

FISK, LDA  BOKS       % PROCESSING AFTER EACH PING
ADD  DLAY1
SKP  IF DL UEQ 0
LDA  TELL1
RSUB SX DA
COPY CM2 SA DX
AAA  0177
JAP  LEV14
STA  DELAY
STA  DLAY1
SKP  IF DL EQL 0
JMP  * 013
STZ  CCC
STZ  CCC 1
STZ  CCC 2
COPY SX DA
ADD  UPL
NLZ  020
FMU  MPS
STF  FDYP
DNZ  -020
STA  DYP
```

```
RINC DL
BSKP ZRO 050 DL
JMP  LEV14
SWAP CLD SL DA
SHA  1
STA  PING
RCLR DX
BSET ONE 0150 DX
RSUB SB DX
LDA  ,X ,B
SKP  IF DA LST SL
COPY SA DL
NLZ  020
STF  VOLT
FMU  VOLT
FAD  CCC
STF  CCC
JNC  * -010
BSET ONE 0150 DX
RSUB SB DX
SWAP CLD SL DT
STT  MAX
SHT  SHR 1
LDA  ,X ,B
SKP  IF DA LST ST
RINC DL
MIN  PING 5
STA  I PING 5
JNC  * -5
MIN  PING 5
STZ  I PING 5
BSET ONE 0150 DX
LDA  PING
RSUB SA DX
LDT  PING 2
COPY ST DB
COPY SL DA
NLZ  020
FMU  (2.1
DNZ  -020
STA  1 ,X
LDA  MAX
NLZ  020
FDV  QAD-K,B
FMU  FDYP
JPL  I ALOG-K,B
FMU  BLOGE-K,B
FMU  FL20-K,B
```

```
DNZ  -020
ADD  F
STA  ,X
RCLR DD
LDX  BOKS
LDA  PING
SHA  ZIN SHR 1
COPY SA DL
JMP  I PING 4


DBMAX,-016            % MAXIMUM DB-VALUE ALLOWED IN TABLE
F,0                   % CONSTANT ALLOWING FOR SETTING OF ECHO SOUNDER
ANTAL,0               % NUMBER OF FISH TO BE CLASSIFIED
BOKS,0                % SAMPLING INTERVAL WHEN TARGET OBSERVED
LOGG,0                % FLAG DECIDING WHICH ROUTINE TO BE OPERATED
MAX,0                 % MAX AMPLITUDE
DYP,0                 % DEPTH TO TARGET
FDYP,<0               % DEPTH TO TARGET
PULSR,<0              % PULSE RATE, ECHO SOUNDER
CCC,<0.0              % INTEGRATED SAMPLE VALUE
VOLT,<0.0             % TEMPORARY STORAGE
MPS,<0.015            % SOUND PROPAGATION BETWEEN SAMPLES
PING,0                % FLAG FOR MULTIPLE PING ON TARGET
AVEL,VELOC 4          % POINTER TO SHIP'S SPEED
K                     % BASE ADDRESS, NORMALLY IN B-REGISTER
LEV14                 % POINTER TO ENTRY,LEVEL 14
START                 % POINTER TO ENTRY, ECHO CLASSIFICATION
023000                % UPPER LOCATION, BUFFER FOR TABLES
023000
0


ENDOF,RCLR DB         % PROCESSING WHEN FISH HAS LEFT BEAM
BSET ONE 0150 DB      %  LOWER LOCATION, TABLE BUFFER
LDX  PING
COPY CM2 SX DX
SAA  -0200
COPY SA DD
LDA  ,X ,B
SKP  IF DA GRE SD
JMP  * 3
COPY SA DD            % MAX AMPLITUDE
LDT  1 ,X ,B          % ASSOCIATED PULSE LENGTH
AAX  1
JNC  * -6
COPY SD DA
STA  -052 ,B
```

```
STT   -051 ,B
LDA   DYP
STA   -055 ,B
LDF   CCC
FDV   (513.004
DNZ   -020
STA   -053 ,B
COPY AD1 SL DA
NLZ   020
FMU   I PING 1
RDCR DT
FDV   PULSR
FDV   FDYP
LDX   PING 2
SWAP SX DB
JPL   I ATAN-K ,B
FDV   DTR-K ,B
COPY SX DB
DNZ   -020
STA   -054 ,B

STORE,COPY SA DX       % FREQUENCY TABLE, FISH ANGLE
JXZ   * 016            % ANGLE LESS THEN ONE DEGREE
LDA   -052 ,B
SUB   DBMAX
JAP   * 013            % TOO BIG AMPLITUDE, DECIBEL
COPY CM1 SA DA
BSET ZRO 00 DA
SAT   036
SKP   IF DA GRE ST
SKP   IF DX LST ST
JMP   * 5              % ANGLE TOO BIG
SHA   4
RADD SA DB
AAB   0177
MIN   055 ,X ,B        % COUNT IN ASSOCIATED COLUMN OF FREQUENCY TABLE
SAA   040
MST   PID              % INTERRUPT TO LEVEL 5
LDA   PING 5
STA   PING 7
JMP   I PING 3


)FILL.

% PRELIMINARY PROGRAM FOR BOTTOM BACK SCATTERING

TOM,LDA PING 2         % SAMPLING AND FILTERING
COPY SA DB
LDX I (UPL 2
COPY CM2 SX DX
RCLR DT
IOT ACT 052
SKP IF DA LST ST
SKP IF DA GRE ST
JMP * 4
COPY SA DT
COPY SX DD
JMP * 4
JMP * 1
JMP * 1
JMP * 1
JMP * 1
JMP * 1
JMP * 1
JMP * 1
JNC *-016

COPY SD DA                 % PROCESSING
COPY ST DX
ADD I (UPL
ADD I (UPL 2
NLZ 020
FMU MFS
FSB (175.
FDV (179.167
BSKP ZRO 0170 DT
LDF FLO-K,B
STF S
COPY SX DA
NLZ 020
FDV @AD-K,B
JAZ * 3
JPL I ALOG-K,B
FMU BLOGE-K,B
FMU FL20-K,B
FAD S
STF S
LDA I (F
NLZ 020
FAD S
FAD BES
STF BES
MIN BC
WAIT
JMP I (LEV14
```

```
S,<0                    % TEMPORARY STORAGE
BES,<0                  % TEMPORARY STORAGE
BC,0                    % COUNTER

)FILL

)KILL TOM S APING BPING AVEL
)KILL BOT PLOTS PLOT WHERE FACT NRR2 SYMBL SPECT NUMBR HGHT

)KILL LEV15 UPL LEV14 START INLES EKKO LIMIT TELL1 DELAY DLAY1
)KILL FISK DBMAX MAX DYP FDYP CCC VOLT MPS ENDOF STORE TARG TB14

)LINE

% PROGRAM ON LEVEL 13
% THIS LEVEL IS ACTIVATED EVERY SECOND BY THE REAL-TIME CLOCK

% CLOCK

LEV13,LDA  DATO 1
COPY AD1 SA DL
SAT  074
SAX  -03
COPY CM1 SX DD
SHD  1
BACK,COPY ST DA
RAND SL DT
REXO ST DA
JAF  UT 1          % EXIT IF NOT TWELVE O'CLOCK (AM. OR PM.)
RADD SD DL
SHT  6
SHD  6
JNC  BACK

% DATE

SAA  077
LDX  DATO
BLDA 0110 DX
BSKP BAC 060 DX
JMP  * 011              % MONTH WITH 31 DAYS.
BSKP BAC 070 DX
BSKP BAC 0100 DX
JMP  * 5                % MONTH WITH 30 DAYS.
BSKP ONE 0130 DX
BSKP ZRO 0120 DX        % SKIP NEXT STATEMENT IF LEAP-YEAR.
AAT  2
AAT  2
AAT  2
AAX  1
RAND SX DA
RADD ST DA
BSET ZRO 060 DA
JAF  UT                 % EXIT IF NOT END OF MONTH.
RADD ST DX
AAX  2
BSKP ZRO 0110 DX
BSKP ONE 0100 DX
JMP  UT                 % EXIT IF NOT END OF YEAR.
BSET ONE 0100 DA
RADD SA DX
UT,  STX  DATO
COPY SL DA
STA  DATO 1

% VESSEL-VELOCITY.

LDX  TB13 013
SAA  6
JPL  I MPXX
NLZ  020
FMU  010,X
FDV  013,X
STF  4,X
MIN  7,X

% CALLING SEQUENCE FOR RUNNING SUBROUTINES
% EVERY SUBROUTINE HAS ONE SPECIFIED BIT IN TESTWORD (T5),
```

```
% INDICATING WHETHER IT IS RUNNING.

JPL  I TB13 2
LDA  T5-K,B
BSKP ZRO 0130 DA
JPL  I TB13
JPL  I TB13 11
LDA  T5-K,B
BSKP ZRO 0140 DA
JPL  I TB13 014
LDA  TB13 015
MST  PID                    % INTERRUPT TO LEVEL 12
LDA  T5-K ,B
BSKP ZRO 00 DA
JPL  I TB13 3
LDA  T5-K,B
BSKP ZRO 0150 DA
JPL  I TB13 010
LDA  DATO 1
SHA  012
JAF  UT13                   % EXIT IF NOT FULL MINUTE
JPL  I TB13 7
LDA  T5-K ,B
LDX  TB13 4
BSKP ZRO 060 DA
JPL  I MPX-K ,B
LDA  T5-K ,B
LDX  TB13 5
BSKP ZRO 050 DA
JPL  I MPX -K ,B
LDA  T5-K ,B
LDX  TB13 6
BSKP ZRO 040 DA
JPL  I MPX-K ,B
MIN  TB13 1
JMP  UT13                   % EXIT IF NOT FULL TEN-MINUTE
SAA  -012
STA  TB13 1
JPL  I TB13 12
LDA  T5-K ,B
LDX  TB13 4
BSKP ZRO 060 DA
JPL  I AV1-K ,B
LDA  T5-K ,B
LDX  TB13 5
BSKP ZRO 050 DA
JPL  I AV1-K ,B
LDA  T5-K ,B
LDX  TB13 6
BSKP ZRO 040 DA
JPL  I AV1-K ,B

% TEST FOR FULL-HOUR OUTPUT

UT13,LDA  DATO 1
SHA  4
JAF  * 05
SAA  -1
STA  T4-K ,B
SAA  020
MST  PID
WAIT
JMP  LEV13

DATO,0                  % DATE
0                       % CLOCK
TB13,DRECF              % POINTER TO DEAD-RECKON SUBROUTINE
-012                    % COUNTER
GYRO                    % POINTER TO COURSE SUBROUTINE
ECSP                    % POINTER TO ECHO-ABUNDANCE SUBROUTINE
ATEMD                   % POINTER TO AIR-TEMPERATURE DATA-BLOCK
ATEMW                   % POINTER TO DEWPOINT-TEMPERATURE DATA-BLOCK
APRES                   % POINTER TO AIR-PRESSURE DATA-BLOCK
AVC1                    % POINTER TO MEAN-COURSE SUBROUTINE
TDS2                    % POINTER TO STD SUBROUTINE
WNDS                    % POINTER TO WIND-DATA SAMPLING SUBROUTINE
WNDAV                   % POINTER TO WIND-DATA AVERAGING SUBROUTINE
VELOC                   % POINTER TO VESSEL-VELOCITY DATA-BLOCK
SMDPT                   % POINTER TO BOTTOM-DEPTH SUBROUTINE
010000

MPXX,MPX2

)KILL LEV13 BACK UT UT13 TB13

% COURSE SUBROUTINE
% FIRST PART OF THE ROUTINE IS A DECODING TO BINARY CODE.
% THE RESULTS OF THIS ROUTINE ARE THE VESSEL'S COURSE,AND THE
% N-S AND E-W COMPONENTS OF THE VESSEL'S VELOCITY.

GYRO,IOT ACT 0135
SWAP CLD SA DT
COPY CM1 ST DD
BLDA 0120 DT
BSKP ONE 0120 DT
AAA 044
```

```
BSKP BAC 0110 DT
AAA 022
BSKP BCM 0110 DT
COPY CM1 ST DT
BSKP ZRO 0100 DT
BLDA 010 DA
COPY SD DT
BSKP BCM 060 DT
JMP  * 3
AAA  3
COPY CM1 ST DT
BSKP ZRO 050 DT
AAA  1
BSKP ZRO 040 DT
AAA  1
SAT  3
BSKP ONE 010 DD
JMP  * 6
BSKP ZRO 00 DD
AAT  -1
BSKP ZRO 020 DD
AAT  1
JMP  * 2
RAND SD DT
BLDA 00 DA
BSKP BCM 030 DD
JMP  * 3
COPY CM2 ST DT
AAT  011
MPY  HTS-K,B
RADD ST DA
COPY SL DT
STT LR
NLZ 070
FDV FL2-K,B
FMU DTR-K,B
STF LR 1
JPL I SIN-K,B
STF LR 4
LDF DRPO1 4
JPL I COS-K,B
STF C101-K,B
FDV FL4-K,B
FDV VELOC 4
FAD LR 4
STF LR 4
LDF LR 1
JPL I COS-K,B
FDV LR 4
JPL I ATAN-K,B
BSET BCM 0170 DT
FAD LR 1
STF COURS 4
JPL I SIN-K,B
FMU VELOC 4
STF COURS 015
FAD COURS 7
STF COURS 7
LDF COURS 4
JPL I COS-K,B
FMU VELOC 4
STF COURS 020
FAD COURS 012
STF COURS 012
JMP I LR

% DEAD-RECKON SUBROUTINE
% THE RESULTS OF THIS ROUTINE ARE THE VESSEL'S POSITION
% AND THE EARTH-RADIUS AT THE ACTUAL POINT.

DRECF,LDF C101-K,B
FMU C101-K,B
FMU C3
FAD C2
FMU C101-K,B
FMU C101-K,B
FAD C1
FMU ER-K,B
STF ERL-K,B
LDF COURS 020
FMU C4
FDV ERL-K,B
FAD DRPO1 4
STF DRPO1 4
FDV DTR-K,B
STF DRPO1 1
LDF COURS 015
FMU C4
FDV ERL-K,B
FDV C101-K,B
FAD DRPO2 4
STF DRPO2 4
FDV DTR-K,B
STF DRPO2 1
EXIT
```

```
C1,<0.99633
C2,<0.0036984
C3,<-0.0000284
C4,<1852.

% WIND-DATA SAMPLING SUBROUTINE
% THE RESULTS OF THIS SUBROUTINE ARE THE
% N-S AND E-W COMPONENTS OF THE WIND-FORCE

WNDS,COPY SL DX
SAA 012
JPL I MPXX
NLZ 020
FMU WNDF 012
FAD WNDF 015
FDV VELOC 013
STF LR 1
SAA 013
JPL I MPXX
NLZ 020
FMU WNDD 7
STF LR 4
FAD COURS 4
JPL I COS-K,B
FMU LR 1
FSB COURS 020
FAD WNDF 4
STF WNDF 4
LDF LR 4
FAD COURS 4
JPL I SIN-K,B
FMU LR 1
FSB COURS 015
FAD WNDF 7
STF WNDF 7
MIN WNDF 020
COPY SX DF

LR,0
<0
<0

DRPO1,040463          % DATA-BLOCK LONGITUDE
<0                    % DEGREES
<0                    % RADIANS

DRPO2,040664          % DATA-BLOCK LATITUDE
<0                    % DEGREES
```

```
<0                    % RADIANS

VELOC,041062          % DATA-BLOCK VESSEL'S VELOCITY
<0                    % MEAN-VELOCITY FOR LATEST NAUTICAL-MILE
<0                    % INSTANTANEOUS VELOCITY
0                     % SECONDS PASSED SINCE LAST FULL NAUTICAL-MILE
<0.007816
<3600.
<0

COURS,041061          % DATA BLOCK VESSEL'S COURSE
<0                    % DEGREES (MEAN)
<0                    % RADIANS (INSTANTANEOUS)
<0                    % CUMULATIVE SUM OF E-W COMPONENT OF VELOCITY
<0                    % CUMULATIVE SUM OF N-S COMPONENT OF VELOCITY
<0                    % INSTANTANEOUS E-W COMPONENT OF VELOCITY
<0                    % INSTANTANEOUS N-S COMPONENT OF VELOCITY

WNDF,042064           % DATA BLOCK WIND-FORCE
<0                    % WIND-FORCE (MEAN)
<0                    % CUMULATIVE SUM OF N-S COMPONENT OF WIND-FORCE
<0                    % CUMULATIVE SUM OF E-W COMPONENT OF WIND-FORCE
<0.01954
<40.
0                     % NUMBER OF OBSERVATIONS IN CUMULATIVE SUM

WNDD,042065           % DATA BLOCK WIND-DIRECTION
<0                    % DEGREES (MEAN)
<0                    % RADIANS (MEAN)
<0.00153473

BTMDP,142661          % DATA BLOCK BOTTOM-DEPTH
<0                    % BOTTOM-DEPTH (INSTANTANEOUS)

% WIND-DATA AVERAGING SUBROUTINE

WNDAV,COPY SL DA
STA LR
LDF WNDF 7
COPY ST DL
LDX WNDF 4
JXZ * 4
FDV WNDF 4
JPL I ATAN-K,B
JMP * 4
LDF PI2-K,B
BSKP ZRO 0170 DL
BSET ONE 0170 DT
```

```
BSKP ZRO 0170 DX
FAD PI-K,B
BSKP ZRO 0170 DT
FAD TPI-K,B
STF WNDD 4
FDV DTR-K,B
STF WNDD 1
LDA WNDF 020
NLZ 020
STF LR 1
LDF WNDF 4
FMU WNDF 4
STF LR 4
LDF WNDF 7
FMU WNDF 7
FAD LR 4
JPL I SQR-K,B
FDV LR 1
FMU VELOC 13
STF WNDF 1
LDF FLO-K,B
STF WNDF 4
STF WNDF 7
STZ WNDF 020
JMP I LR

% COURSE AVERAGING SUBROUTINE

AVC1,COPY SL DA
STA LR1
LDF COURS 7
COPY ST DL
LDX COURS 12
JXZ * 4
FDV COURS 12
JPL I ATAN-K,B
JMP * 4
LDF PI2-K,B
BSKP ZRO 0170 DL
BSET ONE 0170 DT
BSKP ZRO 0170 DX
FAD PI-K,B
BSKP ZRO 0170 DT
FAD TPI-K,B
FDV DTR-K,B
STF COURS 1
LDF FLO-K,B
STF COURS 7
```

```
STF COURS 12
JMP I LR1

LR1,0


% BOTTOM-DEPTH SUBROUTINE

SMDPT,IOT ACT 0131
BSKP ZRO 0170 DA
JMP *-2                % DEVICE BUSY
BSKP ZRO 0150 DA
EXIT                   % DEVICE OVERFLOW
SHA ROT 4
SAD ZIN SHR 014
MPY HT6-K,B
SWAP CLD SA DT
SAD 4
MPY HT5-K,B
RADD SA DT
RCLR DA
SAD 4
RADD ST DA
BSKP ZRO 0140 DD
MPY HT5-K,B
BLDA 0160 DD
NLZ 020
BSKP ZRO SSK
FDV FL10-K,B
STF BTMDP 1
EXIT

)KILL MPXX GYRO DRECF C1 C2 C3 C4 WNDS LR SMDPT AVC1 WNDAV LR1

% ECHO-ABUNDANCE SAMPLING SUBROUTINE

ECSP,MIN LOO1 1
JMP * 2
EXIT                   % AVOID READING WHEN RESETTING INTEGRATOR
STX SX9
LDX (ECMD1
LDA 7,X
COPY SL DT
JPL I MPXX
COPY ST DL
SHA SHR 1
COPY SA DT
SUB 011,X
```

```
JAN * 3
ADD 010,X
STA 010,X
AAA 1
JAZ * 2
STT 011,X
AAX 015
MIN LOO1
JMP ECSP 5
SAA -6
STA LOO1
LDX SX9
EXIT

SX9,0
LOO1,-6
-1

% SAVING OF ECHO-ABUNDANCE LAST NAUTICAL MILE SUBROUTINE


ECAD,SAA -1
STA LOO1 1
LDF FLO-K,B
STF SUM1 1
STF SUM1 4
STX SX9
LDX (ECMD1
LDA 010,X
NLZ 020
FMU (0.04888
FMU 012,X
STF 1,X
FAD 4,X
STF 4,X
FAD SUM1 4
STF SUM1 4
LDF 1,X
FAD SUM1 1
STF SUM1 1
STZ 010,X
STZ 011,X
AAX 015
MIN LOO1
JMP ECAD 7
SAX -6
STX LOO1
LDX SX9
```

```
EXIT

MPXX,MPX2

)FILL

ECMD1,142662        % DATA BLOCK ECHO-ABUNDANCE (INTEGRATOR-CH. 1)
<O                  % ECHO-ABUNDANCE LAST NAUTICAL MILE
<O                  % CUMULATIVE SUM OF MILE VALUES OF ECHO-ABUNDANCE
0                   % MULTIPLEXER CHANNEL
0                   % ECHO-ABUNDANCE CURRENT NAUTICAL MILE
0                   % ECHO-ABUNDANCE SINCE LAST PEAK
<O                  % INTEGRATOR GAIN

ECMD2,142463        % DATA BLOCK ECHO-ABUNDANCE (INTEGRATOR-CH. 2)
<O
<O
1
0
0
<O

ECMD3,142664        % DATA BLOCK ECHO-ABUNDANCE (INTEGRATOR-CH. 3)
<O
<O
2
0
0
<O

ECMD4,142465        % DATA BLOCK ECHO-ABUNDANCE (INTEGRATOR-CH. 4)
<O
<O
3
0
0
<O

ECMD5,142466        % DATA BLOCK ECHO-ABUNDANCE (INTEGRATOR-CH. 5)
<O
<O
4
0
0
<O

ECMD6,142667        % DATA BLOCK ECHO-ABUNDANCE (INTEGRATOR-CH. 6)
<O
```

```
<0
5
0
0
<0

SUM1,142670          % DATA BLOCK ECHO-ABUNDANCE (TOTAL)
<0                   % ECHO-ABUNDANCE LAST FULL MILE
<0                   % CUMULATIVE SUM OF MILE VALUES

)KILL SX9 LOO1 MPXX ECMD2 ECMD3 ECMD4 ECMD5 ECMD6 ECSP


TDS3,TDS1
<1.9035532
<18496.82644
<0.017909
<40.092449
<0.003441156
<12.811424

% STD SUBROUTINE
% THIS SUBROUTINE OBSERVES DEPTH,TEMPERATURE AND SALINITY,
% AND COMPUTES DENSITY (SIGMA-T),SPESIFIC VOLUME ANOMALY (DELTA-ALFA)
% AND DYNAMIC DEPTH ANOMALY (DELTA-D).


TDS2,LDX TDS3
LDA DV7-K,B
JAF * 010            % EXIT IF PUNCH BUSY
IOT ACT 0133
NLZ 020
FMU TDS3 1
FSB TDS3 4
FAD SKD-K,B
FSB ,X
BSKP ZRO 0170 DT
EXIT                 % EXIT IF DEPTH LESS THAN PREVIOUS DEPTH
FAD ,X
STF ,X
IOT ACT 0132
NLZ 020
FMU TDS3 7
FSB TDS3 012
FAD SKT-K,B
STF 3,X
IOT ACT 0134
NLZ 020
FMU TDS3 015
FAD TDS3 020
FAD SKS-K,B
STF 6,X
FSB 22,X
STF 165,X
FMU 165,X
STF 170,X
FMU 165,X
FMU 25,X
FAD 30,X
STF 176,X
LDF 165,X
FMU 33,X
FAD 176,X
STF 176,X
LDF 170,X
FMU 36,X
FAD 176,X
STF 176,X
LDF 3,X
FAD 41,X
FMU 44,X
STF 165,X
LDF 3,X
FSB 47,X
STF 170,X
FMU 170,X
STF 170,X
LDF 3,X
FAD 52,X
FMU 170,X
FDV 165,X
STF 165,X
LDF 3,X
FMU 3,X
FMU 55,X
STF 170,X
LDF 3,X
FMU 60,X
FAD 63,X
FAD 170,X
FMU 3,X
FDV FLTUS-K,B
STF 170,X
LDF 3,X
FMU 66,X
FAD 71,X
```

```
STF 173,X
LDF 3,X
FMU 3,X
FMU 74,X
FAD 173,X
FMU 3,X
FDV -3,X
STF 173,X
LDF 176,X
FSB 77,X
FMU 173,X
FSB 170,X
FAD FL1-K,B
STF 173,X
LDF 176,X
FAD 77,X
FMU 173,X
FSB 165,X
STF 11,X
FDV FLTUS-K,B
FAD FL1-K,B
STF 165,X
LDF FL1-K,B
FDV 165,X
STF 165,X
LDF 3,X
FMU 102,X
FAD 105,X
STF 170,X
LDF 3,X
FMU 3,X
FMU 110,X
FAD 170,X
STF 170,X
LDF 3,X
FMU 113,X
FAD 116,X
FMU ,X
FDV -6,X
BSET BCM 0170 DT
FAD 170,X
STF 170,X
LDF ,X
FMU ,X
FMU 121,X
FAD 170,X
FMU 3,X
STF 170,X
LDF 3,X
FMU 3,X
FMU 124,X
STF 173,X
LDF 3,X
FMU 127,X
FAD 173,X
FAD 132,X
FMU ,X
FDV -6,X
STF 173,X
LDF 3,X
FMU 3,X
FMU 135,X
FSB 173,X
STF 173,X
LDF 3,X
FMU 140,X
FAD 143,X
FAD 173,X
STF 173,X
LDF 176,X
FSB 154,X
FDV FL10-K,B
FMU 173,X
FAD 170,X
FSB 157,X
STF 170,X
LDF 165,X
FSB 146,X
FMU -3,X
STF 173,X
LDF ,X
FMU 151,X
FAD FL1-K,B
FMU 173,X
STF 173,X
LDF ,X
FMU 162,X
FAD 170,X
FMU 165,X
FMU ,X
FDV FLTUS-K,B
FAD 173,X
FDV FL10-K,B
STF 14,X
LDA -35,X
BLDA 0170 DA
```

```
LDF 014, X
FAD -033, X
BSKP ZRO SSK
FDV FL2-K, B
STF -041, X
LDF , X
FSB -036, X
FMU -041, X
FDV FL10-K, B
FAD 017, X
STF 017, X
LDF , X
STF -036, X
LDF 014, X
STF -033, X
SAA 040
MIN C131-K, B
JMP * 013
SAA -6
STA C131-K, B
LDF , X
STF -030, X
AAX 3
MIN C131-K, B
JMP *-4
LDA C131 2-K, B
STA C131-K, B
SAA 050
MST PID                 % INTERRUPT FOR OUTPUT
EXIT
<0                      % TEMPORARY STORAGE
<0                      % TEMPORARY STORAGE
<0                      % TEMPORARY STORAGE
<0                      % DEPTH (FOR OUTPUT TELETYPE)
<0                      % TEMPERATURE
<0                      % SALINITY
<0                      % SIGMA-T
<0                      % DELTA-ALFA
<0                      % DELTA-D
<10000.
<1000000.
TDS1, <0                % DEPTH (FOR OUTPUT PAPERTAPE-PUNCH)
<0                      % TEMPERATURE
<0                      % SALINITY
<0                      % SIGMA-T
<0                      % DELTA-ALFA
<0                      % DELTA-D
<35. 0
<0. 0000068
<28. 1263
<0. 806
<0. 00023
<67. 26
<503. 57
<3. 98
<283.
<0. 0010843
<-0. 098185
<4. 7867
<-0. 8164
<18. 03
<0. 01667
<0. 1324
<-0. 551
<28. 33
<0. 004
<-0. 158
<9. 5
<0. 000000015
<0. 02
<-0. 87
<32. 4
<0. 04
<-2. 72
<147. 3
<0. 972643
<-0. 00000466
<28. 0
<1. 85
<0. 00004

<0
<0
<0
<0

)KILL TDS2 TDS3

)LINE

% PROGRAM ON LEVEL 12
% THIS LEVEL  COMPUTES SHIP'S POSITION ACCORDING TO
% DECCA-NAVIGATOR
```

```
KJEDE                     % POINTER TO CHAIN-CONSTANTS
041                       % NUMBER OF CONSTANTS FOR EACH CHAIN
LEV12,LDA T1-K,B
BSKP ONE 010 DA           % TEST WHETHER DECCA-PROGRAM IS RUNNING
JMP E12                   % EXIT
LDX SX3
SAA 2
MPY LUP
AAA 030
JPL MPX2                  % READ SINE
COPY CM2 SA DA
LDT 015,X
STA 015,X
BLDA 0170 DA
REXO SA DT
COPY AD1 SD DA
JPL MPX2                  % READ COSINE
COPY CM2 SA DA
JAF * 4
LDF PI2-K,B
BSET BAC 0170 DT
JMP L12
JAN * 011
SWAP SA DT
JAP * 6
SAA 1
BSKP ZRO SSK
SAA -1
ADD 014,X
STA 014,X
SWAP SA DT
NLZ 020
STF K1-K,B
BLDA 0170 DT
LDA 015,X
NLZ 020
FDV K1-K,B
BSTA 0160 DX
JPL I ATAN-K,B
BSKP ZRO 0160 DX
FAD PI-K,B

L12,BSKP ZRO 0170 DT
FAD TPI-K,B
FDV TPI-K,B
STF 3,X
LDA 014,X
NLZ 020
FAD 3,X
STF 3,X
AAX 016
MIN LUP
JMP LEV12 4
SAA -3
STA LUP
JPL INN

E12,WAIT
JMP LEV12

% ROUTINE FOR READING OF MULTIPLEXER

MPX2,COPY SA DD
IOT ACT SKA 050
JMP *-1
COPY SD DA
IOT ACT SKA 050
JMP *-1
SHA 4
SHA SHR 4
EXIT

SX3,VARIA                 % POINTER TO DATA-BLOCK FOR DECCA READINGS
T20,TXX20                 % POINTERS TO TEXT-BLOCK
T25,TXX25

% INITIALIZATION OF DECCA-PROGRAM


INNLF,COPY SL DX
STX S2-K,B
LDT T20
JPL I TXT-K,B
L91
JPL I HTI-K,B
L92
MPY LEV12-1
ADD LEV12-2
STA CH1-K,B
LDT T25
JPL I TXT-K,B
L91
LDX SX3

DIN,JPL I FLIN-K,B
L92
```

```
STF 3,X
JPL I FLIN-K,B
L92
STF 6,X
LDF ,X
FDV FL10-K,B
STF 011,X
JAF * 3
LDF FL10-K,B
FMU FL4-K,B
FMU FL3-K,B
FDV FL5-K,B
FMU 3,X
FAD 6,X
FSB 011,X
STF 3,X
DNZ -020
STA 014,X
LDF 3,X
FSB MIN05-K,B
DNZ -020
SUB 014,X
COPY CM2 SA DA
STA 015,X
AAX 016
MIN LUP
JMP DIN
SAA -3
STA LUP
JMP DECCA
LUP,-3              % LOOP-COUNTER ( 3 DECCOMETERS )

% ROUTINE TO COMPUTE CONSTANTS ON INITIATING DECCA-ROUTINE


DECCA,LDF I CH1-K,B
JPL I TAN-K,B
STF K1-K,B
FMU MIN05-K,B
STF FA-K,B          % FA=-(TAN V)/2
FMU K1-K,B
FMU FL6-K,B
FSB FL1-K,B
FDV FL6-K,B
STF FD-K,B          % FD=-(1+3*(TAN V)^2)/6
LDF K1-K,B
FMU EX1-K,B
STF K2-K,B
FMU K2-K,B
FAD FL1-K,B
STF K2-K,B
LDF FL1-K,B
FDV K2-K,B
STF K2-K,B
JPL I SQR-K,B
STF K3-K,B
FMU K2-K,B
FSB K3-K,B
STF K4-K,B
LDF FL1-K,B
FDV K3-K,B
STF STG-K,B          % STG=1/(COS U)
LDF I CH1-K,B
JPL I COS-K,B
STF K3-K,B
FMU K1-K,B
FMU STG-K,B
STF GA-K,B           % GA=(SIN V)/(COS U)
LDF K3-K,B
FMU K3-K,B
STF K1-K,B
FMU K3-K,B
FSB K3-K,B
FDV K4-K,B
STF GRF-K,B          % GRF=(COS V)*(SIN V)^2/(COS U)*(SIN U)^2
LDF FA-K,B
FMU K1-K,B
FMU EX2-K,B
FMU FL3-K,B
STF FB-K,B           % FB=3*FA*(1-EX2)*(COS V)^2
LDF K2-K,B
FMU FL5-K,B
FAD FL1-K,B
FMU EX2-K,B
FMU MIN05-K,B
FAD FL1-K,B
FMU FA-K,B
STF FC-K,B           % FC=FA*(1-0.5*(5*(COS U)^2+1)*(1-EX2))
LDF FL3-K,B
FSB K1-K,B
FSB K1-K,B
FDV FL3-K,B
FDV K2-K,B
STF GB-K,B           % GB=(3-2*(COS V)^2)/3*(COS U)^2
LDF FL4-K,B
FDV FL3-K,B
```

```
FSB K1-K,B
FDV K2-K,B
STF GC-K,B          % GC=(4-3*(COS V)^2)/3*(COS U)^2
JMP INN 2

INN,COPY SL DA
STA S2-K,B

% ROUTINE FOR CONVERTING LANE-READINGS TO HYPERBOLIC VARIABLES

SUBR1,LDX SX3
LDA CH1-K,B
AAA 6
STA CH2-K,B
AAA 3
STA CH3-K,B
LDF ,X
FSB I CH2-K,B
STF K1-K,B
LDF 3,X
FDV K1-K,B
FMU FL2-K,B
FAD FL1-K,B
STF 6,X
FMU 6,X
FSB FL1-K,B
FMU I CH3-K,B
FMU MIN05-K,B
STF 011,X
AAX 016
LDA CH3-K,B
MIN LUP
JMP SUBR1 2
SAT -3
STT LUP
AAX -044
AAA -022
STA CH2-K,B
AAA 011
STA CH3-K,B

% TESTING SEQUENCE TO SELECT 2 SLAVES

TEST1,STX CH2 1-K,B
AAX 016
STX CH3 1-K,B
LDF -016,X
BSET ZRO 0170 DT
STF K1-K,B
LDF ,X
BSET ZRO 0170 DT
AAX 016
STF K2-K,B
FSB K1-K,B
BLDA 0170 DT
LDF ,X
BSET ZRO 0170 DT
BSKP ZRO SSK
FSB K1-K,B
BSKP ONE SSK
FSB K2-K,B
BSKP ONE 0170 DT
JMP TEST2
LDA CH3-K,B
AAA 011
COPY SX DD
BSKP ZRO SSK
STD CH2-K,B
BSKP ONE SSK
STD CH3-K,B

TEST2,LDA T1-K,B
BSKP ONE 020 DA
JMP NEXT

TEST3,LDD CH2-K,B
STD K1-K,B
LDD CH3-K,B
STD CH2-K,B
LDD K1-K,B
STD CH3-K,B

NEXT,SAX 3
SAA -0144
STA IT1
LDA T1-K,B
BSKP ZRO 010 DA
JMP ITERA
LDA I CH2 1-K,B
BLDA 0170 DA
LDF TPI-K,B
BSKP ONE SSK
LDF PI2-K,B
FDV FL4-K,B
FSB PI-K,B
FAD I CH2-K,B,X
```

```
BSKP ZRO 0170 DT
FAD TPI-K,B
STF TETA-K,B

% ITERATION-LOOP

ITERA,LDF TETA-K,B
FSB I CH3-K,B,X
JPL I SIN-K,B
FMU I CH3-K,B
FMU RR-K,B
FDV ERL-K,B
FDV MFL6
FAD TETA-K,B
FSB I CH3-K,B,X
JPL I COS-K,B
FAD I CH3 1-K,B
FDV I CH3 1-K,B,X
STF K3-K,B
LDF TETA-K,B
FSB I CH2-K,B,X
JPL I SIN-K,B
FMU I CH2-K,B
FMU RR-K,B
FDV ERL-K,B
FDV MFL6
FAD TETA-K,B
FSB I CH2-K,X,B
JPL I COS-K,B
FAD I CH2 1-K,B
FDV I CH2 1-K,B,X
FSB K3-K,B
STF K1-K,B
FMU T
FAD TETA-K,B
STF TETA-K,B
LDF FL1-K,B
FDV K3-K,B
BSET ZRO 0170 DT
STF R1-K,B
FDV ERL-K,B
STF RR-K,B

LDF K1-K,B
BSET ZRO 0170 DT
FSB (0.000000000001
BSKP ZRO 0170 DT
JMP UTP1
```



```
MIN IT1
JMP ITERA
LDT (TEXT7
JMP FEIL

IT1,0                   % LOOP-COUNTER
MFL6,<-6.               % -6.
T,<50000.               % 50000. ( USED IN ITERATION-LOOP )

)FILL

% ROUTINE TO SELECT THE OTHER POINT OF INTERSECTION
BYTT,LDA T1-K,B
BSET BCM 020 DA
STA T1-K,B
JMP TEST3

% ROUTINE TO CONVERT POINT OF INTERSECTION TO GEOGRAPHICAL COORDINATES

UTP1,LDF TETA-K,B
JPL I COS-K,B
STF K1-K,B
LDF TETA-K,B
JPL I SIN-K,B
STF K2-K,B
FMU K2-K,B
STF K3-K,B
FMU FC-K,B
FAD FB-K,B
STF K4-K,B
LDF K1-K,B
FMU K3-K,B
FMU FD-K,B
FMU RR-K,B
FAD K4-K,B
FMU RR-K,B
FAD K1-K,B
FMU RR-K,B
FMU GRF-K,B
FAD I CH1-K,B
STF DPOS1 4
FDV DTR-K,B
STF DPOS1 1
LDF K2-K,B
FMU GC-K,B
FSB GBK,B
FMU RR-K,B
```

```
STF K3-K,B
LDF K1-K,B
FMU GA-K,B
FSB K3-K,B
FMU RR-K,B
FAD FL1-K,B
FMU RR-K,B
FMU K2-K,B
FMU STG-K,B
FAD I CH1-K,B,X
STF DPOS2 4
FDV DTR-K,B
STF DPOS2 1
LDA T1-K,B
BSKP ZRO 010 DA
JMP TEST4

% ROUTINE TO PRINT OUT POSITION ( ONLY AFTER INITIATION )

UTP2,JPL I CLF-K,B
L91
LDT T21
JPL I TXT-K,B
L91
LDX (DPOS1 1
JPL I KONV-K,B
L91
3
1
LDA DS-K,B
JPL I RIO-K,B
L91
LDT T22
JPL I TXT-K,B
L91
LDX (DPOS2 1
JPL I KONV-K,B
L91
3
1
LDT (TEXT3
JPL I TXT-K,B
L91
JPL I RIO-K,B
L92
BSKP ONE 00 DA
JMP BYTT
```

```
% ROUTINE TO SAVE LATEST POINT OF INTERSECTION

RESET,SAA -5
STA FTEST
LDF TETA-K,B
STF OTETA
LDF R1-K,B
STF R2-K,B
LDA T1-K,B
BSET ONE 010 DA
STA T1-K,B
JMP I S2-K,B        % EXIT

% TESTING SEQUENCE FOR DISTANCE BETWEEN POINTS OF INTERSECTION

TEST4,LDF R1-K,B
FSB R2-K,B
BSET ZRO 0170 DT
FSB FLTUS-K,B
BSKP ONE 0170 DT
JMP * 7
LDF TETA-K,B
FSB OTETA
BSET ZRO 0170 DT
FSB DTR-K,B
BSKP ZRO 0170 DT
JMP RESET
LDF OTETA
STF TETA-K,B
MIN FTEST
JMP RESET 6
LDT (TEXT8

% EXIT IF DISTANCE BETWEEN POINTS OF INTERSECTION IS TOO LARGE,
% OR IF NUMBER OF ITERATION EXCEEDS 100

FEIL,LDA T1-K,B
BSET ZRO 010 DA
STA T1-K,B
LDA DV3-K,B
BSET ONE 0140 DA
STA DV3-K,B
JPL I TXT-K,B
FEI
LDA DV3-K,B
BSET ZRO 0140 DA
STA DV3-K,B
JMP I S2-K,B        % EXIT
```

```
FEI,3                 % OUTPUT-DEVICE FOR ERROR-MESSAGE
FTEST,-5              % NUMBER OF FAULTY READINGS BEFORE ERROR MESSAGE
OTETA,<0              % ANGLE TO LATEST POINT OF INTERSECTION
TEXT3,'  KEEP=1, CHANGE=2 .
TEXT7,'
WRONG ITERATION
'
TEXT8,'
POS WR
'

)FILL

DPOS1,040661          % DATA-BLOCK FOR DECCA-POSITION ( LATITUDE )
<0
<0

DPOS2,040662          % DATA-BLOCK FOR DECCA-POSITION ( LONGITUDE )
<0
<0
T21,TXX2              % POINTERS TO TEXT-BLOCK
T22,TXX3

VARIA,<0              % DATA-BLOCK ( RED SLAVE )
<24.0
<0
<0
0
0
<300.0                % DATA-BLOCK (GREEN SLAVE )
<18.0
<0
<0
0
0
<500.0                % DATA-BLOCK (PURPLE SLAVE )
<30.0
<0
<0
0
0

% CONSTANT-BLOCKS FOR VARIOUS DECCA-CHAINS

KJEDE,<1.22855735  % DECCA-CHAIN 0 (FINMARK )
<0.44512863
<434.99
<190248.
<1.95771299
<652.615
<205628.4
<4.60117019
<746.64
<86299.
<0.105470201

<1.20682257           % DECCA-CHAIN 1 ( LOFOTEN )
<0.27979953
<412.43
<182099.0
<0.801958369
<708.978
<240764.2
<3.89769212
<747.48
<87268.1
<2.61563397

<1.15526454           % DECCA-CHAIN 2 ( HELGELAND )
<0.21763430
<342.69
<149558.9
<6.18500413
<563.98
<153609.6
<3.55468197
<718.7
<76374.6
<1.41254661

<1.10547659           % DECCA-CHAIN 3 ( TRØNDELAG )
<0.14759007
<498.39
<219802.5
<0.621161375
<661.74
<212717.6
<4.09437535
<779.25
<98327.6
<2.16521775

<1.05429364           % DECCA-CHAIN 4 ( VESTLANDET )
<0.08743320
<446.44
```

```
<198575. 8
<0. 03141712
<887. 85
<348635. 8
<4. 64518198
<1014. 0
<182903. 8
<2. 97144195

<1. 02139911         % DECCA-CHAIN 5 ( SKAGERRAK )
<0. 197125484
<241. 45
<105277. 4
<5. 10323147
<509. 27
<121658. 4
<2. 81041858
<804. 39
<106176. 3
<0. 49396504

<0. 97641513         % DECCA-CHAIN 6 ( DANISH )
<0. 18467743
<369. 5
<162044. 8
<2. 30235777
<568. 7
<157121. 0
<4. 01352858
<986. 5
<170657. 4
<6. 09528787

<1. 03079902         % DECCA-CHAIN 7 (NORTH-SCOTTISH )
<-0. 05664689
<374. 7
<184997. 7
<4. 38891582
<588. 7
<169295. 2
<0. 74244835
<1043. 5
<190995. 9
<2. 68823209

)KILL DIN SXS LUP [illegible] [illegible] DECCA TEST1 TEST2 TEST3 NEXT NEXT1 ITERA
)KILL [illegible] UTP2 SL1 T21 T22
)KILL SUBR1 LUP1
```

```
)LINE


% PROGRAM ON LEVEL 11
% THIS LEVEL RECEIVES INTERRUPT-SIGNALS  FROM TELETYPES (INPUT),
% PAPER-TAPE READER, AND  SHIP'S NAVIGATIONAL LOG.
% PROGRAM-TRIGGERED INTERRUPT IS GIVEN TO OTHER LEVELS,DEPENDING ON
%  INTERRUPTING DEVICE.

LEV11,IOT SNI 2
JMP TT1U            % INTERRUPT FROM TELETYPE 1
IOT SNI 4
JMP TT2U            % INTERRUPT FROM TELETYPE 2
IOT SNI 010
JMP TT3U            % INTERRUPT FROM TELETYPE 3
IOT SNI 022
JMP TREAD           % INTERRUPT FROM PAPER-TAPE READER
IOT SNI 0123
JMP TREAD 2         % INTERRUPT FROM NAVIGATIONAL LOG
WAIT
JMP LEV11

TT1U,SAT 3
LDA DV3-K,B
BSET ONE 0110 DA
STA DV3-K,B
JMP TT3U 4

TT2U,SAT 5
LDA DV5-K,B
BSET ONE 0110 DA
STA DV5-K,B
JMP TT3U 4

TT3U,SAT 011
LDA DV11-K,B
BSET ONE 0110 DA
STA DV11-K,B
LDX I (L91
JXZ *3
SKP IF DX EQL ST
JMP *5
STT I (L91
AAT -1
STT I (L92
MST PID
```

```
JMP LEV11

TREAD,LDA DV22-K ,B
JMP TREAD-7
RCLR DA
BSET ONE 0120 DA
IOT  PIN 0123
JMP TREAD-2

)FILL

)KILL LEV11 TT1U TT2U TT3U TREAD


% PROGRAM ON LEVEL 10
% THIS LEVEL IS TRIGGERED BY INTERRUPT FROM THE SHIP'S NAVIGATIONAL
% LOG EVERY CABLE'S LENGTH (0.1 NAUTICAL MILE)

% THIS SUBROUTINE PRODUCES TABLE OF BOTTOM BACK SCATTERING VALUES
% SAMPLED ON LEVEL 14.
BSC,LDX TAB10 6
SAA 3
MPY 4,X
COPY SA DX
LDA I BSCT
NLZ 020
STF BSCT 2
LDF I BSCT 1
FDV BSCT 2
STF I ,X (BSCR
LDF FL0-K,B
STF I BSCT 1
STZ I BSCT
JMP LEV10 3

BSCT,BC
BES
<0
BSCR,<0
<0
<0
<0
<0
<0
<0
<0
<0
<0
```

```
% CALLING SEQUENCE FOR ACTIVATED SUBROUTINES

LEV10,LDA I TAB10 6
AAA 2
JAZ BSC
LDX  TAB10
LDA  T5-K ,B
BSKP ZRO 0100 DA
JPL  I MPX-K ,B
LDX  TAB10 1
LDA  T5-K ,B
BSKP ZRO 0110 DA
JPL  I MPX-K ,B
LDX  TAB10 2
LDA  T5-K ,B
BSKP ZRO 0120 DA
JPL  I MPX-K ,B
LDX  TAB10 4
LDF  1 ,X
FAD  (0.1           % COUNTING OF NAUTICAL MILE
FSB  FLTUS-K,B
BSKP ZRO 0170 DT
FAD  FLTUS-K,B
STF  1 ,X
LDA  4 ,X
RINC DA
SAT  012
SKP  IF DA LST ST
RCLR DA
STA  4 ,X
JAF  UTL10          % EXIT IF NOT FULL MILE
LDX  TAB10 3
LDA  7,X            % SECONDS ELAPSED THIS MILE
STZ  7,X
NLZ  020
STF  016,X
LDF  013,X
FDV  016,X
STF  1,X            % MEAN VELOCITY THIS MILE
LDX  TAB10
LDA  T5-K ,B
BSKP ZRO 0100 DA
JPL  I AV1-K ,B
LDX  TAB10 1
LDA  T5-K ,B
BSKP ZRO 0110 DA
JPL  I AV1-K ,B
```

```
LDX  TAB10 2
LDA  T5-K ,B
BSKP ZRO 0120 DA
JPL  I AV1-K ,B
LDA  T5-K ,B
BSKP ZRO 00 DA
JPL  I TAB10 5
SAA  -1
STA  T3-K ,B
SAA  020
MST  PID              % INTERRUPT TO LEVEL 4 FOR OUTPUT
UTL10,WAIT
JMP  LEV10

TAB10,STEMP           % POINTER TO DATA BLOCK (SEA-SURFACE TEMPERATURE)
SSALI                 % POINTER TO DATA BLOCK (SEA-SURFACE SALINITY)
TRANS                 % POINTER TO DATA BLOCK (SEA-SURFACE TRANSPARENCY)
VELOC                 % POINTER TO DATA BLOCK (SHIP'S SPEED)
LOG                   % POINTER TO DATA BLOCK (SHIP'S NAVIGATIONAL LOG)
ECAD                  % POINTER TO  ECHO-ABUNDANCE SUBROUTINE
LOGG                  % TESTWORD FOR ACTIVATED ECHO-SAMPLING ROUTINE

)FILL

ATEMD,042061          % DATA BLOCK AIR-TEMPERATURE
<0                    % MEAN TEMPERATURE LAST TEN MINUTES
06012                 % MULTIPLEXER CHANNEL (BIT 8-15)
<0                    % LAST OBSERVED VALUE
<0                    % CUMULUTAVIE SUM OF OBSERVED VALUES
<5.
<-3.6

ATEMW,042062          % DATA BLOCK (AIR DEW-POINT TEMPERATURE)
<0
06412
<0
<0
<3.9158
<0.842

APRES,042063          % DATA BLOCK (AIR PRESSURE)
<0
07012
<0
<0
<5.
<1000.
```

```
TRANS,141463          % DATA BLOCK (SEA-SURFACE TRANSPARENCY)
<0
004412
<0
<0
<10.
<0

LUX,141664            % DATA BLOCK (LUXMETER)
<0
0
<0
<0
<0
<0

STEMP,141661          % DATA BLOCK (SEA-SURFACE TEMPERATURE)
<0
03412
<0
<0
<0
<0

SSALI,141662          % DATA BLOCK (SEA-SURFACE SALINITY)
<0
04012
<0
<0
<0
<0

% CONSTANTS FOR THE VARIOUS CHANNELS ON THE TERMO-SALINOGRAPH

TTAB,<2.24719
<-3.05
<1.60514
<5.
<2.24719
<8.
<1.60514
<19.
<1.60514
<26.
```

```
STAB,<1.60514
<20.
<1.60514
<26.
<0.80257
<31.
<0.321027
<36.
<0.321027
<30.96
<0.321027
<32.487
<0.321027
<34.


)KILL BSC LEV10 UTL10 TAB10


% PROGRAM ON LEVEL 9

TDS,LDT TXO 1        % INITIATION OF STD SUBROUTINE
JPL I TXT-K,B
L91
JPL I HTI-K,B
L92
COPY SA DX
LDA DV7-K,B
BSET ONE 0110 DA
STA DV7 -K,B
LDA LV9A 3
JPL I RIO-K,B
LV9A 4
COPY SX DA
JPL I HTO-K,B
LV9A 4
4
JPL I CLF-K,B
LV9A 4
LDA DV7-K,B
BSET ZRO 0110 DA
STA DV7-K,B
LDT TXO 5
JPL I TXT-K,B
L91
JPL I HTI-K,B
L92
```

```
COPY CM2 SA DA
STA C131-K,B
STA C131 2-K,B
LDT TXO 2
JPL I TXT-K,B
L91
LDF SKD-K,B
JPL I DORTE-K,B
L91
2
1
LDT TXO 3
JPL I TXT-K,B
L91
LDF SKT-K,B
JPL I DORTE-K,B
L91
1
2
LDT TXO 4
JPL I TXT-K,B
L91
LDF SKS-K,B
JPL I DORTE-K,B
L91
1
3
JPL I CLF-K,B
L91
LDX LV9A 2
LDF FLO-K,B
STF ,X
STF -33,X
STF -30,X
STF 14,X
SAA -6
STA C131 1-K,B
SAA -1
STA S6-K,B
SAA 020
JMP * 2

SMB,SAA 2            % INTERRUPT TO LEVEL 1 FOR USE OF MAC
ORA ,B
STA ,B
JMP I LEAV2

KORR,LDT TXO 2       % INPUT CALIBRATION DATA STD
```

```
JPL I TXT-K,B
L91
JPL I FLIN-K,B
L92
LDT TXO 3
JPL I TXT-K,B
L91
JPL I FLIN-K,B
L92
STF SKT-K,B
LDT TXO 4
JPL I TXT-K,B
L91
JPL I FLIN-K,B
L92
STF SKS-K,B
JMP I LEAV2

TXO,TXXO              % POINTERS TO TEXT BLOCK
TXX33
TXX35
TXX36
TXX37
TXX23
KODE,041505           % COUNTER FOR CODE IDENTIFICATION
NOTKN,JMP I LV9A 1 % EXIT IF ILLEGAL ABBREVIATION
LV9A,LEV9A
NTKN
TDS1                  % POINTER TO STD DATA BLOCK
041465
7

% TEST-SEQUENCE FOR DESIRED SUBROUTINE


LEV9,LDT TXO
JPL I TXT-K,B
L91
JPL I INP2-K,B        % INPUT ABBREVIATION
L92
SUB KODE
JAP NOTKN
COPY SA DX
JPL  I CLF-K ,B
L91
JPC STDST             % JUMP TO STOP STD
JPC DSTOP             % JUMP TO STOP DECCA
JPC STOP              % JUMP TO STOP ECHO-CLASSIFYING
JPC ESTOP             % JUMP TO STOP ECHO-ABUNDANCE
AAX 177
AAX 165
JPC NOTKN
JPC SMB               % JUMP TO MAC
JPC KORR              % JUMP TO CALIBRATION OF STD
JPC TDS               % JUMP TO START STD
JPC DECIN             % JUMP TO START DECCA
JPC CLAS              % JUMP TO START ECHO-CLASSIFYING
JPC DRD               % JUMP TO START DISPLAY
JPC LOG1              % JUMP TO START NAVIGATIONAL LOG
JPC DRIN              % JUMP TO START DEAD-RECKON
JMP I LV9A

% C-ROUTINES, STOP OF PROGRAMS

ESTOP,LDA T5-K,B  % STOP ECHO-ABUNDANCE
BSET ZRO 00 DA
JMP * 03

STOP,LDA T5-K,B   % STOP ECHO-CLASSIFYING
BSET ZRO 0160 DA
STA T5-K,B
JMP I LEAV2

DSTOP,LDA T1-K,B  % STOP DECCA
BSET ZRO 010 DA
STA T1-K,B
JMP I LEAV2

STDST,LDA T5-K,B  % STOP STD
BSET ZRO 0150 DA
STA T5-K,B
JMP I LEAV2

LEAV2,LEAV1       % EXIT

)KILL KODE NOTKN LV9A ESTOP STOP DSTOP STDST

% B-ROUTINES, START OF PROGRAMS


DECIN,LDA T1-K,B  % INITIATION OF DECCA SUBROUTINE
BSET ZRO 010 DA
STA T1-K,B
```

```
JPL I INIZ
JMP I LEAV2

INIZ,INNLE


CLAS,LDX ECT       % INITIATION OF ECHO-CLASSIFYING SUBROUTINE
LDT ,X
JPL I TXT-K,B
L91
JPL I HTI-K,B
L92
SWAP SX DB
STA I 1,B
SWAP SX DB
AAX 2
LDA ,X
JAF * -012
LDA I ECT 4
NLZ 020
FDV ECT 020
STF I ECT 4
LDA I ECT 6
COPY CM2 SA DA
STA I ECT 6
SAA -050
MPY I ECT 010
STA I ECT 010
LDX ECT 016
STZ I ECT 017,X
JNC *-1
SAA -1
STA S6-K,B
SAA 020
ORA ,B
STA ,B
LDA T5-K,B
BSET ONE 0160 DA
STA T5-K,B
JMP I LEAV2



DRD,LDT ECT -1     % INITIATION OF SIFFER-DISPLAY SUBROUTINE
JPL I TXT-K,B
L91
JPL I HTI-K,B
```

```
L92
LDX T1-K,B
BLDC 0170 DA
BSTA 060 DX
BLDA 00 DA
BSTA 050 DX
STX T1-K,B
JMP I LEAV3


LOG1,LDT TX1 3     % INITIATION OF NAVIGATIONAL LOG SUBROUTINE
JPL I TXT-K,B
L91
JPL I FLIN-K,B
L92
STF LOG 1
DNZ -020
COPY CM2 SA DA
NLZ 020
FAD LOG 1
FMU FL10-K,B
DNZ -020
STA LOG 4
JMP I LEAV3

LOG,041065         % DATA-BLOCK FOR NAVIGATIONAL LOG
<0                 % NAVIGATIONAL LOG COUNTER
0                  % CABLE-LENGTH COUNTER IN CURRENT NAUTICAL MILE


DRIN,LDX TWO 1     % INITIATION OF DEAD RECKON SUBROUTINE
LDT TX1 1
JPL I TXT-K,B
L91
JPL I FLIN-K,B
L92
STF C91-K,B
JPL I FLIN-K,B
L92
FDV ECT 020
FAD C91-K,B
STF 1,X
FMU DTR-K,B
STF 4,X
AAX 7
LDT TX1 2
MI TWO
```

```
JMP DRIN 2
SAA -2
STA TWO
LDA T5-K,B
BSET ONE 013 DA
STA T5-K,B
JMP I LEAV3

TWO,-2                  % LOOP-COUNTER
DRP01                   % POINTER TO LATITUDE (DEAD RECKON POSITION)
TXX24                   % POINTER TO TEXT BLOCK
ECT,ECT 1               % POINTER TO NEXT LOCATION
TXX26                   % POINTER TO TEXT BLOCK
F                       % POINTER TO GAIN (ECHO-CLASSIFYING)
TXX27                   % POINTER TO TEXT BLOCK
PULSR                   % POINTER TO PULSE-RATE (ECHO-CLASSIFYING)
TXX28                   % POINTER TO TEXT BLOCK
ANTAL                   % POINTER TO NUMBER OF FISH TO BEE CLASSIFIED
TXX29                   % POINTER TO TEXT BLOCK
BOKS                    % POINTER TO FRAME (ECHO-CLASSIFYING)
TXX30                   % POINTER TO TEXT BLOCK
LOGG                    % POINTER TO DESIRED SUBROUTINE (ECHO-CLASSIFYING)
TXX31                   % POINTER TO TEXT BLOCK
ANTAL-2
0
-02251                  % TABLE-SPACE FOR ECHO CLASSIFYING
022201                  % UPPER BOUNDERY FOR TABLE (ECHO-CLASSIFYING)
<60.


F1,6
TTAB
STAB
STEMP 013
STEMP 016
SSALI 013
SSALI 016

CLT,DATO                % POINTER TO DATE AND TIME
013770

TX1,TXX1                % POINTERS TO TEXT BLOCK
TXX2
TXX3
TXX4

TX17TXX17
TXX18
TXX19
TXX20


LEAV3,LEAV1             % EXIT


CLOCK,LDT TX17          % INITIATION OF DATE AND TIME SUBROUTINE
JPL  I TXT-K ,B
L91
JPL  I HTI-K ,B
L92
SHA  1
COPY SA DX
JPL  I HTI-K ,B
L92
SHA  6
RADD SA DX
JPL  I HTI-K ,B
BRØ  012
RADD SX D
STA  I CLT
LDT  TX1
JPL  I TXT-K ,B
L91
JPL  I HTI-K ,B
L92
AAA  -014
JAP  * 3
AAA  014
JMP  * 2
MIN  I CLT
SHA  014
COPY SA DX
JPL  I HTI-K ,B
L92
SHA  6
RADD SA DX
JPL  I HTI-K ,B
L92
RADD SX DA
SAX 1
TA   I CLT,X
LDA  CT 1
ORA T5-K,B
ST   T5-K ,B
SAA  -01
```

```
STA  C41 1-K ,B
RCLR DA
BSET ONE 0150 DA
MST  PIE
JMP I LEAV3


THSAL,LDT TX17 1  % INITIATION OF THERMO-SALINOGRAPH SUBROUTINE
JPL I TXT-K,B
L91
JPL I HTI-K,B
L92
LDX F11
MPY F1
RADD SA DX
LDF -6 ,X
STF I F1 3
LDF -3,X
STF I F1 4
LDT TX17 2
JPL I TXT-K,B
L91
JPL I HTI-K,B
L92
LDX F1 2
MPY F1
RADD SA DX
LDF -6,X
STF I F1 5
LDF -3,X
STF I F1 6
JMP I LEAV3


ECST,LDA T5-K,B   % INITIATION OF ECHO-ABUNDANCE SUBROUTINE
BSET ZRO 00 DA
SA T5-K ,B
LDX ECH
LDT TX17 3
JPL I TXT-K,B
L91
LDA LOO4
AAA 067
JPL I RIO-K,B
L91
LDA D3-K,B
JPL I RIO-K,B
L91
LDT ECT 1
JPL I TXT-K,B
L91
JPL I HTI-K,B
L92
COPY SX DL
COPY SA DX
LDF I ECH 4
JXZ * 4
FDV FL10-K,B
AAX -012
JMP *-3
COPY SL DX
STF 012 ,X
AAX 015
JPL I CLF-K,B
L91
MIN LOOP4
JMP ECST 4
SAA -6
STA LOOP4
LDT TX1 3
JPL  I TXT-K ,B
L91
JPL  I HTI-K ,B
L92
COPY CM2 SA DT
STT  I ECH 1
NLZ  020
STF  I ECH 2
SAA  -1
STA  I ECH 3
LDA T5-K,B
BSET ONE 00 DA
STA T5-K ,B
JMP I LEAV3
JMP CLOCK

LOOP4,-6            % LOOP COUNTER
ECH,ECMD1           % POINTER TO ECHO-ABUNDANCE DATA-BLOCK
E1,L3 2             % POINTER TO NO. OF MILES BETWEEN OUTPUT (ECHO-AB.)
E2,L3 3
E3,L3 6
TD31-6

)KILL TDS BEGIN INIT CLAS ECT DRD LOG1 DRIN TWO F1 CLT TX1 TX17 LEAV2
```

```
LEV9A,JPC LOOP4-1 % JUMP TO START DATE AND TIME
JPC THSAL         % JUMP TO START THERMO SALINOGRAPH
JPC ECST          % JUMP TO START ECHO-ABUNDANCE
AAX 177
AAX 166
JPC 9NTKN
JPC CHECK         % JUMP TO REQUEST MULTIPLEXER-CHANNELS
JPC MET           % JUMP TO REQUEST METEOROLOGICAL OBSERVATIONS
JPC OC            % JUMP TO REQUEST SURFACE TEMP. AND SALINITY
JPC COUR          % JUMP TO REQUEST SHIP'S COURSE
JPC SPEED         % JUMP TO REQUEST SHIP'S SPEED
JPC EDEPR         % JUMP TO REQUEST ECHO-DEPTH (BOTTOM)
JPC ULOG          % JUMP TO REQUEST NAVIGATIONAL LOG
JPC CLPRI         % JUMP TO REQUEST TIME
JPC DEPOS         % JUMP TO REQUEST DECCA POSITION
9NTKN,JMP I * 1
NTKN


DEPOS,LDX PSADR   % OUTPUT OF DECCA POSITION
JMP * 2

DRPOS,LDX PSADR 1 % OUTPUT OF DEAD RECKON POSITION
LDT TX2
JPL I TXT-K,B
L91
JPL I KONV-K,B
L91
3
1
LDT TX3
AAX 7
MIN PSADR 2
JMP * -11
SAA -2
STA PSADR 2
JMP LEAV1

PSADR,DPOS1 1     % POINTER TO DECCA POSITION
DRPO1 1           % POINTER TO DEAD RECKON POSITION
-2                % LOOP-COUNTER
BTMDP 1           % POINTER TO ECHO-DEPTH
VELOC 4           % POINTER TO CURRENT SHIP'S SPEED
COURS 1           % POINTER TO SHIP'S COURSE
MPX2              % POINTER TO INPUT ROUTINE FOR MULTIPLEXER
STEMP             % POINTER TO SURFACE TEMPERATURE DATA-BLOCK
SSALI             % POINTER TO SURFACE SALINITY DATA-BLOCK
APRES 1           % POINTER TO AIR PRESSURE
ATEMD 1           % POINTER TO AIR TEMPERATURE
ATEMW 1           % POINTER TO DEW POINT TEMPERATURE
WNDF 1            % POINTER TO WIND FORCE
WNDD 1            % POINTER TO WIND DIRECTION
LOG 1             % POINTER TO NAVIGATIONAL LOG


CLPRI,LDT TX2-1   % OUTPUT OF TIME
JPL I TXT-K,B
L91
JPL I TIME-K,B
L91
JMP LEAV1

ULOG,LDX PSADR 16 % OUTPUT OF NAVIGATIONAL LOG
LDT TX4
JMP COUR 2

EDEPR,LDX PSADR 3 % OUTPUT OF ECHO-DEPTH
LDT TX9
JMP COUR 2

SPEED,LDX PSADR 4 % OUTPUT OF SHIP'S SPEED
LDT TX5
JPL I TXT-K,B
L91
LDF ,X
FMU 7,X
JMP COUR 5

TXX1              % POINTERS TO TEXT-BLOCK
TX2,TXX2
TX3,TXX3
TX4,TXX4
TX5,TXX5
TX9,TXX9
TX10,TXX10
TXX38
TXX39
TXX40

COUR,LDX PSADR 5  % OUTPUT OF SHIP'S COURSE
LDT TX10
JPL I TXT-K,B
L91
```

```
LDF ,X
JPL I DORTE-K,B
L91
4
01
JMP LEAV1

OC,LDT TX10 1      % OUTPUT OF SEA SURFACE TEMPERATURE AND SALINITY
JPL I TXT-K,B
L91
LDX PSADR 7
JPL MPX3
JPL I DORTE-K,B
L91
3
2
LDT TX10 2
JPL I TXT-K,B
L91
LDX PSADR 10
JPL MPX3
JPL I DORTE-K,B
L91
3
3
JMP LEAV1

MET,LDT TX10 3    % OUTPUT OF METEOROLOGICAL OBSERVATIONS
JPL I TXT-K,B
L91
SAA -5
STA MET1 1
LDX MET1
SWAP SX DB
LDF I ,B
SWAP SX DB
JPL I DORTE-K,B
L91
5
1
MIN MET1 1
JPC *-010
JMP LEAV1

MET1,PSADR 011
0
```

```
CHECK,IOT ACT 52  % OUTPUT OF MULTIPLEXER CHANNELS
SAX -030
COPY SX DA
AAA 30
JPL I PSADR 6
JPL I HTO-K,B
L91
5
JPL I CLF-K,B
L91
JNC * -010
IOT ACT 52
JPL I HTO-K,B
L91
5
JMP LEAV1


NTKN,LDT TX32      % OUTPUT IF UNKNOWN ABBREVIATION IS USED
JPL I TXT-K,B
L91


LEAV1,JPL I CLF-K,B
L91
SAX 3
LDA L91
LDT DV3-K,B
BSKP ZRO 010 DA
BSET ZRO 0110 DT
BSKP ZRO 0110 DT
STX  L91
STT DV3-K,B
AAX 2
LDT DV5-K,B
BSKP ZRO 020 DA
BSET ZRO 0110 DT
BSKP ZRO 0110 DT
STX  L91
STT DV5-K,B
AAX 4
LDT DV11-K,B
BSKP ZRO 030 DA
BSET ZRO 0110 DT
BSKP ZRO 0110 DT
STX  L91
```

```
STT DV11-K,B
LDX L91
AAX -1
STX L92
AAX 1
SKP IF DA EQL SX
JMP * 6
STZ L91
LDA ,B
STZ ,B
MST PID
WAIT
JMP I LEV9B

MPX3,LDA 4,X
SHA ZIN SHR 010
COPY SA DD
IOT ACT SKA 050
JMP *-1
COPY SD DA
IOT ACT SKA 050
JMP *-1
SHA 4
SHA SHR 4
NLZ 020
FDV MPF-K,B
FMU 013,X
FAD 016,X
EXIT

TX32,TXX32

L91,0                  % CURRENT OUTPUT DEVICE FOR THIS LEVEL
L92,0                  % CURRENT INPUT DEVICE FOR THIS LEVEL
LEV9B,LEV9

% TEXT-BLOCK

TXX0,'
YES?
'
TXX1,'TIME '
TXX2,'LAT '
TXX3,'LONG '
TXX4,'LOG '
TXX5,'SPD '
TXX6,'STMP '
TXX7,'SSAL '
TXX8,'TRSP '
TXX9,'DPT '
TXX10,'CRS '
TXX11,'PRES '
TXX12,'AIRT'
TXX13,'DEWP'
TXX14,'LUXM '
TXX15,'WF '
TXX16,'WDIR '
TXX17,'DATE '
TXX18,'TEMP-RANGE: '
TXX19,' SAL-RANGE: '
TXX20,'CH NO '
TXX23,'
OBSERVATIONS. '
TXX24,'DR=-1 DEC=1 DIS=0 '
TXX25,'
RED    GREEN  PURPLE
'
TXX26,'GAIN '
TXX27,'
PULS-RATE '
TXX28,'
TOTAL '
TXX29,'
FRAME '
TXX30,'
PROGRAM '
TXX31,'
MAX DB '
TXX32,'
NOT KNOWN'
TXX33,'

ST NO '
TXX34,'
DEPTH    TEMP.    SAL.   SIGMA-T  D-ALFA  DELTA-D
'
TXX35,'
CORRECTION FOR DEPTH. '
TXX36,'  TEMPERATURE. '
TXX37,'  SALINITY. '
TXX38,'
SEA SURFACE TEMPERATURE. '
TXX39,'  SALINITY. '
TXX40,'
 PRESSURE  TEMP.  DEW-P.  W-FORCE  W-DIR.
'
```

```
)KILL LEAV3 CLOCK THSAL ECST LOOP4 CHNO ECH DEPOS DRPOS PSADR TX2 TX3
)KILL CLPRI EDEPR SPEED TX5 COUR TX9 TX10 CHECK NTKN LEAV1 TXS2
)KILL LEV9B F PULSR  BOKS LEV9A KORR

% PROGRAM ON LEVEL 8.  THIS LEVEL IS NOT USED.
LEV8,WAIT
JMP *-1

% PROGRAM ON LEVEL 7

% IDENTIFICATION OF INTERUPTING OUTPUT DEVICES

LEV7,IOT SNI 3
JMP TT1             % INTERRUPT FROM TELETYPE 1
IOT SNI 5
JMP TT2             % INTERRUPT FROM TELETYPE 2
IOT SNI 011
JMP TT3             % INTERRUPT FROM TELETYPE 3
IOT SNI 7
JMP TAL1            % INTERRUPT FROM PAPER TAPE PUNCH 1
IOT SNI 017
JMP TAL2            % INTERRUPT FROM PAPER TAPE PUNCH 2

WAIT
JMP LEV7

TT1,LDA DV3-K,B
IOT PIN 2
MST PID
JMP LEV7

TT2,LDA DV5-K,B
IOT PIN 4
JMP TT1 2

TT3,LDA DV11-K,B
IOT PIN 010
JMP TT1 2
TAL1,LDA DV7-K,B
JMP TT1 2
TAL2,LDA DV17-K,B
JMP TT1 2

)KILL LEV7 TT1 TT2 TT3 TAL1 TAL2

% PROGRAM ON LEVEL 6.  THIS LEVEL IS NOT USED.
LEV6,WAIT
JMP *-1

)LINE

% LEVEL 5

% OUTPUT OF STD-DATA ON PAPER TAPE
% LISTING AND PLOTTING OF ECHO CLASSIFICATION DATA

TARGX,<0                % X-COORDINATE FOR PLOTTING
TARGY,<0                % Y-COORDINATE FOR PLOTTING
TARGP,2                 % PLOT PEN UP OR DOWN
TADR,ADR 1              % POINTER TO HEADING
TDATA,TDS1 011          % POINTER TO STD-DATA, PUNCH
7                       % OUTPUT DEVICE
041466                  % IDENTIFICATION CODE, STD

STDPC,LDA DV7-K,B       % PUNCH ROUTINE, STD
BSET ONE 050 DA
STA DV7-K,B
LDA TDATA 2
JPL I RIO-K,B
TDATA 1
SAX -011
STZ * 5
LDF I TDATA,X
JPL I DORTE-K,B
TDATA 1
4
0
SAA 2
STA *-2
SAA 040
JPL I RIO-K,B
TDATA 1
AAX 2
JNC *-013
JPL I CLF-K,B
TDATA 1
LDA DV7-K,B
BSET ZRO 050 DA
STA DV7-K,B
WAIT
```

```
LEV5,LDA T5-K,B      % IDENTIFICATION OF ENTRY
BSKP ZRO 0150 DA
JMP STDPC            % JUMP TO PUNCH ROUTINE, STD
BSKP ONE 0160 DA
JMP LEV5 -1          % EXIT
LDA I (LOGG
BSKP ZRO 0170 DA
JMP TARGU            % JUMP TO LISTING, ECHO STRENGTH SPECTER
LDA DV11-K,B         % LISTING, ECHO CLASSIFICATION
BSET ONE 050 DA
STA DV11-K,B
LDT TARGP 1
```

```
JPL I TXT-K ,B
DEK
LDA DV11-K,B
BSET ZRO 050 DA
STA DV11-K,B
RCLR DA
BSET ONE 0170 DA
MST  PIE
WAIT
MCL  PIE
SHA  ZIN SHR 2
```

```
AAA  -050
STA  ADR
LDA T5-K,B
BSKP ONE 0160 DA
JMP LEV5 -1
LDA DV11-K,B
BSET ONE 050 DA
STA  DV11-K ,B
SAX  -5
LDA  I ADR ,X
JPL  I HTO-K ,B
DEK
3
JNC  * -4
SAA 040
JPL I RIO-K,B
DEK
BSET ONE 0150 DX
STX  ADR
LDX  I (PING
COPY CM2 SX DX
LDA  I ADR ,X
JPL  I HTO-K ,B
DEK
2
RINC DX
JNC  * -5
JPL  I CLF-K ,B
DEK
LDA I (LOGG
JAZ * 035              % JUMP TO AVOID PLOTTING
LDX (023000
LDA ,X
NLZ 020
FDV (102.3
STF TARGY
JPL I TRACE-K,B
TARGX
TARGY
TARGP
LDF TARGX
FAD (0.1
STF TARGX
LDA I (PING 7
SKP IF DX GRE SA
JPC * -015
LDF FLO-K,B
STF TARGX
```

```
JPL I TRACE-K,B
TARGX
TARGY
TARGP
LDF FL4-K,B
BSET ONE 0170 DT
STF TARGY
JPL I TRACE-K,B
TARGX
TARGY
TARP
MIN  I (ANTAL
JMP LEV5 016
JMP NN1

)FILL

TARGU,RCLR DA          % LISTING OF ECHO STRENGTH SPECTER
BSET ONE 0170 DA
MST PIE
WAIT
MCL PIE
LDA DV11-K,B
BSET ONE 050 DA
STA DV11-K,B
SAX -0200
STZ TAR
RCLR DB
BSET ONE 0150 DB
BSET ONE 0120 DB
BSET ONE 070 DB
RADD SX DB
LDA ,B
STZ ,B
STA TAR 1
LDT DEK 1
COPY ST DB
JAZ * 025
JPL I HTO-K,B
DEK
5
LDA TAR 1
SUB TAR
JAP * 2
RCLR DA
LDT TAR
RADD SA DT
STT TAR
JPL I HTO-K,B
DEK
5
SAA -0200
RSUB SX DA
JPL I HTO-K,B
DEK
5
JPL I CLF-K,B
DEK
JNC TARGU 012
LDA T5-K,B
BSET ZRO 0160 DA
STA T5-K,B
LDA DV11-K,B
BSET ZRO 050 DA
STA DV11-K,B
JMP I TABS 5
TAR,0                  % TEMPORARY STORAGE
0                      % TEMPORARY STORAGE
ADR,0
'
 DYP  FV  C  MAX  DT  DB
'
DEK,011                % OUTPUT DEVICE
TABS,K                 % BASE ADDRESS, COMMON AREA
0
0
737                    % SIZE OF TABLE
TARP,-3                % PLOT PARAMETER
LEV5 -1                % EXIT
PD11                   % POINTER TO PAGING ROUTINE

NN1,JPL I TABS 6       % LISTING OF FINAL TABLE, ECHO CLASSIFICATION
SAT  017
LDX  ADR
COPY SX DB
AAB  0177
AAB  055
RCLR DA
SAX  036
JXZ  * 4
ADD  ,X ,B
RDCR  DX
JMP  * -3
STA  037  ,B
AAB  040
RDCR DT
```

```
SKP  IF DT EQL 0
JMP  * -012
LDX  ADR
BSET ONE 070 DX
SAA  017
COPY SA DL
AAX  -3
LDA  -1 ,B
NLZ  020
STF  ,X
AAB  -040
RDCR DL
SKP  IF DL EQL 0
JMP  * -7
AAB  -054
COPY SB DL
AAB  -055
RCLR DX
LDF  ,B
STF  -055 ,B
FMU  055 ,X ,B
BSET BCM 0170 DT
AAX  3
FAD  ,X ,B
STF  ,X ,B
COPY SX DA
RADD SB DA
SKP  IF DA EQL SL
JMP  * -012
AAB  3
SKP  IF DB EQL SL
JMP  * -016
COPY SB DX
SAA  017
COPY SA DL
AAX  -0132
AAB  0114
LDF  ,X
DNZ  -020
STA  ,B
AAX  3
AAB  040
RDCR DL
SKP  IF DL EQL 0
JMP  * -7
LDA  TABS
COPY SA DB
AAX  0132
```



```
SAA  -040
RINC DA
STA  TABS 1
SAA  -017
RINC DA
STA  TABS 2
LDA  ,X
JPL  I HTO-K ,B
DEK
2
AAX  040
LDA  TABS 2
JAF  * -010
JPL  I CLF-K ,B
DEK
LDA  TABS 3
RSUB SA DX
LDA  TABS 1
JAF  * -021
JMP  TAR -010

)KILL TARGX TARGY TARGP TDATA STDPC LEV5 TARGU TAR ADR DEK TABS TARP
)KILL NN1 ANTAL PING TADR

% LEVEL 4

% LISTING EVERY WHOLE HOUR, INTERRUPT FROM REAL-TIME CLOCK
% LISTING EVERY WHOLE MILE OUTSAILED DISTANCE, INTERRUPT FROM
% NAVIGATIONAL LOG



LEV4,MIN S6-K,B
JMP LO                % OUTPUT ON TELETYPE 2 AND PUNCH 2
LDD DV7-K,B           % OUTPUT ON TELETYPE 3 AND PUNCH 1
BSET ONE 040 DA
BSET ONE 040 DD
STD DV7-K,B
SAA 7
STA DEVHP
SAA 011
STA  DEVTT
JPL  I DAG
LDA  LOADR 1
STA  C42-K ,B
STA  C42 1-K ,B
JPL  I HHP17
```

```
LDX  LOADR
JPL  I TXTHH
JPL  I TTTS
LDX  C131 1-K ,B
JXZ  * 5
LDT  DAG 1
JPL  I TXT-K ,B
DEVTT
STZ  C131 1-K ,B
SAA  17
STA  DEVHP
SAA  05
STA  DEVTT
LDD DV7-K,B
BSET ZRO 040 DA
BSET ZRO 040 DD
STD DV7-K,B
JXZ  * 5
LDA  T5-K ,B
BSET ONE 0150 DA
STA  T5-K ,B
JXN  * 3
SAA  040
MST  PID                   % INTERRUPT TO LEVEL 5
JMP  LEV4

DAG,DATUM                  % POINTER TO OUTPUT ROUTINE FOR DATE
TXX34                      % POINTER TO TEXT
LO,LDD DV5-K,B
BSET ONE 040 DA
BSET ONE 040 DD
STD DV5-K,B
MIN T3-K,B
JMP L1                     % WHOLE HOUR
IOT ACT 5                  % WHOLE NAUTICAL MILE
LDF LOADR
MIN I DEVTT 1
JMP * 5
IOT ACT 011
LDX T5-K,B
BSET ONE 010 DX
STX T5-K,B
JMP * 5
L1,MIN T4-K,B
JMP LOWTP
IOT ACT 5
LDF TIADR
STD C42-K,B
```

```
STT TEST
JPL I HHP17
LDA LOADR
SUB TEST
JAF * 4
JMP * 1
SAA 010
MST PID                    % INTERRUPT TO LEVEL 3
PAGE,SAA 012               % PAGING ROUTINE
ADD C41 1-K,B
JAN * 012
SAA 012
JPL I RIO-K,B
DEVTT
MIN C41 1-K,B
JMP *-4
JPL I DAG
SAA -0100
STA C41 1-K,B
STA TEST 1
LDD TEST
STA TEST 1
REXO SD DA
JAZ * 5
LDX TEST
JPL I TXTHH
MIN C41 1-K,B
MIN C41 1-K,B
JPL I TTTS
MIN C41 1-K,B
JMP LEV4
LOADR,ADRLO                % POINTER TO HEADING, LOG PRINT OUT
LDLG                       % POINTER TO ADRESS BLOCK FOR DATA
LDLG
TIADR,ADRTI                % POINTER TO HEADING, HOUR PRINT OUT
TDLG                       % POINTER TO ADRESS BLOCK FOR DATA
TDLG
TEST,0                     % DECISION OF OUTPUT DEVICE FOR HEADING
0
HHP17,HP17                 % POINTER TO OUTPUT, PUNCH
ABDNC                      % POINTER TO OUTPUT ON PUNCH, ECHO ABUNDANCE
TXTHH,TXTHD                % POINTER TO ROUTINE FOR OUTPUT OF HEADINGS
TTTS,TTS                   % POINTER TO OUTPUT OF DATA, TELETYPE
DEV3,3                     % DEVICE NUMBER
DEVHP,17                   % DEVICE NUMBER
DEVTT,5                    % DEVICE NUMBER
LADR,L3 2                  % POINTER TO OUTPUT RATE, ECHO ABUNDANCE
LOWTP,LDD DV5-K,B
```

```
BSET ZRO 040 DA
BSET ZRO 040 DD
STD DV5-K,B
WAIT                % EXIT
JMP LOADR-1

%HEADINGS FOR HOUR AND LOG PRINT OUT.

TXTHD,COPY SL DA
STA  C41-K ,B
JPL  I CLF-K ,B
DEVTT
 LDT  ,X
JPL  I TXT-K ,B
DEVTT
COPY  AD1 SX DT
LDX  1 ,X
JXZ  * 7
DEVTT
JNC  *-3
COPY AD1 ST DX
JMP  TXTHD 4
JPL  I CLF-K ,B
DEVTT
JMP I C41-K,B

ADRLO,TXX1          % ADDRESS BLOCK LOG HEADING
-3
TXX2
-6
TXX3
-3
TXX4
-3
TXX5
-2
TXX6
-1
TXX7
-1
TXX8
-1
TXX9
-1
TXX10
0

ADRTI,TXX1          % ADDRESS BLOCK HOUR HEADING
-3
TXX2
-6
TXX3
-3
TXX4
-2
TXX11
-2
TXX12
-2
TXX13
-1
TXX14
-2
TXX15
-2
TXX16
0


%HOUR AND LOG OUTPUT ON PAPER TAPE PUNCH.

HP17, COPY SL DA
STA  C41-K ,B
LDA  DKL
JPL  I RIO-K ,B
DEVHP
JPL  I TIME-K ,B
DEVHP

POS,  LDX  DP022
LDA  T1-K ,B
BSKP ONE 010 DA
LDX  DRPOS2
SAA  -2
STA  C41 2-K ,B
LDA  ,X
JPL  I RIO-K ,B
DEVHP
LDF  1,X
JPL I DORTE-K,B
DEVHP
3
3
SAA  040
JPL  I RIO-K ,B
DEVHP
```

```
AAX
MIN  C41 2-K ,B
JMP  POS 6

LLOGO,LDX  I C42-K ,B
MIN  C42-K ,B
JXZ  * 015
LDA  ,X
JPL  I RIO-K ,B
DEVHP
LDF  1 ,X
JPL  I DORTE-K ,B
DEVHP
4
1
SAA  040
JPL  I RIO-K ,B
DEVHP
JMP  LLOGO

LDX  I C42-K ,B
MIN  C42-K ,B
JXZ  * 015
LDA  ,X
JPL  I RIO-K ,B
DEVHP
LDF  1 ,X
JPL  I DORTE-K ,B
DEVHP
5
0
SAA  040
JPL  I RIO-K ,B
DEVHP
JMP  *-016
JPL  I CLF-K ,B
DEVHP
JMP  I C41-K ,B

DPO22,DPOS1          % POINTER TO DECCA POSITION
DRPOS2,DRPO1         % POINTER TO DEAD RECKON POSITION
DKL,043461           % DATA IDENTIFICATION, TIME


%HOUR AND LOG PRINTOUT ON TELETYPE.

TT5, COPY SL DA
STA  C41-K ,B
JPL  I TIME-K ,B
DEVTT

TPOS,LDX  DPO22
LDA  T1-K ,B
BSKP ONE 010 DA
LDX  DRPOS2
AAX  1
JPL  I KONV-K ,B
DEVTT
2
1
AAX  7
LDA DB-K,B
JPL I RIO-K,B
DEVTT
JPL  I KONV-K,B
DEVTT
2
1
SAA  040
JPL  I RIO-K ,B
DEVTT

TLOGO,LDX  I C42 1-K ,B
MIN  C42 1-K ,B
JXZ  * 7
LDF  1 ,X
JPL  I DORTE-K ,B
DEVTT
3
1
JMP  TLOGO
LDX  I C42 1-K ,B
JXZ  * 010
LDF  1 ,X
JPL  I DORTE-K ,B
DEVTT
4
0
MIN  C42 1-K ,B
JMP  *-010
JPL  I CLF-K ,B
DEVTT
JMP  I C41-K ,B

% POINTERS TO DATABLOCKS, HOUR PRINTOUT
```

```
TDLG,LOG                % NAVIGATIONAL LOG
APRES                   % AIR PRESSURE
ATEMD                   % AIR TEMPERATURE
ATEMW                   % DEW POINT
LUX                     % RADIATION
0
WNDF                    % WIND FORCE
WNDD                    % WIND DIRECTION
0

% POINTERS TO DATABLOCKS, LOG PRINTOUT


LDLG,LOG                % NAVIGATIONAL LOG
VELOC                   % SHIP'S SPEED
STEMP                   % SEA SURFACE TEMPERATURE
SSALI                   % SEA SURFACE SALINITY
TRANS                   % TRANSPARENCY
0
BTMDP                   % ECHO DEPTH
COURS                   % SHIP'S COURSE
0


% ROUTINE FOR OUTPUT OF DATE ON TELETYPE AND PAPER TAPE

DATUM,COPY SL DA
STA C41-K,B
LDA  DDT
JPL  I RIO-K ,B
DEVHP
JPL  I DATE-K ,B
DEVHP
JPL  I CLF-K ,B
DEVHP
LDT  (TXX17
JPL  I TXT-K ,B
DEVTT
JPL  I DATE-K ,B
DEVTT
JMP I C41-K,B

DDT,043462              % DATA IDENTIFICATION, DATE
0
ECMD1                   % POINTER TO DATA BLOCK, ECHO ABUNDANCE

% ROUTINE FOR OUTPUT OF ECHO ABUNDANCE, PAPER TAPE
```

```
ABDNC,COPY SL DA
STA C41-K,B
SAX -7
STX DDT 1
LDX DDT 2
LDA ,X
JPL I RIO-K,B
DEVHP
LDF 1,X
JPL I DORTE-K,B
DEVHP
6
0
SAA 040
JPL I RIO-K,B
DEVHP
AAX 015
MIN DDT 1
JMP ABDNC 5
JPL I CLF-K,B
DEVHP
JMP I C41-K,B

)FILL

)KILL LEV4 DAG L0 L1 PAGE LOADR TIADR TEST HHP17 TXTHH TTT5 DEVS
)KILL DEVHP DEVTT LOWTP TXTHD ADRLO ADRTI HP17 POS LLOGG DP022
)KILL DRPO82 DKL TT5 TPOS TLOGG TDLG LDLG DATUM DDT ABDNC LADR



%PROGRAM ON LEVEL 3.

% LISTING OF ECHO ABUNDANCE DATA
% LISTING OF STD DATA
% LISTING OF BOTTOM BACK SCATTERING


LEV3,LDA  T5-K ,B
BSKP ZRO 0150 DA
JMP TDS3                % LISTING OF STD DATA
BSKP ZRO 010 DA
JMP ECMD                % LISTING OF ECHO ABUNDANCE DATA
LDA I (LOGG
AAA 2
JAZ BSCO                % LISTING OF BOTTOM BACK SCATTERING
WAIT                    % EXIT
```

```
JMP LEV3
ECMD,BSET ZRO 010 DA % ECHO ABUNDANCE OUTPUT
JPL L3SUB
LDF  L3 3
DNZ  -020
COPY CM2 SA DA
STA  L3 2
MIN  L3 6
JMP  * 2
JPL  PD11
JPL I TIME-K,B
L3
LDF  I (LOG 1
JPL  I DORTE-K ,B
L3
5
0
LDX  (ECMD1 4
LDF  ,X
STZ  ,X
STZ  1 ,X
STZ  2 ,X
FDV  L3 3
JPL I DORTE-K,B
L3
5
0
AAX 015
MIN L3 1
JMP *-13
SAA -7
STA L3 1
JPL I CLF-K,B
L3
LDA DV11-K,B
BSET ZRO 030 DA
STA DV11-K,B
JMP LEV3 5
BSCO,LDA T5-K,B      % BOTTOM BACK SCATTERING OUTPUT
JPL L3SUB
SAX -036
LDF I ,X (BSCR 036
JPL I DORTE-K,B
L3
3
0
AAX 2
JNC *-6
```

```
JMP * 020
TDS3,JPL L3SUB        % STD OUTPUT
LDX TDS4
LDA C131 2-K,B
STA TDS4 1
STZ * 5
LDF ,X
JPL I DORTE-K,B
L3
4
0
SAA 2
STA * -2
AAX 3
MIN TDS4 1
JMP * -011
JPL I CLF-K,B
L3
LDA DV11-K,B
BSET ZRO 030 DA
STA DV11-K,B
JMP LEV3 010
L3,11                 % DEVICE NUMBER
-7                    % PARAMETER COUNTER FOR OUTPUT
-1                    % PRINTOUT RATE (NAUTICAL MILES)
<0                    % NUMBER OF NAUTICAL MILES BETWEEN OUTPUTS
-1                    % LINE COUNTER, PAGING
0                     % TEMPORARY STORAGE
PD11,COPY SL DA       % ROUTINE FOR PAGING
STA  L3 7
SAX  -012
SAA  012
JPL  I RIO-K ,B
L3
JNC  *-3
JPL  I DATE-K ,B
L3
JPL  I CLF-K,B
SAA  012
JPL  I RIO-K ,B
L3
SAA  -70
STA  L3 6
JMP  I L3 7

L3SUB,BSET ZRO 0160 DA % WAIT IF TELETYPE BUSY
STA T5-K,B
LDA DV11-K,B
```

```
BSKP ZRO 050 DA
JMP * -2
BSET ONE 030 DA
STA DV11-K,B
EXIT

TDS4,TDS1 -030        % POINTER TO DATABLOCK, STD
0                     % PARAMETER COUNTER FOR OUTPUT

)FILL

)KILL LEV3 ECMD BSCO TDS3 L3 FD11 L3SUB TDS4 LOGG ECMD1 BSCR

% LEVEL 2. THIS LEVEL NOT USED

LEV2,WAIT
JMP * -1


% LEVEL 1

OFF,SAA -1            % EXIT FROM MAC (ASSEMBLER)
STA LEV1 1
WAIT                  % EXIT FROM LEVEL 1
LEV1,SMIL             % ACCESS TO ASSEMBLER
0

% LEVEL 0
% WAITING MODE

LEV0,LDA LEV1 1
JAZ * 3
STZ LEV1 1
IOT PIN 2
JMP * -4

)KILL LEV2 LEV1 LEV0

)LINE
```

APPENDIKS 2

Beskrivelse av en regneprosedyre til å konvertere DECCA-avlesninger til geografiske koordinater.

Av

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INTRODUKSJON

DECCA Navigasjonssystem er nå fullt utbygget langs Norges kyst med i alt seks kjeder. Denne rapport presenterer rutiner for konvertering fra Decca-koordinater til geografiske koordinater. Bare selve verktøyet (ligningene) er tatt med, uten de teoretiske utledninger.

PARAMETERLISTE

b = basislengde fra master til slave (redusert).

r = avstand fra master til punktet P.

r_r = avstand fra master til punktet P (redusert).

θ = vinkelen fra rett nord til linjen gjennom P.

A = vinkelen fra rett nord til linjen gjennom slaven.

T = Legendres vinkelkorreksjon.

R = $\frac{1}{r}$

l = linjetallet, index M ved master og S ved slave.

RLN = riktig linjenummer.

ALS = antall linjer i sonen.

AVK = avlest kodetall.

Z = tall som avløser kodebokstaven.

L_o = masters geografiske lengde.

$\emptyset_o$ = masters geografiske bredde.

L_s = slavens geografiske lengde.

$\emptyset_s$ = slavens geografiske bredde.

U = redusert geografiske bredde.

E = $\frac{c}{a}$ = 0.996659151, eksentrisiteten.

$\Delta\emptyset$ = breddekoordinat i forhold til master.

ΔL = lengdekoordinat i forhold til master.

a = jordens store akse.

c = jordens lille akse.

a' = jordens radius avhengig av breddegraden, $a' = a \cos \emptyset_o$.

1. GEOMETRIEN

Den bygger på et teorem av Legendre som sier at en sfærisk trekant kan behandles som en plan hvis vinklene reduseres med;

$$T = \frac{1}{6} \cdot b \cdot r_r \cdot \sin(\theta - A) \qquad (1)$$

Dette er $\frac{1}{3}$ av den sfæriske flate, og T kommer ut i radianer.

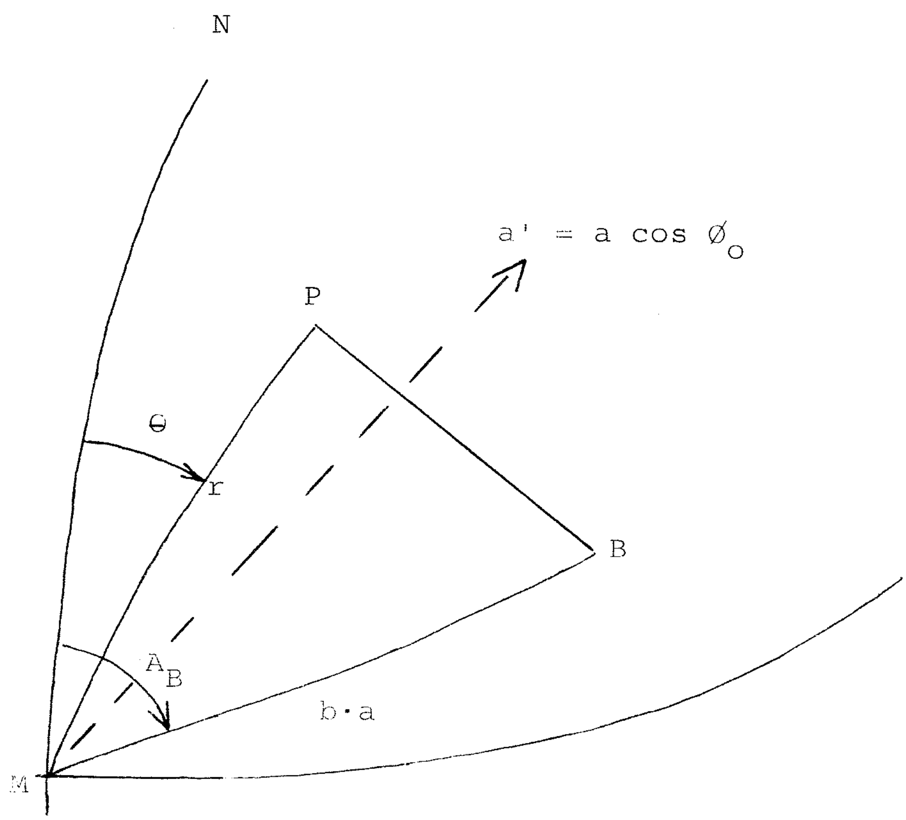


Fig. 1.

På fig. 1 er den sfæriske trekanten utspent av M (master), B (slave) og P som er det aktuelle punktet vi ønsker å bestemme.

Ved å bruke cosinus-satsen og hyperbelbetingelsene kan man stille opp følgende ligninger:

$$PB^2 = MB^2 + MP^2 - 2MB \cdot MP \cdot \cos(PMB - T_B) \qquad (2)$$

Ut fra hyperbelbetingelsen defineres en størrelse X_B,

$$X_B = \frac{PB - PM}{MB} \qquad (3)$$

som er konstant for vedkommende hyperbel.

Løses nå (2) med hensyn på cos $(PMP - T_B)$, fåes

$$\cos\ (PMB - T_B) = \frac{MB^2 + MP^2 - PB^2}{2 \cdot MB \cdot MP} \qquad (4)$$

Av ligning (3) finnes PB:

$$PB = X_B \cdot MB + PM$$

$$PB^2 = X_B^2\ MB^2 + PM^2 + 2X_B \cdot MB \cdot PM$$

Dette settes inn i (4), og det hele reduseres til:

$$\cos(\theta - A_B - T_B) = \frac{MB}{2} \cdot \frac{1 - X_B^2}{MP} - X_B \qquad (5)$$

Vi definerer to nye størrelser for å få ligningen litt penere:

$$Y_B = \frac{MB}{2}\ (1 - X_B^2)$$

$$R = \frac{1}{MP}$$

Innsatt i (5) blir resultatet:

$$\cos(\theta - A_B - T_B) = Y_B \cdot R - X_B \qquad (6)$$

Tilsvarende ligninger fåes mot de andre slavene i kjeden, så ligningssettet blir følgende:

$$\cos(\theta - A_B - T_B) = y_B \cdot R - X_B$$

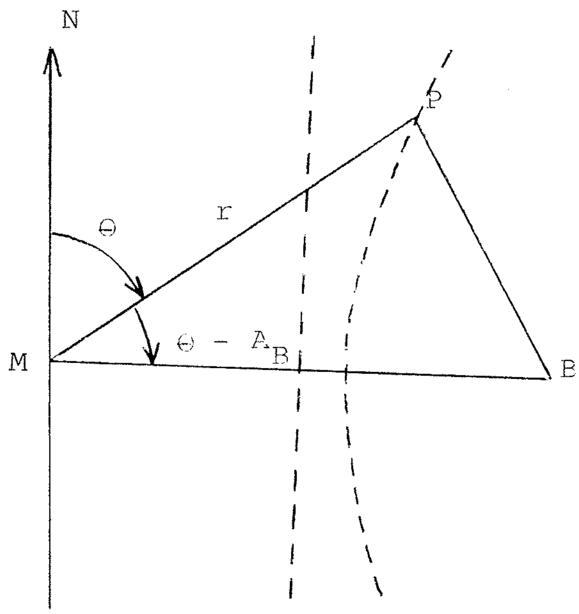
$$\cos(\theta - A_C - T_C) = y_C \cdot R - X_C \qquad (7)$$

$$\cos(\theta - A_D - T_D) = y_D \cdot R - X_D$$

Disse ligningene er transcendente, og ligningssettet overbestemmer θ og R. Regneprosedyren baseres bare på to av dem.

2. BESTEMMELSE AV X

X er tidligere definert (lign.(3)) ut fra hyperbelbetingelsene slik at X er konstant for hver hyperbelgren. Fig.2 viser en slik hyperbelgren som går gjennom P.



Alle punkter på hyperbelen gjennom P har samme X og følgelig samme Y. Videre må X forandre seg lineært mellom master og slave. Det kan skrives:

$$X = p \cdot l + q \qquad (8)$$

der l = linjetallet for hyperbelen.

Tenker en seg hyperbelen gjennom M og slik at P ligger i M, blir PM = O og PB = MB og følgelig $X_M = +1$. Legges P i B, finner vi $X_B = -1$. Av (8) kan det dermed settes opp to ligninger for å bestemme p og q:

$$\text{I master:} \quad +1 = p \cdot l_M + q$$

$$\text{I slave:} \quad -1 = p \cdot l_S + q \tag{9}$$

Dette fører til: $p = \dfrac{2}{l_M - l_S}$

$$q = 1 - \frac{2}{l_M - l_S} \tag{10}$$

3. BESTEMMELSE AV LINJETALLET l

I en DECCA-avlesning er det en koding med en bokstav som angir sonenummer, og et tall som viser hvilken slave det leses mot og linjetallet i den bestemte sonen.

Sonene starter med master og vanligvis med bokstaven A. Det kan visstnok også begynne med andre bokstaver (Dansk kjede ?). Vanligvis er det 10 soner mellom master og slave, men det kan også være flere, og da begynnes det igjen på bokstaven A.

Masters linjetall mot de forskjellige slaver er som følger:

Master mot slave B: $l_M = 0$
" " " C: $l_M = 300$
" " " D: $l_M = 500$

For å finne riktig linjenummer må følgende gjøres:

$$RLN = Z \quad ALS_S + AVK - \frac{9\ l_M}{10}$$

RLN = riktig linjenummer
ALS = antall linjer i sonen (varierer)
AVK = avlest kodetall
Z = tall som avløser bokstaven i koden

Eks.: Avlesning B52

B viser at Z = 1, 52 sier at det leses mot slave D, da er ALS = 30 og l_M = 500. Dette gir:

$$RLN = 1 \cdot 30 + 52 - \frac{500}{10} + 500 = 532$$

Linjetallet i sonen varierer som følger:

$$ALS_B = 24$$

$$ALS_C = 18$$

$$ALS_D = 30$$

4. KORREKSJONER

Følgende korreksjoner er aktuelle:

a) DECCA-korreksjoner p.g.a. landlinjen
b) Natt- og dagkorreksjoner

Disse korreksjoner er det ikke mulig å fremstille matematisk og det kan derfor bare bli tale om å legge dem inn i maskinen i tabellform, som i sin tur vil bli uhyre plasskrevende.

5. KONVERTERING AV VINKELEN θ OG AVSTANDEN r TIL GEOGRAFISKE KOORDINATER

Denne konverteringen foregår etter følgende formler:

$$\Delta \emptyset = F \cdot r_r (\cos\theta + f_1 \cdot r_r + f_2 \cdot r_r^2 + \ldots\ldots) \qquad \textbf{(II)}$$

$$\Delta L = G \cdot r_r \cdot \sin\theta \, (1 + g_1 \, r_r + g_2 \, r_r^2 + \ldots\ldots) \qquad (12)$$

idet høyere ordens ledd sløyfes.

r_r = redusert avstand): $\frac{r}{a}$, a = jordradien

$$F = 3437{,}75 \, \frac{\sin^2(\emptyset_o) \, \cos(\emptyset_o)}{\sin^2(U_o) \cdot \cos(U_o)} \qquad (13)$$

$$f_1 = -\frac{1}{2}\text{tg}(\varnothing_o)\left[3(1 - E^2)\cos^2(\varnothing_o) + \sin^2\theta\right.$$

$$\left.\left[1 - \frac{1}{2}(1 - E^2)(1 + 5\cos^2(\varnothing_o))\right]\right] \quad (13)$$

$$f_2 = -\frac{1}{6}\sin^2\theta\cdot\cos\theta\cdot(1 + 3\,\text{tg}^2(\varnothing_o)) \quad (13)$$

$$G = 3437{,}75\,\frac{1}{\cos U_o}$$

$$g_1 = \frac{\sin(\varnothing_o)}{\cos U_o}\cos\theta \quad (14)$$

$$g_2 = \frac{(3 - 2\cos^2(\varnothing_o)) - (4 - 3\cos^2(\varnothing_o))\cdot\sin\theta}{3\cos^2 U_o}$$

De nye koordinatene er da gitt av:

$$\underline{\varnothing = \varnothing_o + \Delta\varnothing} \quad \text{(Bredde)}$$

$$\quad (15)$$

$$\underline{L = L_o + \Delta L} \quad \text{(Lengde)}$$

APPENDIX 3

OPERATION OF THE SYSTEM

This appendix describes procedures for operation of the different application programs in the system.

ROUTINE FOR UPDATING OF HOUR AND DATE

This routine keeps record of the time (GMT) and the date. When starting the system the operator must give initial data for month, day in the month and year, and further for the time in hours, minutes and seconds. The seconds will be counted from the final press on the tabulator of the teleprinter when the routine is started. The following procedure must be followed (characters written by operator are underlined):

PRINTING		COMMENTS
"TAB"	YES?	Call to computer and response.
BC		Code for the computer to identify this routine.
DATE	19"TAB" 2"TAB" 71"TAB"	Date (19 February 1971).
TIME	10"TAB" 55"TAB" 0"TAB"	TIME GMT e.g. 10.55.00 hours.
OK		Final response, program is started.

The time can be printed out any time a code is printed to ask for it:

PRINTING		COMMENTS
"TAB"	YES?	Call to computer and response.
AC		Code for computer to identify routine.
TIME:	10 55	Time in hours and minutes is printed out.

ROUTINE FOR PRINTOUT OF ECHO ABUNDANCE

This is the routine which prints out values of echo abundance associated with echo integrator deflection. On start of the routine, constants indicating integrator gain in each of the six integrator channels must be printed into the computer via operators teleprinter. Each constant should be the same as the setting on the gain selector for the associated integrator channel (0, 10, 20, 30 or 40).

The operator must also give a constant to indicate the outsailed distance between outputs. If printout is wanted for instance on log 15, 20, 25 etc., the program must be started when the log is showing 10, and the constant chould be 5.

Starting procedure is as follows (characters printed by operator are underlined):

PRINTING		COMMENTS
"TAB" (underlined)	YES?	Call to computer and response.
BA (underlined)		Code for the computer to identify this routine.
CH NO 1	GAIN 10 "TAB" (underlined)	Gain as set on integrator channel 1.
CH NO 2	GAIN 0 "TAB" (underlined)	Gain as set on integrator channel 2.
CH NO 3	GAIN 10 "TAB" (underlined)	Gain as set on integrator channel 3.
CH NO 4	GAIN 20 "TAB" (underlined)	Gain as set on integrator channel 4.
CH NO 5	GAIN 30 "TAB" (underlined)	Gain as set on integrator channel 5.
CH NO 6	GAIN 40 "TAB" (underlined)	Gain as set on integrator channel 6.
LOG	5 "TAB" (underlined)	Five n. miles between outputs.
OK		Final response, routine started.

There is also a procedure to stop this routine:

PRINTING		COMMENTS
"TAB" (underlined)	YES?	Call to computer and response.
CA (underlined)		Identification code for computer.
OK		Final response before routine is stopped.

ROUTINE FOR THERMO-SALINOGRAPH

This is the routine for sampling of sea surface temperature and salinity from the thermo-salinograph. When starting the system the operator must indicate the setting of the temperature and salinity range selectors on the Thermo-salinograph. For this purpose the ranges are numbered from left to right consecutively from 1 to 5. The following procedure should be used for starting, and it should also be repeated if the setting of the range selectors is changed (characters printed by operator are underlined):

PRINTING		COMMENTS
"TAB"	YES?	Call to computer and response.
BB		Code for the computer to identify routine.
TRANGE	3 "TAB"	Constant according to range selector, temperature.
SRANGE	2 "TAB"	Constant according to range selector, salinity.
OK		Final response, routine started.

There is also a procedure to ask for sea surface temperature and salinity.

PRINTING		COMMENTS
"TAB"	YES?	Call to computer and response.
AH		Code for the computer to identify routine. Example of printout below:

SEA SURFACE TEMPERATURE: 11.2 SALINITY: 35.1

ROUTINE GIVING DEAD RECKONING POSITION

When starting the system the operator must apply the procedure below to give initial values of the position. The same procedure can also be used if the position for some reason has to be corrected. For latitude south and longitude west the degrees as well as the minutes must have a leading minus.

PRINTING		COMMENTS
"TAB"	YES?	Call to computer and response.
BD		Code for the computer to identify routine.
LAT	63"TAB" 25.5"TAB"	Latitude 63° 25.5'N
LONG	-5"TAB" -19.1"TAB"	Longitude 05°19.1'W
OK		Final response, routine started.

The position may also be printed out any time a code is printed to ask for it:

PRINTING		COMMENTS
"TAB"	YES?	Call to computer and response.
AA		Code to identify the routine.
LAT 63 30.5	LONG 5 18	Position. 63°30.5'N 5°18'E.

ROUTINE FOR THE SHIP'S LOG

When the system is started, initial values for the ship's log must be given by the operator so that the reading from the log meters are in agreement with the outputs from the computer. The following procedure for initiating the log routine can be repeated to give corrections if necessary.(Characters printed by operator are underlined)

PRINTING		COMMENTS
"TAB"	YES?	Call to computer and response.
BE		Code for the computer to identify routine.
LOG	716.4 "TAB"	Log value entered to the first decimal place.
OK		Final response, routine started.

There is also a procedure to ask for the log reading:

PRINTING		COMMENTS
"TAB"	YES?	Call to computer and response.
AE		Code for the computer to identify routine.
LOG	718.3	Printout of log reading.

ROUTINE TO ENTER CALIBRATION DATA FOR STD-SYSTEM

Calibration constants for the STD-system must be entered when the data logging system is started. These data are printed on the listing for every station. The following procedure is used. (Characters printed by operator are underlined):

PRINTING:	COMMENTS:
"TAB" YES?	Call to computer and response.
BJ	Code to identify procedure in computer.
CORRECTION FOR DEPTH 7	Depth correction in metres.
TEMPERATURE 0.02	Temperature correction in ^{o}C.
SALINITY -0.03	Salinity correction in ‰.
OK	Final response.

ROUTINE FOR THE STD-SYSTEM ON STD-STATIONS

This routine must be started every time an STD station shall be worked and stopped when the station is completed. The operator must enter station number and amount of parameters to be printed out. Depth, temperature, salinity, sigma-t, D-alfa and delta-D are printed out from left to right. If 6 is entered after the legend "OBSERVATIONS" in the procedure below, a printout is produced every 6th second and all six parameters are printed. If 3 is entered only the 3 parameters from the left are printed and a printout is produced every third second. (Characters printed by operator are underlined):

PRINTING:	COMMENTS:
"TAB" YES?	Call to computer and response.
BI	Code to identify routine in computer.
ST NO 186	Station number.
OBSERVATIONS 6	Print frequency and number of parameters to be included.

The routine is now started and headings are printed out.

When stopping the routine the following procedure should be used:

PRINTING:	COMMENTS:
"TAB" YES?	Call to computer and response.
CD	Code to identify stop in computer.
OK	Final response, routine stopped.

ROUTINE FOR ECHO CLASSIFICATION

Some of the software sequences in the echo classification routine are included in the routine giving echo strength distribution. Also the starting procedure is common for the two routines and the code with the legend "PROGRAM" indicates which program to be started. The complete start procedure for echo classification is entered below (characters printed by operator are underlined):

PRINTING		COMMENTS
"TAB"	YES?	Call to computer and response.
BG		Code for computer to identify routine.
GAIN	-82"TAB"	Gain depending on setting of echo sounder and interface unit.
RATE	48"TAB"	Ping rate of echo sounder, 48 or 96.
TOTAL	100"TAB"	Number of fishes to be classified.
FRAME	4"TAB"	Depth interval to be sampled around target e.g. 4 m.
PROGRAM	0"TAB"	Code for choise of option,classification.
MAX DB	-30"TAB"	Max. dB value in table according to fish size.
OK		Final response, routine started.

The routine stops automatically when the indicated number of fishes is observed and the final table printed out. If it for some reason must be stopped before, the following procedure can be used:

PRINTING		COMMENTS
"TAB"	YES?	Call to computer and response.
CB		Code to identify stop routine.
OK		Final response, routine stopped.

ROUTINE FOR ECHO STRENGTH DISTRIBUTION

This routine which gives the distribution of echo strengths observed in a given number of transmissions, can not be operated simultaneously with the echo classification routine. The start procedure entered below has many features in common with the start procedure of the echo classification. (Characters printed by operator are underlined):

PRINTING		COMMENTS
"TAB"	YES?	Call to computer and response.
BG		Code for identification of procedure in computer.
GAIN	-82 "TAB"	Gain depending on setting of echo sounder and interface unit.
RATE	48 "TAB"	Ping rate of echo sounder, 48 or 96.
TOTAL	50 "TAB"	Number of ping to be processed.
FRAME	0 "TAB"	Zero should be entered.
PROGRAM	- 1 "TAB"	Code for choise of option, echo streng
MAX DB	0 "TAB"	Zero should be entered.
OK		Final response, program started.

The routine stops automatically after printout of the echo strength distribution.

ROUTINE FOR DECCA NAVIGATION

When the program for DECCA-navigation shall be started it is necessary to enter initial DECCA-coordinates for the current position of the ship. This is also necessary when the DECCA-navigator is switched over from one DECCA-chain to an other. In the initiation procedure below is also included code to identify DECCA-chain in use.(Characters printed by operator are underlined)

PRINTING	COMMENTS
"TAB" YES?	Call to computer and response.
CH NO 4	Number to indicate DECCA-chain.
RED GREEN PURPLE	Indicates red, green and purple deccometer.
0 "TAB"	Letter on red deccometer, A=0, 10 or 20. B=1,11 or 21 etc.
9.5 "TAB"	Reading on red deccometer.
8 "TAB"	Letter on green deccometer, I=8.
44.9 "TAB"	Reading on green deccometer.
22 "TAB"	Letter on purple deccometer.
LAT 63 03.3 LONG -02 18.8	Position printed.
KEEP = 1, CHANGE = 2 1	If position is correct, 1 is entered, otherwise 2.

The routine has two error messages POS WR and WRONG ITERATION. If one of these are printed out, the DECCA routine is automatically stopped.

The stop routine is as follows:

PRINTING	COMMENTS
"TAB" YES?	Call to computer and response.
CC	Code to stop the routine.
OK	Final response, routine stopped.

Decca

The DECCA-position can be printed out when a code is printed to ask for it:

PRINTING	COMMENTS
"TAB" YES?	Call to computer and response.
AB	Code to identify routine.
LAT 63 03.5	DECCA position 63°03.5'N.
LONG -02 18.8	02°18.8'W.

NUMBERS OF DECCA CHAINS

When starting the routine for Decca navigation, an identification number of the chain to be applied has to be entered into program. Numbers for some chains are listed below.

DECCA CHAIN	NUMBER
Finnmark	0
Lofoten	1
Helgeland	2
Trøndelag	3
Vestlandet	4
Skagerak	5
Danish chain	6
North Scottish	7

ACCESS TO MAC ASSEMBLER

Access to the assembler is obtained in the same manner as the different application routines are started. (Characters printed by operator are underlined):

PRINTING:		COMMENTS:
"TAB"	YES?	Call to computer and response.
BK		Code to identify access to MAC.
OK		Final response, MAC has control.

When the use of MAC-assembler is finished, the control is returned to Level 9 by the command) OFF.

PRINTOUT OF PARAMETERS ON REQUEST

Besides the parameters already mentioned there is possibility to ask for the current values of some parameters.

For instance echo depth is obtained by the following procedure:

PRINTING		COMMENTS
"TAB"	YES?	Call to computer and response.
AE		Code to ask for echo depth.
DEPTH	289	Echo depth in metres.

Codes for all parameters to be used in the same manner are:

CODE	PARAMETER
AA	Dead reckoning position.
AB	DECCA position.
AC	Time, GMT.
AD	Reading of ship's log.
AE	Echo depth.
AF	Ship's speed, knots.
AG	Ship's course, degrees.
AH	Surface temperature and salinity.
AI	Meteorological parameters, pressure, temperature, dew point, wind force, wind direction.
AJ	Numeric content in all ADC channels.