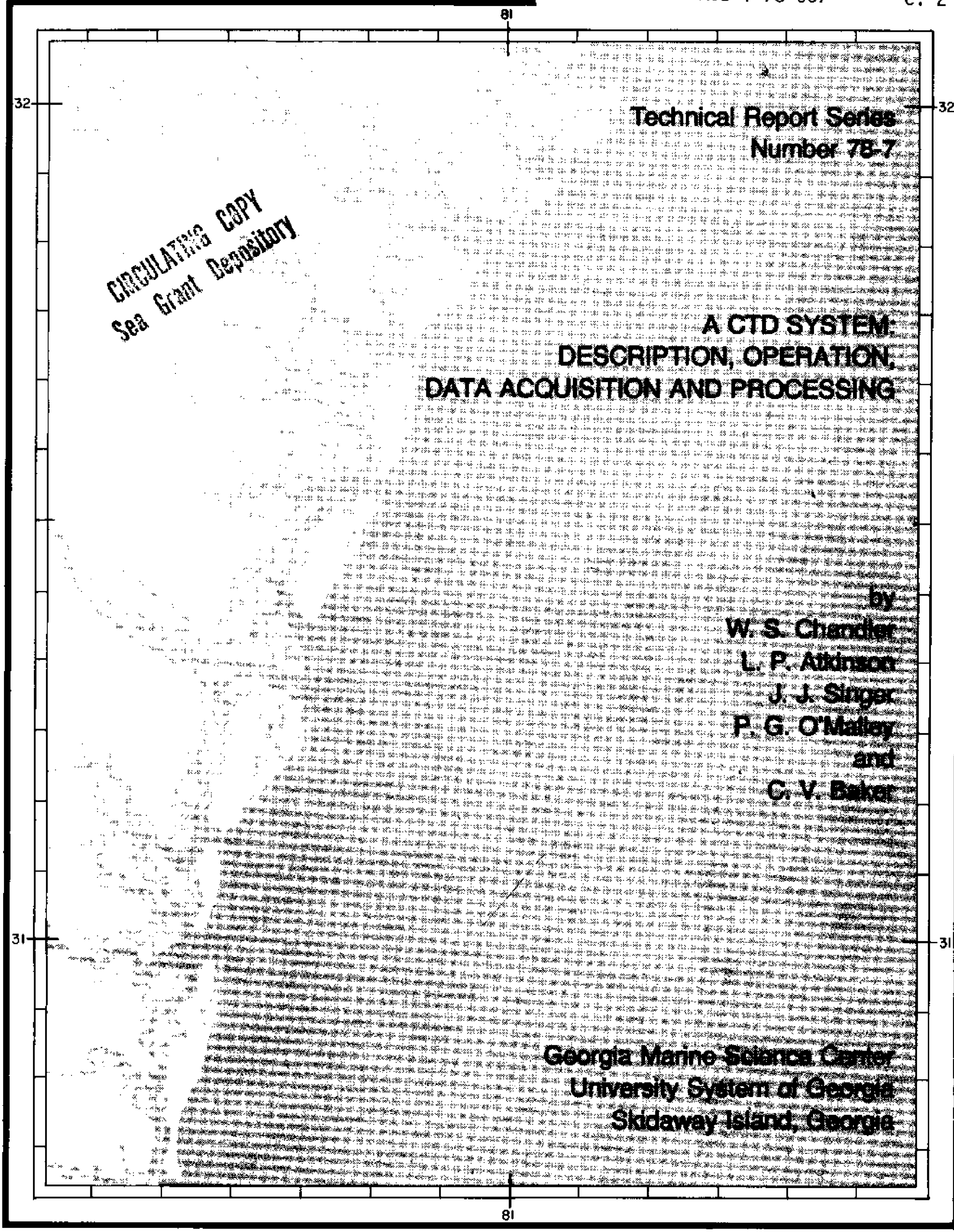

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A CTD SYSTEM: DESCRIPTION, OPERATION, DATA ACQUISITION AND PROCESSING

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The development of this system is the result of the cooperation of many people. The initial effort was inspired by the success of Dr. William W. Broenkow, Moss Landing Laboratories, Moss Landing, California, and his assistance is appreciated. We also thank Mr. Lee Knight, engineer, Skidaway Institute, for his assistance in the development. Others who assisted through direct effort or helpful comments included Drs. Tom Curtin and T. N. Lee. Mrs. Cindy Miller typed the manuscript. Funding support for the system was and is provided by the Department of Energy (Contract No. EY-76-S-09-0889) to Dr. L. P. Atkinson.

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INTRODUCTION

The level of sophistication of today's marine research dictates the need for a rapid, reliable and accurate system for acquiring and processing temperature and salinity data.

In order to meet these needs, we at the Skidaway Institute of Oceanography have acquired a conductivity/temperature/depth (CTD) system. With principal support from the U. S. Department of Energy, we have developed the software and made numerous modifications to the hardware of the system, facilitating the principal task of investigating and explaining the chemical and physical processes in the South Atlantic Bight.

The purpose of this report is to describe our CTD system, document the developments and improvements we have made thus far, and relate our practical experience. It is hoped this report will be useful to oceanographers who now have, or will in the future have, a CTD system. The system is in a continual state of upgrading and modification, so this report represents the state of our system as of May 1978. Recent additions to the system are an HP Flexible Disk Unit (0.5 megabyte) and an HP-BCD Interface Bus. The XBT has also been interfaced to the HP 9825A.

DESCRIPTION OF THE SYSTEM

The CTD system, shown schematically in Figure 1, has four major components: 1) the underwater unit, consisting of the depth, conductivity, and temperature sensors, and a mixer that powers the sensors and multiplexes the signals; 2) the winch, conductor wire, and Rosette Multi-Bottle Array fitted with a variety of Niskin sampling bottles; 3) the deck unit that powers the rosette and the CTD sensors and filters and digitizes the multiplexed CTD signal; and 4) the data processing system. The data processing system is actually two separate systems, one which records the raw data digitally on magnetic tape and another that performs real-time data processing and stores and displays the data in a variety of ways (i.e., Hewlett-Packard (HP) tape cartridge, calculator plotter, printer and analog plotter). All components of the CTD system are listed in Table 1. In the following discussion, the hardware components, the shipboard operating procedure, and the software of the system will be described, some in more detail than others. Troubleshooting problems, causes, and repairs for those problems that we have encountered are listed in Appendix I.

The CTD Sensor System

The CTD unit consists of the three sensors powered by a 120 ma constant current supply in the mixer. The sensors output AC signals of frequencies that are proportional to the parameters being sensed (Table 2). The AC signals from these sensors are multiplexed by the mixer and transmitted through a single conductor to the deck unit. Thus, only one conductor is required by the CTD for input power and an output multiplexed signal. To

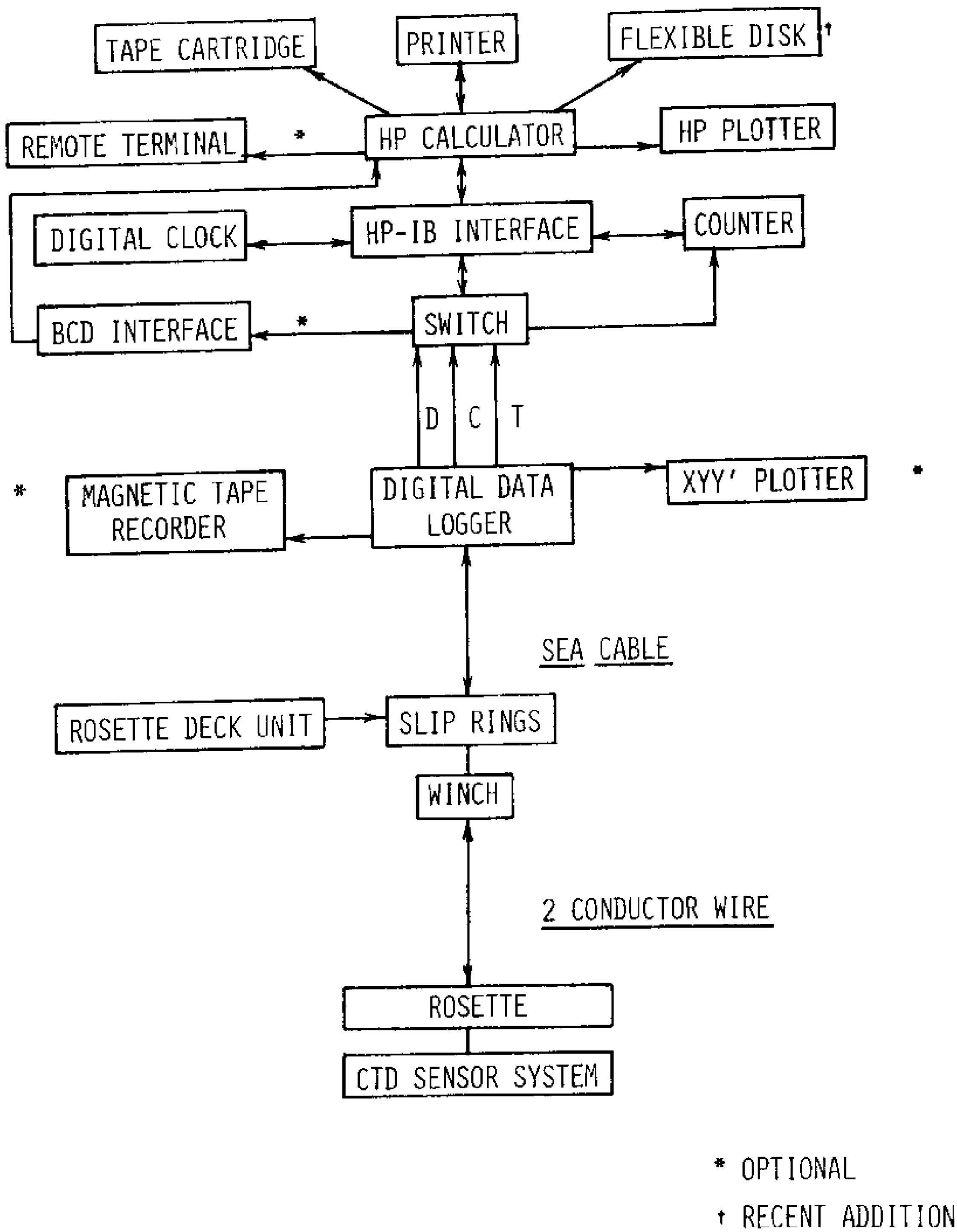


Figure 1. Schematic of CTD System.

Table 1. Component List of the CTD System.

Plessey Model 9400 System
Plessey Model 6500 Conductivity Sensor
Plessey Model 4500 Temperature Sensor
Plessey Model 4600 Pressure Sensor
Plessey Model 4400 Mixer
General Oceanics Rosette Multi-Bottle Array Model 1015 Mark V
Plessey Model 7400 Winch
Plessey Model 8400 Digital Data Logger
HP 7046A X-Y Recorder
Kennedy Model 1600 Incremental Magnetic Tape Recorder
HP 59307A VHF Switch
HP 98034A HP-IB Interface
HP 5328A Universal Counter
HP 59309A HP-IB Digital Clock
HP 9825A Calculator
HP 9862A Calculator Plotter
Texas Instruments Silent 700 ASR Electronic Data Terminal

guard against applying reverse voltage to the CTD sensors, a reverse biased diode is installed on the input power line to the mixer. Our system is dismantled and reassembled frequently and such protection is good insurance against damaging the sensors.

Table 2. Parameters Measured and Sensor Ranges.

Parameter	Frequency Range	Sensor Range
Temperature	2127-4193 hz	-2-35°C
Conductivity	4995-7901 hz	0-60 mmhos/cm
Depth	9712-11288 hz	0-600 m

The pressure vessels housing the sensors protect the sensors to 600 meters; however, flooding of the vessels, even at shallow depths, has been a problem. According to Plessey, Inc., replacing the plastic endcaps with stainless steel endcaps has solved the flooding problem. When our system is not functioning properly and flooding is suspected, the sensors are disassembled and dried out. Pins in the connectors are also examined and dried out when wet. Care should be exercised when handling the O-ring seals for the connectors. Silicone grease is used to seal the connections. It should be used sparingly to avoid insulating the electrical connecting pins.

We have spare C, T, and D sensors, connectors, Scotchcast electrical splicing kits, and wire harnesses so that any malfunctioning part can be replaced on board, allowing sampling to proceed after repairs are made.

The Winch and Rosette Multi-Bottle Array

The winch should be equipped with at least two conductor oceanographic electromechanical cables and the appropriate slip rings. One conductor is for the CTD and the other for the rosette. The winch should be capable of lowering and raising at rates of 15 m/min or less. This low winch speed is necessary so that enough data points are collected to average over one meter increments, especially in strong thermoclines such as those encountered in the South Atlantic Bight.

Most oceanographic ships are equipped with conductor winches. However, the wire and/or slip rings are often in disrepair and should be checked out beforehand. We bring a portable winch for backup. Our portable winch (Plessey Model 7400) has 250 m of 4-conductor wire and runs on 110 Volts AC power at a constant speed of 15 m/min. It handles a maximum load of 200 pounds, which is of minimum acceptable capability. Changes have been made to improve the operation of the winch. The operating switch installed by Plessey, Inc. burned out after very little use, so a heavy duty switching relay was installed. The new switch also increases safety since a spring returns it to the off position upon release; therefore, the operator cannot leave the switch unattended while the CTD is being raised or lowered. Solid state relays will be installed soon in order to minimize the electrical noise that spikes the data signals. An occasional overhaul and repainting of the winch housing is necessary due to corrosion from salt spray. It should also be disassembled, cleaned, and lubricated regularly.

The Rosette Multi-Bottle Array is manufactured by General Oceanics, Inc. as are the Niskin bottles mounted on it. The rosette is mounted on a frame which encloses the CTD sensor system (Figure 2). Reference to the "Fish" includes the sensors and rosette as one unit. The sensors are located beneath the rosette so that they are not in the wake of the rosette as the Fish is lowered through the water column. Conversely, during the upcast the sensors are in the wake of the rosette, degrading the data. During the upcast, the Niskin bottles are triggered serially on command from the deck unit at desired depths.

Plessey, Inc. had designed the system so that the sea cable from the winch's single slip ring entered the rosette deck unit, then continued on to the digital data logger (DDL). The wire harness connected to the winch wire went through the rosette, then to the sensors. With only one path as such, powering the rosette with the high voltage required to trip a bottle interrupted the connection to the sensors.

We have modified the system and now use multi-conductor wire, allowing separate rosette and sensor operation. A branching cable connects the slip ring wires to the rosette deck unit and the DDL. An underwater harness branches from the winch wire connector to the rosette and to the CTD sensors.

The rosette requires continual mantenance to perform reliably. After every cast the cam/trip mechanism should be washed with fresh water and sprayed with a penetrating lubricant such as CRC. Recommended spare parts are appropriate relays for the winch, rosette, and rosette deck unit and SCR for the rosette deck unit.

A Helle pinger is mounted on the frame of the Fish to aid in recovery if the Fish becomes severed from the conductor wire. A buoy, chain, and anchor are also kept ready to use to mark a lost instrument.

The Deck Unit and Data Processing System

The Plessey Model 8400 Digital Data Logger (DDL) provides power to the CTD sensors, receives and demultiplexes the CTD signal, and determines the frequencies for depth, conductivity, and temperature for output to recording devices.

Several modifications were made to the DDL that make control of the system more convenient. An on-off switch for power to the Fish, as well as voltage and current meters, were installed in the front panel of the DDL that readily indicate the power status of the Fish. Thus, an opened, closed, or shorted circuit in the system can easily be detected. One input

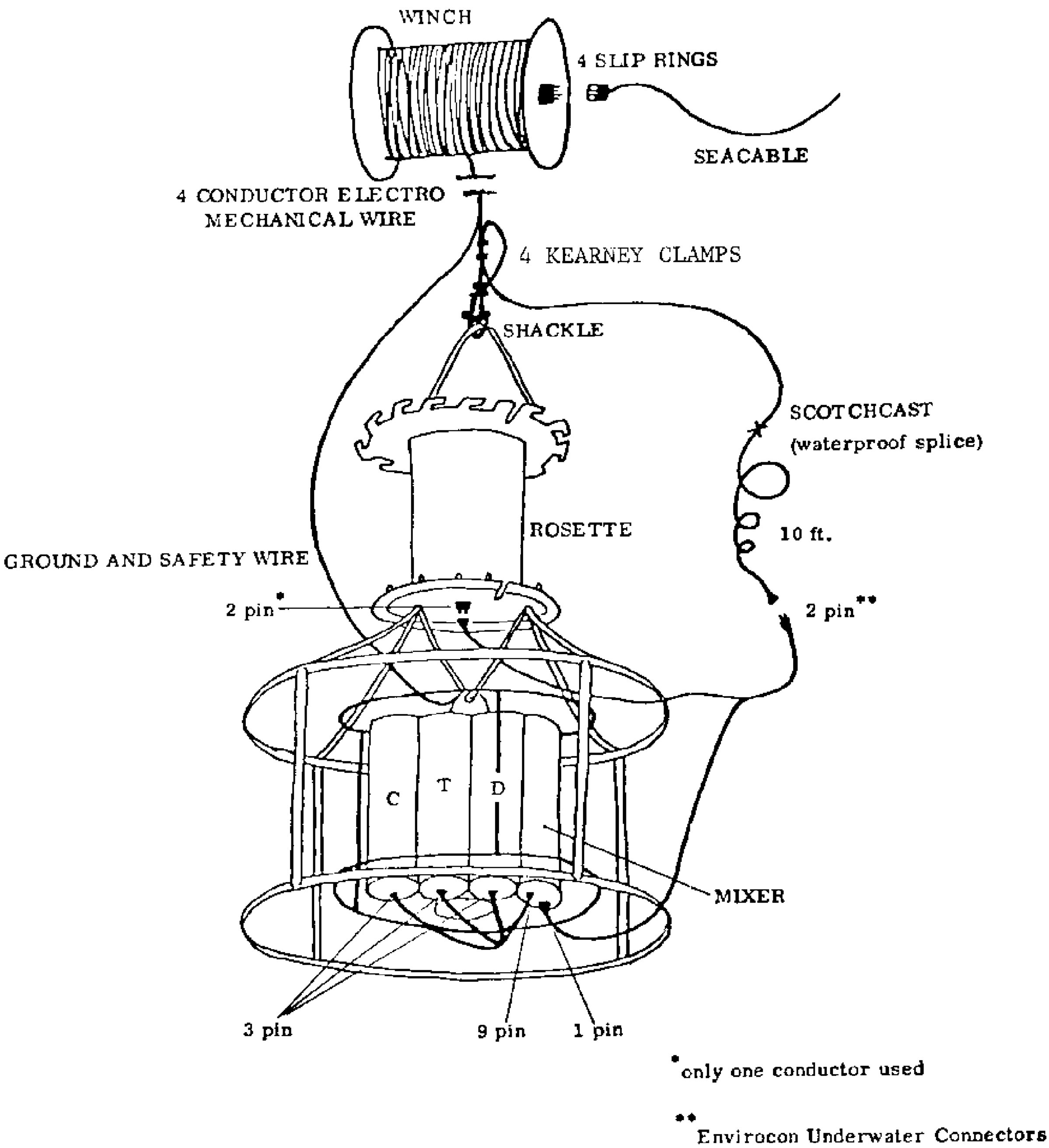


Figure 2. Underwater Assembly.

and two outputs may be connected to one of the three channels, and a switch and porter LEDs for selecting a channel also were installed in the front panel of the DDL. The two outputs allow an oscilloscope and frequency counter to monitor any one channel at a time. A signal generator can be attached to the input. When using a winch with a short wire, a capacitor is put on the DDL input line to attenuate the signal, simulating a longer wire, and thus preventing interference of one channel with another. Another modification was the replacement of the 741 operational amplifier in the DDL with a higher grade ultra-linear operational amplifier.

Spare parts for the DDL include spare counting and digitizing boards. D, C, or T counting and digitizing boards are essentially interchangeable. The plastic integrated circuits (ICs) that Plessey, Inc. used on our unit are less reliable than ceramic ICs and do not stand up to the humid, salt-air environment. Consequently, our boards have been sprayed with a sealer to reduce failure. The newer Plessey, Inc. units, however, are equipped with ceramic ICs.

The digital signal output from the DDL is recorded on a Kennedy Model 1600 Incremental Magnetic Tape Recorder. The digital-to-analog converter in the DDL outputs an analog voltage proportional to the input range which drives an HP-XYY' Recorder (Model 7046A). The DDL folds the signals proportional to 0 to 10 Volts full scale (Table 3). We have found that shipboard generators are not stable, therefore, a line conditioner is required. The greatest problem caused by a power failure is that the magnetic tape must be started up again and the lack of continuity will cause tape reading errors when it is played back.

Table 3. Analog Characteristics.

	D	C	T
Full Scale	0-600	0-80 mmhos/cm	-5-35^{o}C
Ranges	4	8	8
Folded Range Scale	0.06666 v/m	1 v/mmhos/cm	2 v/^{o}C
Scale on Paper	0.25 cm/m	2.5 cm/mmhos/cm	5.0 cm/^{o}C
Finest Line Reading	0.4 m	0.2 mmhos/cm	0.02^{o}C

After this CTD system was in use for one year, an HP 9825A Calculator and peripherals were added which decreased the time and cost of data acquisition. The HP recording devices are the 9862A Plotter and the tape cartridge and printer in the 9825A Calculator.

CTD Assembly

Loading and assembling the components of the CTD system aboard various ships can become routine, as it has for us. The deck unit must be situated in a dry, preferably air-conditioned lab. Most of the HP components are rack-mounted, and the racks are bolted to lab tables. Everything that is not in a rack is secured with rope or tape.

A full complement of tools and spare electronic parts is necessary (see Appendix II for a complete list). If the ship does not have adequate communications between the lab, deck, and bridge, a portable intercom system is placed so that the deck unit operator can talk with the winch operator. The CTD sea cable must reach the deck, where it is affixed to the slip rings on the winch. Enough conductor wire is unspooled from the winch to reach the Fish after it is put through a block or metering wheel on an A-frame or boom that can be extended away from the ship. A splice must be made to join the Envirocon underwater connector that mates the two pin connectors on the wire harness of the Fish to the conductor wire used on most ships' winches. Using Scotchcast over the spliced wire is a convenient method of waterproofing underwater connections. Scotchcast is mechanically and electrically sound because of its rigidity, unlike underwater tape that can bend and break. Our small winch is equipped with the connector that joins the conductor wire and Fish.

Niskin bottles appropriate for the anticipated sampling are mounted on the rosette. Invariably, a rack to hold three reversing thermometers (two of the protected type and one unprotected) is put on the bottle that will be tripped at the deepest sampling depth. Expendable Bathythermograph (XBT) pins (one ground to a point and another to a flat blade) are convenient tools to cock the bottles on the rosette and to rotate the cam/trip mechanism. While not in use, the Fish should be secured in a shaded place to protect the rosette's rubber pressure-compensating diaphram and reversing thermometers.

Early CTD tests indicated that the pendulum motion of the Fish while in the air between the deck and the water should be dampened by weight suspended from a rope harness beneath the Fish. In practice, the pendulum motion ceases as the weight enters the water. In calm-to-moderate seas, a 10-pound weight is used. In heavy seas more weight is added in accordance with the capacity of the winch. Our winch can support 30 pounds in addition to the weight of the Fish.

OPERATING PROCEDURE

To utilize ship time to the fullest, the CTD should be ready for a cast before arriving on station. The sensors are powered up for a short time on deck, and the frequencies for D and C are recorded to use as offsets from the manufacturer's zero D and C frequencies during the ensuing cast. In order to prevent accidents, power to the Fish is on only during a cast. The rest of the deck unit has power to it throughout the cruise to insure electronic stability.

The HP plotter is programmed for 5 to 30°C and 0 to 400 meters full scale and the XYY' recorder plots conductivity and temperature-versus-depth proportional to the analog voltage output by the DDL (Table 3). The XYY' recorder must be calibrated often with a precision 10 Volt source to check the 0 to 10 Volts full scale. Both plotters are made ready before arriving on station.

Operating the CTD recording devices requires a complex system of button-pushing. Explicit instructions are displayed on the front of the deck unit (Table 4). Any deviation from this procedure produces a non-standardized tape recording, making processing costly and time consuming. The standard tape recording for the Kennedy should have an identification (header) for each station cast followed by a file gap (blank mark of a specific length) and the cast data followed by a file gap. Missing or extra file gaps must be reported so that tape errors can be found and corrected.

A minimum of two people can operate the CTD. One person on deck runs the winch and guides the Fish into the water while the second person in the lab operates the data acquisition system and fills in the station sheets (Figure 3). Prior to lowering the Fish, the depth at a station should be determined by a depth sounding device, either on the bridge or in the lab. The data acquisition operator instructs the winch operator when to put the Fish in the water and when to lower and raise it. At the beginning of a cast, all of the data-recording devices should be simultaneously set into action. During the downcast, the HP Calculator is programmed to display depth so that the data acquisition operator can tell the winch operator when to stop lowering the Fish. Then the plotter pens are raised, and the programming is switched to a soak routine. After four minutes (to allow the reversing thermometers to equilibrate), the bottom sample bottles are tripped from the rosette deck unit. During the upcast, new plotter paper is used or the pens are raised to trace over the downcast plot. The vertical temperature plot is used to decide where to stop and trip bottles on the upcast (Table 5). While the Fish is stopped at the predetermined sampling depths, the rate of data acquisition is slowed down by using a mid-depth soak program.

After the surface sample bottles are tripped, power to the Fish is turned off, and the Fish is brought on deck and secured. The rest of the CTD operation may be carried out while the ship is steaming towards the next station. Dissolved oxygen, nutrient, salinity and other samples are drawn from the Niskin bottles into appropriate collecting bottles, treated, and stored as needed. The data acquisition operator records the bottle numbers for the samples taken on the station sheets. The reversing thermometers are read, and temperatures are recorded on the station sheets for calibration of the CTD temperature sensor. After the samples are taken, the rosette cam/trip mechanism should be rinsed with fresh water and sprayed with a marine lubricant. Then the cam must be reset and the Niskin bottles cocked in preparation for the next cast. The station sheets and plots are filed, and all data acquisition devices are made ready for the next station.

Examples of other forms we use are in Appendix VI.

Table 4. CTD Operating Procedure.

1. Determine the depth of the water column.
2. Turn Rosette ON (Small button under "8400 DIGITAL").
3. Set heading data. (10(00)) for upcasts; 00(00) for downcasts).

*4. Push "ENTER" five times; push "FILE GAP" once.

5. Set up HP programming (trkl, ldf0, RUN). Try to time the readiness of the HP to receive data so that steps 6 and 7 can immediately be completed.
6. When ready to begin cast push "START" on recording control (tape should begin moving in short increments). Turn on recorder "SERVO" and put pen on "RECORD".
7. Lower CTD (stop 2-3 meters from the bottom).
8. Change to scan 10 at bottom of cast. <u>LIFT PEN</u>.
9. Follow the 4 minute soak instructions on the HP.
10. Push "STOP" after soak. Change back to scan 0.
11. Push "FILE GAP" once.
12. Follow steps 3-6 for upcast.
13. Raise CTD to desired depths and "FIRE" Niskin bottles. (Change to scan 1 while firing bottles).
14. Turn Rosette off (small button under "8400 DIGITAL").
15. For the next cast, repeat procedure with step 1.
16. When tape is completed change header to 9999 and push "ENTER" five times, then push "FILE GAP" three times, rewind and remove tape.

*IF "FILE GAP" IS PUSHED TWICE IN A ROW OR NEGLECTED AT ANY TIME, PLEASE NOTE THIS ON THE RESPECTIVE STATION SHEET. DO NOT "ENTER" A HEADER AND "FILE GAP" MORE THAN ONCE. JUST NOTE THE ERRONEOUS HEADER NUMBER.

STATION SHEET

CRUISE________ GRID STATION________ CONSECUTIVE STATION________

LOCAL TIME IN________ DAY________ MONTH________ YEAR________ DEPTH________ WIRE ANGLE________

MAGNETIC TAPE NO.________ KEYWORD________ HEADER (d)________ (u)________ SCAN RATE (d)________ (u)________

SURFACE FREQ: DEPTH______ COND.______ TEMP.______
BOTTOM FREQ: DEPTH______ COND.______ TEMP.______
MID DEPTH FREQ: DEPTH______ COND.______ TEMP.______
MID DEPTH FREQ: DEPTH______ COND.______ TEMP.______
MID DEPTH FREQ: DEPTH______ COND.______ TEMP.______
SURFACE FREQ: DEPTH______ COND.______ TEMP.______

MIXER
407 411
COND
615 660
TEMP
720 737
DEPTH
817 837

THERMOSAL TEMP.______
SURF. BUCKET TEMP.______
TIME OUT______

CTD SENSORS Depth Freq.	Depth	Meter Wheel	Niskin Bottle	SAMPLE BOTTLES O_2	S‰	Nut	Misc.	REVERSING THERMOMETER #	Main	Aux	V_o	I	G_f	T_w

Reversing Thermometer Correction Calculation:

$$T_w = T_{obs} + C + I$$

V_o, I and G_f are obtained from specifications for thermometers

$$C = \frac{(T_{obs} + V_o)(T_{obs} - T_{aux})}{1/G_f - 100}$$

*Depth Freq. on deck______
*Cond. Freq. in air______
O.K. for T calib. (B)______
O.K. for S calib. (B)____ (M)____ (S)

Figure 2. Station sheet

Table 5. Suggested Sampling Depths.

Depth less than 50 m:	
Mixed	- Surface and bottom
Two-Layer	- Surface, above or below the thermocline and bottom
Depth greater than 50 m and less than 100 m:	
	0, 25, 50, 75, 100 (or bottom)
Depth greater than 100 m:	
	0, 50, 100, 150, 200, 300, 400 (or bottom)

Cyber Processing

After a cruise, the magnetic tape is sent to the University of Georgia Computer Center and stored in their tape library. The tape is then processed at Skidaway where there is access to interactive time-sharing of the University's Control Data Corporation Cyber 70 through a telephone link.

During the shipboard CTD operations, binary coded frequencies are recorded on 7-track magnetic tapes by the Kennedy recorder. The processing of tape data has been adapted from that described by Scarlet (1975). Table 6 shows the basic data flow, though program modifications are necessary for the special situations that arise for each new data set. The programs are listed in Appendix III. The final programming step, NUTMERG, merges additional station data, i.e., nutrients, weather, latitude, longitude, etc., to the CTD data for submission to the NODC. This final product is stored on magnetic tape in our computer system and all data, i.e., CTD, XBT, chemical, etc., are available from the NODC.

Another program, CEMLIST, calculates specific volume anomally, oxygen saturation and apparent oxygen utilization (from the International Oceanographic Tables, 1966), and the distance between successive stations from the NODC formatted data. CEMLIST reformats the NODC data for presentation in a technical report.

Temperature Lag. The Plessey temperature sensor time constant is reported to be 0.35 seconds. The depth and conductivity sensors each have a reported 0.1 second time constant, so that temperature lags behind depth and conductivity. Therefore, the "real" T at the time that D and C are sampled must be calculated from the "indicated" T. From Scarlet, 1975:

Table 6. Cyber CTD Data Flow: Shipboard Acquisition to NODC Submission.

Data Source/Disposition	Program	Data File
Digital Data Logger to Tape	CTDRUN (Copies tape data to a computer file)	
		KEYWORD
	MAGREAD (Converts binary coded data to decimal)	
		BIRANG
	CTDUNIT (Converts decimal units to engineering units)	
		LAG
	LAGFILT (Temperature lag and course filter)	
		CAL
Primary Calibration from Bottle Casts	BROENK (Calculates salinity and sigma-t)	
		LATCH
	DLATCH (Removes decreasing and repeated depths)	
		CTDATA
	CTDAVE (One meter averaged data)	
		AVE
	NODCFO (Converts to NODC format)	
		NODC + HEAD
	NUTMERG (Merges NODC data with headers and chemical data)	
Submission to NODC		FINAL
	CEMLIST (Calculates specific volume anomally, oxygen utilization, etc.)	
		TECHNICAL REPORT

$$T_{R(n)} = T_{I(n)} + \frac{\tau(T_{I(n+1)} - T_{I(n-1)})}{2\sigma}$$

where: T_R = real T

T_I = indicated T

τ = sensor time constant

σ = sampling rate

n = 1,2,3...(each CTD scan)

The sensor with the slowest time constant determines the fastest rate at which a CTD scan can be updated by the digital-to-analog converter in the DDL. The T time constant of 0.229235 seconds governs the fastest rate for this system. Setting the scan interval to 00 provides the fastest rate. The scan interval can be set as high as 99, with each of the 100 increments slowing the sampling rate down by multiples of 0.229235 seconds. The temperature lag of this sytem can be calculated from:

$$T_{R(n)} = T_{I(n)} + \frac{0.35\ (T_{I(n+1)} - T_{I(n-1)})}{(2)(0.229235)(\text{Scan} + 1)}$$

Offsets and Course Filter. Depth and temperature offsets (Table 7), determined by the on-deck frequencies for depth and temperature, are applied in program CTDUNIT. The offsets correct for the deviation of the zero depth and temperature frequency readings from the frequencies preset by the manufacturer. Our temperature sensor has shown no signs of drift or offset with age when compared with protected reversing thermometer readings, so no offset has been applied. In addition, no offset is determined for conductivity though it, like depth, has been observed to drift slightly with age. This drift is compensated for in BROENK by a salinity offset from a comparison of bottle salinity with CTD salinity. This salinity offset may be depth dependent due to the effect of pressure on the conductivity sensor. A simple test for this is a linear regression analysis of bottle salinity less CTD salinity versus depth. When sampling at depths less than 50 meters or when no pressure effect is apparent, the mean offset from bottle salinities less CTD salinities for all stations is most appropriate.

LAGFILT course filters electronic, slip ring, and winch noise. The windows for the filter are ± 5 m, ± 0.8 mmhos/cm and ± 0.5^{o}C.

Depth Latch and Averaging. The normal descent rate of 0.25 meters/second and scan rate of 0.229 seconds should provide 17 scans/meter. The number of scans/meter varies because the motion of the Fish reflects ship roll. Repeated depths are removed by the DLATCH program. The average number of scans (remaining) through a 1 meter interval is 10 ± 7. Scans of data 0.5 meters above and below each 1 meter are averaged for depths less than 100 meters and data 2.5 meters above and below each 5 meters are averaged for depths greater than 100 meters.

Table 7. CTD Offsets.

Cruise	D(m)	T(^oC) S/N 720	S(%)(Bottle-CTD) or equation	Sal. Eq. (from)	Data Source	Deepest Calib. depth
OBIS V (July-Aug. 1976):						
Hydro 1	None	None	+ .138 ± .030	Knowles	XYY	55m
			+ .333 ± .023	Knowles	XYY	55m
Bio 1	None	None	+ .099 ± .008	Knowles	XYY	55m
Hydro/Bio 2	None	None	+ .090 ± .017	Knowles	XYY	55m
Aborted Hydro 3	None	None	+ .101 ± .022	Knowles	Mag tape	55m
Bio 3	None	None	+ .073 ± .025	Knowles	Mag tape	55m
Hydro 4	None	None	+ .064 ± .021	Knowles	Mag tape	55m
Bio 4	None	None	+ .019 ± .008	Knowles	Mag tape	55m
Hydro 5	None	None	+ .068 ± .009	Knowles	Mag tape	55m
CI 12 (December, 1976)	None	None	$S = S_o + 0.023 - 1.57 \times 10^{-4}D$	Broenkow	Mag tape	438m
AD 477 (April, 1977)	+1.714	None	$S = S_o + .007 - 4.97 \times 10^{-4}D$	Bennett	Mag tape	192m
BF 38 (May, 1977)	+2.29	None	+ .06 ± .015	Broenkow	HP	74m
CI 03 (July, 1977)	+2.29	None	$S = S_o + .101 - 3.05 \times 10^{-4}D$	Broenkow	Mag tape	204m
BF 57 (September, 1977)	+2.29	None	$S = S_o + .118 - 5.19 \times 10^{-4}D$	Broenkow	Mag tape	196m
CI 07 (November, 1977)	+3.24	None	Not determined*	Broenkow	XYY	
BF 07 (February, 1978)		None	- .003 ± .004	Broenkow	HP	209m
PIERCE (March, 1978)	+4.57(-1.14)**	None	+ .042 ± .013	Broenkow	HP	398m
CI 01 (April, 1978)		None	+ .125 ± .013	Broenkow	HP	253m
BF 21 (May, 1978)		None	+ .136 ± .011	Broenkow	HP(& XYY)	15m

*Change C sensor (S/N 615 replaced with S/N 660); **change D sensor (S/N 817 replaced with S/N 837)

Salinity. Salinity is calculated from CTD scans using shortened equations adapted from those of Bradshaw and Schleicher (1965) and Cox et al. (1967) by Broenkow (1977) (Table 8). To determine the effects of pressure and temperature on the conductivity sensor, uncorrected and then corrected salinity calculations are required according to the steps in Table 9.

CTD Calibration. The CTD system is calibrated against water samples from rosette bottles tripped in mixed layers to insure that the sensors and the bottles are both sampling the same water. When a mixed layer is not observed, a comparison cannot be made at that station. Consequently, an offset equation is derived from the available data and applied to the entire cruise (Table 7). A Plessey Model 6230N Lab Salinometer is used to determine the salinity of water samples from the rosette bottles.

The Onslow Bay 1976 project was an exception. Each leg of the project had its own offset. At times, more than one offset was necessary during a single leg because of repairs to the CTD system. Many problems were encountered during this initial break-in period. Modifications to the system, as described on pages 1-7 of this report, overcame many of the problems.

Upcasts. Our original Plessey CTD system was set up using a one-conductor wire that would carry the multiplexed C, T, and D and rosette bottle tripper signals. Sending the signal to trip a bottle interrupted the data reception from the CTD (actually sending spiked signals). For this reason, only downcast data was recorded on tape, and bottles were tripped on the upcasts.

The system has since been modified. Two wires and the shield (used for a ground wire) of a four-conductor wire are used, separating the CTD and rosette signals. Upcast data is recorded, unaffected by bottle tripping. However, the sensors lie in the wake of the rosette during upcasts and this causes turbulent disturbance of the water being sampled; therefore, the data reported to NODC and in technical reports are the downcasts only, except were downcast data is lost or incomplete.

CTD Error Analysis. The Plessey Model 9400 CTD system has the following rated accuracy, resolution, and time constants (Table 10). Since salinity is not measured directly, it has to be calculated from the parameters indicated in Table 10, resulting in the composite errors of the C, T, and D sensors and the salinity equation.

Table 8. Broenkow's Salinity Equations.

$$R_Z = 1 + .01\{(1.551 - .0453T + 59 \times 10^{-5}T^2) + \tfrac{1}{4}(35-S)(.043 - .0017T + 23 \times 10^{-6}T^2)\}\{1.037 \times 10^{-3}Z - 32 \times 10^{-9}Z^2\}$$

$$A_T = (676547 + 20131.5T + 99.89T^2 - .1943T^3 - .00672T^4)\ 10^{-6}$$

$$R_T = \frac{C(S,T,Z)}{R_Z\ A_T 42.896}$$

$$\Delta_{15} = R_T(R_T-1)(T-15)\{96.7 - 72R_T + 37.3R_T^2 - (.63 + .21R_T^2)\ (T - 15)\}10^{-5}$$

$$R_{15} = R_T + \Delta_{15}$$

$$S^0/oo = .08996 + 28.2972R_{15} + 12.80832R_{15}^2 - 10.67869R_{15}^3 + 5.98624R_{15}^4 - 1.32311R_{15}^5$$

where: R = conductivity ratio

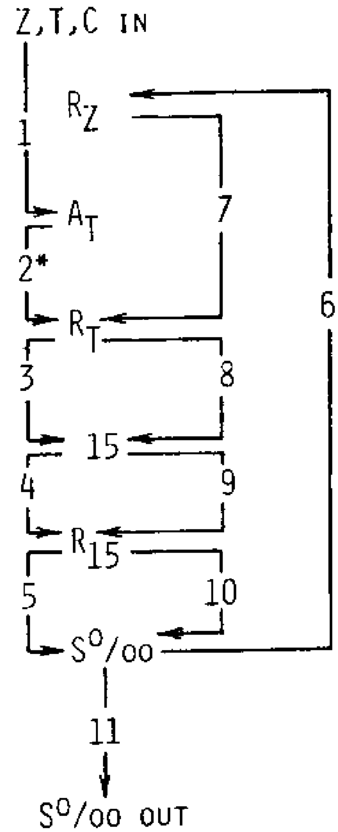
Z = depth (meters)

T = temperature (^{0}C)

C = measured conductivity (mmhos/cm)

S = salinity (^{0}/oo)

Table 9. Flow Using Broenkow's Salinity Equations.



*without the R_Z term

R_Z = pressure effect on conductivity

A_T = temperature effect

R_T = R(S,t,p) conductivity ratio

Δ_{15} = t_{15} correction (International Oceanographic Tables, 1966)

R_{15} = R(S,15°C,0)

Table 10. Specifications for Plessey Model 9400 CTD System.

	Conductivity	Temperature	Depth
Accuracy	± 0.03 mmho/cm	± 0.02°C	± 1.5 m
Resolution	0.0002 mmho/cm	0.0001°C	0.0012 m
Time Constant	0.1 sec	0.35 sec	0.1 sec

We have progressively used several different compact sets of salinity equations in the HP calculator, going from Knowles (1973) to Bennett (1976) to Broenkow (1977). The Knowles equation does not consider the influence of depth on the calculation of salinity and, therefore, is not recommended. Both Bennett and Broenkow include depth dependence. The Bennett equations apparently have received considerable acceptance and use (Lewis and Perkin, 1978). We have gravitated further, now using the equations of Broenkow (1977). These equations give a better fit to Jaeger's (1973) table of salinities calculated from experimental conductivities, temperatures, and depths than Bennett for the temperature, depth, and salinity ranges we experience in our work (Table 11). This in turn gives a better real time look at the salinity structure before introducing the salinity calibration data.

By varying "real" C, T, and D by the rated sensor accuracies in the salinity equation, the maximum error attributable to each sensor can be determined. Those stations with deep casts that have a low conductivity and temperature have been found to cause the maximum error, therefore, those "real" data are used to determine each parameters' effect on the salinity equation. The composite maximum error has been approximately ± 0.06 ‰ for the "real" data sets. However, the standard deviation of all mixed layer samples taken for salinity calibration purposes implies greater accuracy, namely ± 0.03 ‰ after offset. We believe this value is a more realistic measure of the quality of the data set, except in strong thermoclines ($\Delta T > 1^{\circ}C/m$).

Hewlett-Packard System

The previously described digital magnetic tape recording has many advantages. However, there are several serious disadvantages. The principal weaknesses are the lack of onboard confirmation of data acquisition, no real time presentation of data, and costly computer analysis. In an effort to avoid these disadvantages and provide a more redundant system, we have assembled a data acquisition system based on a Hewlett-Packard 9825A calculator.

Presently, our HP-CTD data acquisition system is in the final developmental stages. The remaining problems are principally with software. Our intentions are to use the HP tape cartridge or flexible disk as a primary

Table 11. Jaeger Pressure,Conductivity, Temperature, Salinity Table.

Depth m	Pressure dbar	Conductivity mmhos/cm^2	Temperature ^oC	Experimental Salinity ppt	Knowles Salinity ppt	Bennett Salinity ppt	Broenkow Salinity ppt
0.00	0.00	25.381	0.00	30.200	30.163	30.186	30.183
0.00	0.00	29.267	5.00	30.200	30.177	30.188	30.186
0.00	0.00	33.340	10.00	30.200	30.184	30.187	30.192
0.00	0.00	37.582	15.00	30.200	30.187	30.188	30.196
0.00	0.00	41.977	20.00	30.200	30.189	30.188	30.197
0.00	0.00	46.510	25.00	30.200	30.193	30.187	30.199
0.00	0.00	51.149	30.00	30.200	30.188	30.186	30.197
1714.00	1723.00	39.146	15.00	31.000	-	30.989	31.003
1714.00	1723.00	43.629	20.00	31.000	-	30.988	31.004
0.00	0.00	38.606	15.00	31.118	31.105	31.105	31.113
0.00	0.00	38.094	13.80	31.619	31.610	31.611	31.619
0.00	0.00	44.580	20.90	31.619	31.610	31.608	31.618
0.00	0.00	50.571	27.20	31.619	31.611	31.605	31.618
0.00	0.00	29.021	0.00	35.000	34.976	34.992	35.000
1714.00	1723.00	29.779	0.00	35.000	-	34.993	35.007
3427.99	3446.00	30.451	0.00	35.000	-	34.996	35.023
5141.99	5169.00	31.035	0.00	35.000	-	34.995	35.040
6855.98	6892.00	31.541	0.00	35.000	-	34.993	35.069
0.00	0.00	33.443	5.00	35.000	34.987	34.995	34.998
0.00	0.00	38.073	10.00	35.000	34.989	34.990	34.999
0.00	0.00	42.896	15.00	35.000	34.990	34.991	35.000
1714.00	1723.00	43.623	15.00	35.000	-	34.987	35.004
3427.99	3446.00	44.269	15.00	35.000	-	34.988	35.012
5141.99	5169.00	44.838	15.00	35.000	-	34.993	35.025
0.00	0.00	47.891	20.00	35.000	34.989	34.989	34.998
0.00	0.00	53.046	25.00	35.000	34.993	34.988	35.000
1714.00	1723.00	53.746	25.00	35.000	-	34.985	35.000
0.00	0.00	58.324	30.00	35.000	34.989	34.988	34.999
0.00	0.00	47.186	15.00	38.951	38.944	38.945	38.956
1714.00	1723.00	48.020	15.00	39.000	-	38.989	39.008
1714.00	1723.00	53.495	20.00	39.000	-	38.989	39.009
0.00	0.00	46.290	13.80	39.333	39.319	39.320	39.330
0.00	0.00	54.130	20.90	39.333	39.321	39.320	39.331
0.00	0.00	61.369	27.20	39.333	39.322	39.315	39.331
0.00	0.00	32.880	0.00	40.196	40.178	40.192	40.205
0.00	0.00	37.869	5.00	40.196	40.192	40.198	40.203
0.00	0.00	43.090	10.00	40.196	40.194	40.194	40.205
0.00	0.00	48.524	15.00	40.196	50.192	40.193	40.203
0.00	0.00	54.151	20.00	40.196	40.188	40.188	40.199
0.00	0.00	59.961	25.00	40.196	40.193	40.187	40.202
0.00	0.00	65.911	30.00	40.196	40.190	40.186	40.201

data storage device, with the Kennedy tape recorder and HP XYY' recorder available as backup units. The expanded scale of the HP XYY' recorder (0.2°/cm, 0.4 (mmhos/cm)/cm, 4 m/cm) still makes it valuable for determining at which depths to trip Niskin bottles on the upcast, having plotted T and C versus D during the downcast.

A single HP tape cartridge, which is structured with two parallel tracks, contains programs for the CTD acquisition on one track and has space for data storage for as many as 30 stations on the other. The programs are listed in Appendix IV. The master program instructs the operator how to initiate a CTD cast. Special function keys are defined by this program that enable interactive control of data acquisition modes, i.e., downcast, upcast, soak routines. All subsequent programs prompt the operator on procedures and ask for the necessary variable entries, i.e., offsets, data storage, file numbers. An example of the internal printer output is shown in Appendix V.

The data acquired by the HP is treated using a software scheme similar to the Cyber programming but is real time (Table 12). While the CTD is on the deck of the ship the frequencies for D and C are entered following the station number. These variables are used in the frequency to engineering unit conversion as the frequencies for zero D and C.

Three scans of CTD are acquired and the temperature lag is calculated similar to the Cyber programming:

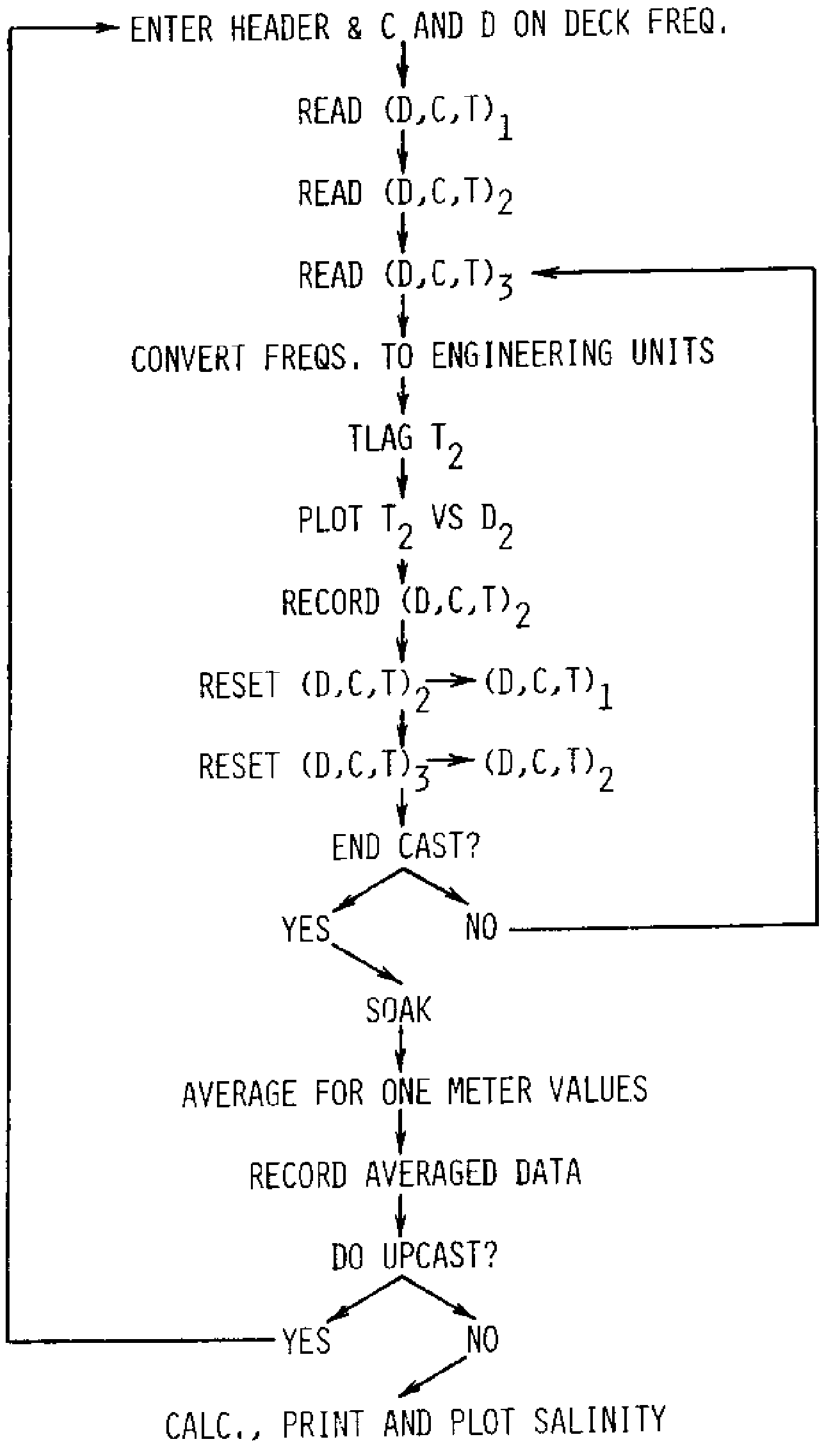
$$T_{R(n)} = T_{I(n)} + \frac{0.35(T_{I(n+1)} - T_{I(n-1)})}{2(0.405)}$$

The difference is the sampling rate; 0.405 seconds are required for the HP to acquire and process a CTD scan. The length and complexity of the HP data acquisition program governs the sampling rate. Further data processing is done after data is acquired and recorded on preliminary tape cartridge files at this fastest sampling rate. A T-versus-D plot is done in real time.

After the CTD Fish is lowered to within 3 meters of the bottom, data collection is stopped and a soak routine begins. Depth, temperature, and salinity are displayed and printed during the four minutes that the reversing thermometers remain at a constant depth for equilibration. T and S printed during the soak are used to calibrate the CTD against the reversing thermometers and salinity bottle samples taken at that depth.

The preliminary down cast data is then averaged for each meter and recorded permanently on the HP tape cartridge. Data collection during upcasts is taken in the same manner. If calibration is to be done at depths other than the deepest sample depth, a mid-depth soaking routine is used to print D, T, and S while a rosette bottle is being tripped. The mid-depth soak can be used at any time the CTD Fish is stopped, so that excessive data is not recorded. At the end of the upcast the preliminary data is averaged to meter increments and recorded on a permanent file.

Table 12. HP-CTD Data Acquisition Scheme.



Our HP calculator was purchased with 8k bytes of core memory. With the program taking up one-fourth of the core, only 100 CTD scans could be input before the array had to be recorded on a preliminary file. The core was then free to receive 100 more CTD scans. As much as two meters of data were missed while the calculator stopped to record each 100 scans. Sixteen k bytes of memory were recently added. Initial tests indicate that 80 m can be stored in an array before copying to the tape cartridge. Use of disk would eliminate this problem.

Further data processing is done aboard ship. Salinity (preferably from downcast data) is plotted versus depth. Until calibration data becomes available, plots are made using uncorrected salinity values. Temperature and salinity onshore-offshore transects are plotted in vertical cross section as well as horizontal plots and station locations. The HP software for this was developed at Skidaway Institute.

SUMMARY

The system described herein is a powerful tool for hydrographic data collection and reduction. Over 900 vertical CTD profiles and 45 hours of horizontal profiling (pumping water over the sensors in a bucket on deck) have been successfully completed in the two years since purchasing the initial system components. Through the first year, a 96% success rate was achieved while the system was being tried and upgraded. The success rate improved in the second year and continues to do so.

The portability of the system has allowed us to work from many of the ships available for research in the South Atlantic Bight. We take part in cooperative cruises and can operate on a minimum of manpower.

Real time data processing aboard ship has been achieved. The HP programmed plotter provides immediate visual presentation of the data. The sensors show drift with time; therefore, an extension calibration scheme is performed for every cruise. Once calibrated and formatted for NODC, cruise data is presented in technical report form.

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APPENDIX I.

Troubleshooting

This section summarizes some of our problems and cures in a trouble-shooting chart. This is not an attempt to list every possible problem nor the probable remedy.

CTD TROUBLESHOOTING

PROBLEM	PROBABLE CAUSE	CORRECTION
*No C, T, and D signals in air	1) Have not made all connections (DDL-slip rings - CTD)	1) Check connections
	2) Bad ground	2) Check ground
	3) Short in armored cable	3) Cut off bad part of cable and re-scotchcast
	4) Bad mixer	4) Replace or repair mixer
	5) Bad connection to C, T, and D sensors from mixer	5) Check connection for too much dielectric grease
Loss of C,T, or D signal in air	1) Bad counter or digitizing board in DDL	1) Replace or repair board
	2) Bad connection to sensor	2) Check connection for too much dielectric grease
Loss of C, T, or D signal or some combination of signals in air but recovery of signal with depth	1) Too much silicone dielectric grease in connection	1) Clean connector pins and sleeves
Loss of all signals as Fish enters water	1) Bad ground	1) Check ground
	2) Leak in C, T, D, or mixer pressure housings containing electronics	2) Disassemble and dry with alcohol and Q-tips
	3) Leak in 9 pin or 3 pin plugs to sensors	3) Dry and seal with silicone dielectric grease
Loss of C, T, and D signals at depth but recovery with return to ship	1) Wire crimped and wedged in pressure housing of mixer	1) Replace or repair wire

*See "Volt-Amp Meter Readings" for troubleshooting problems (page 30).

PROBLEM	PROBABLE CAUSE	CORRECTION
Occasional spiking (blinking) in C, T, and D signals	1) Fluctuation in AC system	1) Use different wall sockets for power cords
	2) Wet or bad connection to slip rings	2) Check slip ring wiring
	3) Loose ground	3) Check ground
	4) Some stress on a connector (on ship or on Fish)	4) Check all connectors
	5) Wet 9 pin or 3 pin connectors on sensors	5) Dry pins
Spiking of C, T, and D signals when winch is turned on or off	1) Relays to winch	1) Solid state relays would be an improvement
Occasional D spiking beginning at a particular depth from one cast to the next	1) Bad armored conductor cable	1) Inspect cable and cut off bad section
Spiking (blinking) of C signal in high salinity water but O.K. in air or in low salinity water. Also note on XYY' that while signal occasionally spikes, conductivity remains too constant (false reading)	1) Defective frequency plug on C board in DDL (Changes the limit of acceptable frequencies which it will allow to pass into DDL for processing)	1) Replace plug or capacitor on plug
Blinking C and analog (XYY') spikes	1) Capacitor to attenuate Fish power to DDL when using a short conductor wire is not in place	1) Connect capacitor
Severe noise on XYY' and/or HP 9825A and Plotter in air or at depth	1) Plotter picking up stray radio frequency from radio communications (Single Side Band)	1) Prohibit radio communications while doing CTD cast
	2) Data lines too near AC power lines	2) Separate Data lines from AC power lines

PROBLEM	PROBABLE CAUSE	CORRECTION
Good signals to DDL but nothing to XYY' plotter	1) S3 switch on back of DDL in wrong position	1) Flick switch to proper position
Good signals to DDL but nothing to frequency counter	1) Bad conductor between the two	1) Repair or replace conductor
Not tripping bottles in air	1) Incorrect armored cable hookup	1) Check hookup
	2) Bad ground	2) Check ground
	3) Loose or wet connection on Fish	3) Check connections
	4) Bad relays in deck box	4) Replace relays
	5) Bad step motor	5) Repair or replace step motor
	6) Bad cold solders in deck unit	6) Check solders
Bottles trip in air but not in water	1) Leakage in armored conductor cable	1) Cut off bad cable and re-scotchcast (entire cable may be bad)

Our Plessey 8400 Digital Data Logger, which also powers the CTD, was modified to indicate sea cable voltage and amperage on the front panel. The following table is very useful for troubleshooting.

Volt-Amp Meter Readings

Problem	Indication of Problem
CTD on Deck:	
Open Circuit	high voltage, low amperage*
Short Circuit:	low voltage, correct amperage
Short is in deck unit	2 Volts
Short is in Fish	5 Volts
During CTD cast:	
Short Circuit	voltage decrease
Corrosion	voltage increase

*For our 250 meter, 4-conductor wire the normal readings are 30 Volts and 135 milliamps.

APPENDIX II.

Cruise Supplies

CRUISE SUPPLIES

General

Drafting supplies
Ruler
Dividers
10 point dividers
Rubber station stamp and ink pad
Stop watch
HP-55 hand held calculator and power cord
Meter-fathoms-feet disc
2 boxes of pencils (#2)
2 magic markers (black)
Graph paper for XYY' and 9862A plotters (25 x 38 cm)
15 legal size white envelopes
2 clip boards
10 large plastic bags
Spare tubing for Niskin Bottles
2 spare Niskin end caps (tops)
Spare landyards and micro-press clamps for Niskin Bottles
Pair of stainless steel wing bolts for each Niskin Bottle (in tool box)
2 scotch cast (type 82-A1) (2 others in electronics box)
1 box scotch auto-electric sealing compound (live rubber tape)
5 G.O. messengers (for Niskins in case of CTD failure)
Inclinometer (wire angle)
Bicycle stretch straps
3 - radiator specialty straps (black rubber) for CTD
1 pair of gloves
50' 1/8" nylon line (for tying down)
50' 1/4" clothes line (for tying down)
2 cans of CRC spray
4 nutrient freezing boxes
2 ice chests (if entering another port)
Nutrient Bottles
Large dissolved oxygen (B.O.D. Bottles)
2 boxes of large salinity bottles (70 total)
1 box of small salinity bottles (50 total)
2 black pails with attached rope
Bucket thermometer and spare thermometer (0.1°C increments)
Weather radio
Anchor, 500 ft. of line and buoy
Desk lamp
Lab stool
Lawn chairs
2 unprotected thermometers
4 protected thermometers (7715 and 7718 are best)
10 and 30 lb. weights
CTD weight harness
Thermometer reader-magnifier
7 small Niskin Bottles (1.7 liter) - 3 with thermometer racks
2 large (5.0 liter) Niskin Bottles
NODC sheets
Ringbinder reinforcers

Cruise Supplies - General (cont'd)

"Cruise Log" ring-binder notebook with: cruise plan, cruise log, data cassette logs (10), cruise section logs (10), station sheets (120), XBT event log (15), CTD procedure, D, C, T frequency conversion tables, protected and unprotected thermometer calibration sheets (copies), oxygen analysis procedure (3), oxygen data sheets (15)
XBT Tester
XBT test canister
XBT chart paper (0-200 m roll)
XBT's
XBT recorder
XBT gun
Plessey Lab Salinometer
Standard seawater
CTD-Rosette with Helle Pinger
CTD Winch + 3 welding brackets
CTD parts box
ELECTRONIC GEAR
EQUIPMENT MANUALS
OXYGEN ANALYSIS SUPPLIES
TOOL BOX

CRUISE SUPPLIES

ELECTRONIC GEAR

Electronics box
HP 9825A (calculator), power cord and packing box
HP 9862A (plotter), interface, power cord and packing box
HP 59307A (VHF switch), *Interface HP-IB and power cord
HP 59309A (Clock), *Interface and power cord — *connected piggyback
HP 5328A (Counter), *Interface and power cord
HP 204C (Frequency oscillator) and power cord and leads
Plessey DDL
Kennedy Recorder and power cord
HP 7046A (XYY') and power cord
DDL - Recorder Interface
DDL - (XXY' Plotter) Interface
3 leads: DDL from switch
1 lead: switch from counter
G.O. Rosette Tripper Box
4 conductor sea cable: (Winch to DDL and Rosette Tripper Box)
Spare harness (9 pin with 3 three pin connectors for C, T, and D) - (in CTD Parts Box)
Assorted spare wires and connectors for CTD (in CTD Parts Box)
Mounting board (for calculator and plotter)
2 multiterminal power strips (be sure they have fuses in them)
Voltmeter and leads (check that it is operational)
Solder iron and solder
Spare mixer, conductivity, temperature, and depth sensors (in CTD Parts Box)
Data Cassettes
Program Cassettes
Rolls of printing paper
Pens for plotters (9862A and 7046A XYY')
HP Tape head cleaner
Kennedy tape head cleaner kit
Check output on 10 volt calibration of XYY' plotter (is it 10 volts?)
Labels for magnetic tapes
3 or 4 magnetic tapes for Kennedy tape drive
Intercom system (winch to DDL communications)
2 rolls of electric tape

CRUISE SUPPLIES

EQUIPMENT MANUALS

HP 9825A Calculator: Operating and Programming
HP 9825A Calculator: System Test Booklet and Test Cartridge 09825-90035
HP 9825A Calculator: Quick Reference Guide
HP 9825A Calculator: General I/O Programming
HP 9825A Calculator: Extended I/O Programming
HP 9825A Calculator and Plotter: Plotter Programming
HP 9825A Calculator: Advanced Programming
HP 9825A Calculator: String Variable Programming
HP 9825A Calculator: Systems Programming
HP 98034A HP-IB Interface: Installation and Service Manual
HP 59307A VHF Switch: Operating and Service Manual
HP 59309A ASCII Digital Clock: Operating and Service Manual
HP 7046A X-Y Recorder: Operating and Service Manual
HP 5328A Universal Counter: User and Service Manual
HP 204C/204D Oscillator: Operation and Service Manual
HP Option 020 Digital Voltmeter: Installation and Service Manual
HP Software General Statistics Binder with 3-tapes
Kennedy Model 1600 Incremental Tape Recorder: Operation and Maintenance Manual
G.O. Model 1015 Rosette: Instruction Manual
G.O. Model 3070 Film Recording Thermograph: Instruction Manual
Plessey Model 7400 Winch: Instruction Manual
Plessey Model 9400 CTD System: Instruction Manual
Plessey Model 8400 DDL: Instruction Manual
Sippican Model R-603 XBT System: Instruction Manual
Plessey Model 6230N Laboratory Salinometer

CRUISE SUPPLIES

OXYGEN ANALYSIS SUPPLIES

3 copies of Oxygen Analysis procedure (in "Cruise Log" notebook)
15 Oxygen Data Sheets (in "Cruise Log" notebook)
1 roll duct tape
1 roll masking tape
paper towels
2 boxes kimwipes
1 clip board
1 pipette bulb
2 - 50 ml Lowy pipettes (and tubing)
2 - 10 ml (.05 ml increment) burettes (and tubing)
2 clean 5.0 ml pipettes
2 clean 1.0 ml pipettes
1 clean 50.0 ml pipette
2 - 10 ml graduate cylinders
6 automatic pipettes (plunger type) with 6 to 10 dispensing tubes (preset 3 of them for 0.5 ml and 1 for 2.5 ml) - these are backup to Oxford Dispensers
4 clean erlenmeyer flasks (125 ml)
1 - 250 ml beaker
1 - 600 ml beaker
2 - 300 ml B.O.D. bottles
3 squeeze bottles of distilled water
1 squeeze bottle of acetone
titration lamp
3 - 0.5 ml Oxford Reagent Dispensers (check to see that they work)
2 extra dispenser bottles
Jug of distilled water
2 ring stands
4 clamps
4 pieces of tubing to cushion and secure burette and pipet with clamps
Vacuum pump (be sure it works)
Trap for vacuum pump (and tubing)
Magnetic stirrer and 2 stir bars
1 pair scissors
Box of Para Film
Sulfuric acid
Starch indicator solution (2 liter)
.01 N Iodate standard (at least 500 ml)
Alkaline Iodide Soln. (1 liter)
Manganous sulfate soln. (1 liter)
6 liters thiosulfate solution (+ stopper and tubing attachments)
300 ml BOD Bottles

CRUISE SUPPLIES

TOOL BOX

1 roll masking tape
1 roll duct tape
1 roll electric tape
1 tube silicone lubricant, 1 tube silicone glue
1 can PVC cement
1 magic marker (black)
1 hammer
3 screw drivers
2 phillips screw drivers (large and small handled)
6 jewelers screw drivers
Channel lock pliers
Needle nose pliers
Regular pliers
Cutting pliers
Vise grips
Cable cutters (that don't fit in Tool Box)
Allen wrenches
Tape measure
Small ratchet set
*1 knife or cutting tool
Triangle file for Copenhagen water
Niskin bottle cocker and screw driver
Electric drill (Separate from box)
Drill bits
*1 pair scissors
8" adjustable wrench
2 - 1/2"-9/16" open end wrenches
1 - 1/2" wrench o/c
1 - 9/16" wrench o/c
2 - 3/8"-7/16" open end wrenches
1 - 3/8" wrench o/c
1 - 7/16" wrench o/c
1 - 1/4"-5/16" open end wrench
1 - 5/16" wrench o/c
1 - 3/4" chisel
Wire strippers

ACCESSORIES TO TOOL BOX

2 - 1/8" thimbles
2 - 3/16" thimbles
2 - 7/16" thimbles
Pair of stainless wing bolts for each Niskin bottle
Nuts and bolts for securing DDL and XYY' plotter
2 shackles
Hard wire (for securing shackles)
Wire clamps (U-bolts)
2" C-clamps
Assorted bolts, wood screws, and screw eyes

APPENDIX III.

Cyber Programs

The following programs are written in CDC Fortran IV extended time sharing (FTNTS). The language is identical to Fortran IV except for the addition line numbers and the relaxed column requirements. These programs are stored and run in compiled (binary) form.

PROGRAM CTDRUN

```
SIO.
USER,SIO3,****.
SETUP,U3002=BF07.
REQUEST,TAPE,VSN=U3002,HI,F=S,PO=R,LB=KU.
DEFINE,BF07,BFCK.
COPY,TAPE,BF07.
REWIND,TAPE.
COPY,TAPE,BFCK.
REWIND,BF07,BFCK.
VERIFY,BF07,BFCK,R.
DAYFILE.
REPLACE,OUTPUT=CK.
EXIT.
DAYFILE.
REPLACE,OUTPUT=CK.
```

PROGRAM MAGREAD

```
PROGRAM MAGREAD (BF07,BIRANG,OUTPUT,TAPE5=BF07,TAPE6=OUTPUT,
+  TAPE7=BIRANG)
C   THIS PROGRAM IS DESIGNED TO CONVERT CTD DATA ON MAGNETIC TAPES
C       TO A BINARY RECORD (PROPORTIONAL TO FREQUENCY) FOR FURTHER
C       CALCULATION TO SALINITY,TEMPERATURE, AND DEPTH VALUES.
INTEGER K(54),M(45),HEAD
INTEGER I0,I1,I2,I3,I4,I5,I6
INTEGER SCAN0,SCAN1,SCAN2,SCAN3,SCAN4,SCAN5,SCAN6
INTEGER Z0,Z1,Z2,Z3,Z4,Z5,Z6
INTEGER C0,C1,C2,C3,C4,C5,C6
INTEGER T0,T1,T2,T3,T4,T5,T6
ISTA=0
C MASK WITH J
J=0000 0000 0000 0000 0001 B
28 BUFFER IN (5,1) (M(1),M(45))
IF (UNIT(5)) 25,24,13
25 N=M(1)
HEAD=AND(SHIFT(N,3),J)*8000 +AND(SHIFT(N,4),J)*4000
+    +AND(SHIFT(N,5),J)*2000 +AND(SHIFT(N,6),J)*1000
+    +AND(SHIFT(N,9),J)*800 +AND(SHIFT(N,10),J)*400
+    +AND(SHIFT(N,11),J)*200 +AND(SHIFT(N,12),J)*100
+    +AND(SHIFT(N,15),J)*80 +AND(SHIFT(N,16),J)*40
+    +AND(SHIFT(N,17),J)*20 +AND(SHIFT(N,18),J)*10
+    +AND(SHIFT(N,21),J)*8 +AND(SHIFT(N,22),J)*4
+    +AND(SHIFT(N,23),J)*2 +AND(SHIFT(N,24),J)*1
C   HOPEFULLY 9999 WAS ENTERED ON THE MAGNETIC TAPE AFTER THE LAST CAST.
IF (HEAD.EQ.9999) GO TO 8
WRITE (7,23)HEAD
23 FORMAT ("9999",/,I4)
GO TO 28
24 WRITE (6,26)HEAD
26 FORMAT (/"***",I4,"***=THE HEADER NUMBER")
C   COUNT THE NUMBER OF STATIONS
ISTA=ISTA+1
ICOUNT=0
9 BUFFER IN(5,1)(K(1),K(54))
IF(UNIT(5))15,14,13
15 CONTINUE
C   COUNT THE NUMBER OF RECORDS OF DATA
ICOUNT=ICOUNT+1
5 DO 2 L=1,7
I0=K(7*L-6)$I1=K(7*L-5)$I2=K(7*L-4)$I3=K(7*L-3)$I4=K(7*L-2)$I5=K(7*L-1)
I6=K(7*L)
SCAN0=AND(SHIFT(I0,3),J)*80+
+  AND(SHIFT(I0,4),J)*40+
+  AND(SHIFT(I0,5),J)*20+
+  AND(SHIFT(I0,6),J)*10+
+  AND(SHIFT(I0,9),J)*8+
+  AND(SHIFT(I0,10),J)*4+
+  AND(SHIFT(I0,11),J)*2+
+  AND(SHIFT(I0,12),J)*1
Z0=AND(SHIFT(I0,15),J)*32768 +AND(SHIFT(I0,16),J)*16384
+  +AND(SHIFT(I0,17),J)*8192 +AND(SHIFT(I0,18),J)*4096
```

```
+  +AND(SHIFT(I0,21),J)*2048 +AND(SHIFT(I0,22),J)*1024
+  +AND(SHIFT(I0,23),J)*512 +AND(SHIFT(I0,24),J)*256
+  +AND(SHIFT(I0,27),J)*128 +AND(SHIFT(I0,28),J)*64
+  +AND(SHIFT(I0,29),J)*32 +AND(SHIFT(I0,30),J)*16
+  +AND(SHIFT(I0,33),J)*8 +AND(SHIFT(I0,34),J)*4
+  +AND(SHIFT(I0,35),J)*2 +AND(SHIFT(I0,36),J)*1
 C0=AND(SHIFT(I0,39),J)*32768 +AND(SHIFT(I0,40),J)*16384
+  +AND(SHIFT(I0,41),J)*8192 +AND(SHIFT(I0,42),J)*4096
+  +AND(SHIFT(I0,45),J)*2048 +AND(SHIFT(I0,46),J)*1024
+  +AND(SHIFT(I0,47),J)*512 +AND(SHIFT(I0,48),J)*256
+  +AND(SHIFT(I0,51),J)*128 +AND(SHIFT(I0,52),J)*64
+  +AND(SHIFT(I0,53),J)*32 +AND(SHIFT(I0,54),J)*16
+  +AND(SHIFT(I0,57),J)*8 +AND(SHIFT(I0,58),J)*4
+  +AND(SHIFT(I0,59),J)*2 +AND(SHIFT(I0,60),J)*1
 T0=AND(SHIFT(I1,3),J)*32768 +AND(SHIFT(I1,4),J)*16384
+  +AND(SHIFT(I1,5),J)*8192 +AND(SHIFT(I1,6),J)*4096
+  +AND(SHIFT(I1,9),J)*2048 +AND(SHIFT(I1,10),J)*1024
+  +AND(SHIFT(I1,11),J)*512 +AND(SHIFT(I1,12),J)*256
+  +AND(SHIFT(I1,15),J)*128 +AND(SHIFT(I1,16),J)*64
+  +AND(SHIFT(I1,17),J)*32 +AND(SHIFT(I1,18),J)*16
+  +AND(SHIFT(I1,21),J)*8 +AND(SHIFT(I1,22),J)*4
+  +AND(SHIFT(I1,23),J)*2 +AND(SHIFT(I1,24),J)*1
 SCAN1=AND(SHIFT(I1,27),J)*80 +AND(SHIFT(I1,28),J)*40
+  +AND(SHIFT(I1,29),J)*20 +AND(SHIFT(I1,30),J)*10
+  +AND(SHIFT(I1,33),J)*8 +AND(SHIFT(I1.34),J)*4
+  +AND(SHIFT(I1,35),J)*2 +AND(SHIFT(I1,36),J)*1
 Z1=AND(SHIFT(I1,39),J)*32768 +AND(SHIFT(I1,40),J)*16384
+  +AND(SHIFT(I1,41),J)*8192 +AND(SHIFT(I1,42),J)*4096
+  +AND(SHIFT(I1,45),J)*2048 +AND(SHIFT(I1,46),J)*1024
+  +AND(SHIFT(I1,47),J)*512 +AND(SHIFT(I1,48),J)*256
+  +AND(SHIFT(I1,51),J)*128 +AND(SHIFT(I1,52),J)*64
+  +AND(SHIFT(I1,53),J)*32 +AND(SHIFT(I1,54),J)*16
+  +AND(SHIFT(I1,57),J)*8 +AND(SHIFT(I1,58),J)*4
+  +AND(SHIFT(I1,59),J)*2 +AND(SHIFT(I1,60),J)*1
 C1=AND(SHIFT(I2,3),J)*32768 +AND(SHIFT(I2,4),J)*16384
+  +AND(SHIFT(I2,5),J)*8192 +AND(SHIFT(I2,6),J)*4096
+  +AND(SHIFT(I2,9),J)*2048 +AND(SHIFT(I2,10),J)*1024
+  +AND(SHIFT(I2,11),J)*512 +AND(SHIFT(I2,12),J)*256
+  +AND(SHIFT(I2,15),J)*128 +AND(SHIFT(I2,16),J)*64
+  +AND(SHIFT(I2,17),J)*32 +AND(SHIFT(I2,18),J)*16
+  +AND(SHIFT(I2,21),J)*8 +AND(SHIFT(I2,22),J)*4
+  +AND(SHIFT(I2,23),J)*2 +AND(SHIFT(I2,24),J)*1
 T1=AND(SHIFT(I2,27),J)*32768 +AND(SHIFT(I2,28),J)*16384
+  +AND(SHIFT(I2,29),J)*8192 +AND(SHIFT(I2,30),J)*4096
+  +AND(SHIFT(I2,33),J)*2048 +AND(SHIFT(I2,34),J)*1024
+  +AND(SHIFT(I2,35),J)*512 +AND(SHIFT(I2,36),J)*256
+  +AND(SHIFT(I2,39),J)*128 +AND(SHIFT(I2,40),J)*64
+  +AND(SHIFT(I2,41),J)*32 +AND(SHIFT(I2,42),J)*16
+  +AND(SHIFT(I2,45),J)*8 +AND(SHIFT(I2,46),J)*4
+  +AND(SHIFT(I2,47),J)*2 +AND(SHIFT(I2,48),J)*1
 IF (L.EQ.7)6,12
 12 CONTINUE
 SCAN2=AND(SHIFT(I2,51),J)*80 +AND(SHIFT(I2,52),J)*40
+  +AND(SHIFT(I2,53),J)*20 +AND(SHIFT(I2,54),J)*10
+  +AND(SHIFT(I2,57),J)*8 +AND(SHIFT(I2,58),J)*4
+  +AND(SHIFT(I2,59),J)*2 +AND(SHIFT(I2,60),J)*1
```

```
Z2=AND(SHIFT(I3,3),J)*32768 +AND(SHIFT(I3,4),J)*16384
  +AND(SHIFT(I3,5),J)*8192 +AND(SHIFT(I3,6),J)*4096
  +AND(SHIFT(I3,9),J)*2048 +AND(SHIFT(I3,10),J)*1024
  +AND(SHIFT(I3,11),J)*512 +AND(SHIFT(I3,12),J)*256
  +AND(SHIFT(I3,15),J)*128 +AND(SHIFT(I3,16),J)*64
  +AND(SHIFT(I3,17),J)*32 +AND(SHIFT(I3,18),J)*16
  +AND(SHIFT(I3,21),J)*8 +AND(SHIFT(I3,22),J)*4
  +AND(SHIFT(I3,23),J)*2 +AND(SHIFT(I3,24),J)*1
C2=AND(SHIFT(I3,27),J)*32768 +AND(SHIFT(I3,28),J)*16384
  +AND(SHIFT(I3,29),J)*8192 +AND(SHIFT(I3,30),J)*4096
  +AND(SHIFT(I3,33),J)*2048 +AND(SHIFT(I3,34),J)*1024
  +AND(SHIFT(I3,35),J)*512 +AND(SHIFT(I3,36),J)*256
  +AND(SHIFT(I3,39),J)*128 +AND(SHIFT(I3,40),J)*64
  +AND(SHIFT(I3,41),J)*32 +AND(SHIFT(I3,42),J)*16
  +AND(SHIFT(I3,45),J)*8 +AND(SHIFT(I3,46),J)*4
  +AND(SHIFT(I3,47),J)*2 +AND(SHIFT(I3,48),J)*1
T2=AND(SHIFT(I3,51),J)*32768 +AND(SHIFT(I3,52),J)*16384
  +AND(SHIFT(I3,53),J)*8192 +AND(SHIFT(I3,54),J)*4096
  +AND(SHIFT(I3,57),J)*2048 +AND(SHIFT(I3,58),J)*1024
  +AND(SHIFT(I3,59),J)*512 +AND(SHIFT(I3,60),J)*256
  +AND(SHIFT(I4,3),J)*128 +AND(SHIFT(I4,4),J)*64
  +AND(SHIFT(I4,5),J)*32 +AND(SHIFT(I4,6),J)*16
  +AND(SHIFT(I4,9),J)*8 +AND(SHIFT(I4,10),J)*4
  +AND(SHIFT(I4,11),J)*2 +AND(SHIFT(I4,12),J)*1
SCAN3=AND(SHIFT(I4,15),J)*80 +AND(SHIFT(I4,16),J)*40
  +AND(SHIFT(I4,17),J)*20 +AND(SHIFT(I4,18),J)*10
  +AND(SHIFT(I4,21),J)*8 +AND(SHIFT(I4,22),J)*4
  +AND(SHIFT(I4,23),J)*2 +AND(SHIFT(I4,24),J)*1
Z3=AND(SHIFT(I4,27),J)*32768 +AND(SHIFT(I4,28),J)*16384
  +AND(SHIFT(I4,29),J)*8192 +AND(SHIFT(I4,30),J)*4096
  +AND(SHIFT(I4,33),J)*2048 +AND(SHIFT(I4,34),J)*1024
  +AND(SHIFT(I4,35),J)*512 +AND(SHIFT(I4,36),J)*256
  +AND(SHIFT(I4,39),J)*128 +AND(SHIFT(I4,40),J)*64
  +AND(SHIFT(I4,41),J)*32 +AND(SHIFT(I4,42),J)*16
  +AND(SHIFT(I4,45),J)*8 +AND(SHIFT(I4,46),J)*4
  +AND(SHIFT(I4,47),J)*2 +AND(SHIFT(I4,48),J)*1
C3=AND(SHIFT(I4,51),J)*32768 +AND(SHIFT(I4,52),J)*16384
  +AND(SHIFT(I4,53),J)*8192 +AND(SHIFT(I4,54),J)*4096
  +AND(SHIFT(I4,57),J)*2048 +AND(SHIFT(I4,58),J)*1024
  +AND(SHIFT(I4,59),J)*512 +AND(SHIFT(I4,60),J)*256
  +AND(SHIFT(I5,3),J)*128 +AND(SHIFT(I5,4),J)*64
  +AND(SHIFT(I5,5),J)*32 +AND(SHIFT(I5,6),J)*16
  +AND(SHIFT(I5,9),J)*8 +AND(SHIFT(I5,10),J)*4
  +AND(SHIFT(I5,11),J)*2 +AND(SHIFT(I5,12),J)*1
T3=AND(SHIFT(I5,15),J)*32768 +AND(SHIFT(I5,16),J)*16384
  +AND(SHIFT(I5,17),J)*8192 +AND(SHIFT(I5,18),J)*4096
  +AND(SHIFT(I5,21),J)*2048 +AND(SHIFT(I5,22),J)*1024
  +AND(SHIFT(I5,23),J)*512 +AND(SHIFT(I5,24),J)*256
  +AND(SHIFT(I5,27),J)*128 +AND(SHIFT(I5,28),J)*64
  +AND(SHIFT(I5,29),J)*32 +AND(SHIFT(I5,30),J)*16
  +AND(SHIFT(I5,33),J)*8 +AND(SHIFT(I5,34),J)*4
  +AND(SHIFT(I5,35),J)*2 +AND(SHIFT(I5,36),J)*1
SCAN4=AND(SHIFT(I5,39),J)*80 +AND(SHIFT(I5,40),J)*40
  +AND(SHIFT(I5,41),J)*20 +AND(SHIFT(I5,42),J)*10
  +AND(SHIFT(I5,45),J)*8 +AND(SHIFT(I5,46),J)*4
```

```
+  +AND(SHIFT(I5,47),J)*2 +AND(SHIFT(I5,48),J)*1
 Z4=AND(SHIFT(I5,51),J)*32768 +AND(SHIFT(I5,52),J)*16384
+  +AND(SHIFT(I5,53),J)*8192 +AND(SHIFT(I5,54),J)*4096
+  +AND(SHIFT(I5,57),J)*2048 +AND(SHIFT(I5,58),J)*1024
+  +AND(SHIFT(I5,59),J)*512 +AND(SHIFT(I5,60),J)*256
+  +AND(SHIFT(I6,3),J)*128 +AND(SHIFT(I6,4),J)*64
+  +AND(SHIFT(I6,5),J)*32 +AND(SHIFT(I6,6),J)*16
+  +AND(SHIFT(I6,9),J)*8 +AND(SHIFT(I6,10),J)*4
+  +AND(SHIFT(I6,11),J)*2 +AND(SHIFT(I6,12),J)*1
 C4=AND(SHIFT(I6,15),J)*32768 +AND(SHIFT(I6,16),J)*16384
+  +AND(SHIFT(I6,17),J)*8192 +AND(SHIFT(I6,18),J)*4096
+  +AND(SHIFT(I6,21),J)*2048 +AND(SHIFT(I6,22),J)*1024
+  +AND(SHIFT(I6,23),J)*512 +AND(SHIFT(I6,24),J)*256
+  +AND(SHIFT(I6,27),J)*128 +AND(SHIFT(I6,28),J)*64
+  +AND(SHIFT(I6,29),J)*32 +AND(SHIFT(I6,30),J)*16
+  +AND(SHIFT(I6,33),J)*8 +AND(SHIFT(I6,34),J)*4
+  +AND(SHIFT(I6,35),J)*2 +AND(SHIFT(I6,36),J)*1
 T4=AND(SHIFT(I6,39),J)*32768 +AND(SHIFT(I6,40),J)*16384
+  +AND(SHIFT(I6,41),J)*8192 +AND(SHIFT(I6,42),J)*4096
+  +AND(SHIFT(I6,45),J)*2048 +AND(SHIFT(I6,46),J)*1024
+  +AND(SHIFT(I6,47),J)*512 +AND(SHIFT(I6,48),J)*256
+  +AND(SHIFT(I6,51),J)*128 +AND(SHIFT(I6,52),J)*64
+  +AND(SHIFT(I6,53),J)*32 +AND(SHIFT(I6,54),J)*16
+  +AND(SHIFT(I6,57),J)*8 +AND(SHIFT(I6,58),J)*4
+  +AND(SHIFT(I6,59),J)*2 +AND(SHIFT(I6,60),J)*1
 WRITE (7,7)SCAN0,Z0,C0,T0,SCAN1,Z1,C1,T1,SCAN2,Z2,C2,T2,SCAN3,
+  Z3,C3,T3,SCAN4,Z4,C4,T4
 7 FORMAT (4(I4,1X,I5,1X,I5,1X,I5,/),I4,1X,I5,1X,I5,1X,I5)
 2 CONTINUE
 6 WRITE (7,3)SCAN0,Z0,C0,T0,SCAN1,Z1,C1,T1
 3 FORMAT (I4,1X,I5,1X,I5,1X,I5,/,I4,1X,I5,1X,I5,1X,I5)
 GO TO 9
 13 WRITE (6,16)
 16 FORMAT (/"THERE IS A PROBLEM.  THE DATA IS NOT BEING READ RIGHT."/)
 14 WRITE (6,10)ICOUNT
 10 FORMAT ("*******",I3,"******=THE NUMBER OF RECORDS")
 GO TO 28
 8 WRITE(7,77)
 77 FORMAT("9999")
 WRITE(6,78)ISTA
 78 FORMAT("###",I6,"###=THE NUMBER OF CASTS NOW ON TAPE7.")
 STOP
 END
```

PROGRAM CTDUNIT

```
PROGRAM CTDUNIT(INPUT,BIRANG,OUTPUT,LAG,TAPE5=BIRANG,TAPE7=LAG,
+ TAPE4=INPUT,TAPE6=OUTPUT)
C THIS PROGRAM READS FREQUENCIES (BINARY RANGE,BR) FROM BIRANG,
C    CONVERTS THEM TO DEPTH, CONDUCTIVITY, AND TEMPERATURE, AND
C    WRITES THE NEW DATA SET ON A FILE DESIGNATED BY TAPE7.
INTEGER HEAD,SCAN,W
INTEGER ZBR,CBR,TBR
REWIND 5
I=0
WRITE(6,8)
READ(4,9)COR
C   W IS THE PRE-HEADER WRITTEN ONTO BIRANG TO IDENTIFY NEW CASTS.
C   W=9999.  THE HEADER NUMBER FOLLOWS.
10 READ (5,11)W
12 READ(5,13)HEAD
IF(EOF(5))6,16
16 CONTINUE
WRITE(7,14)HEAD
C   I COUNTS THE NUMBER OF CASTS.
I=I+1
J=0
2 IF(EOF(5))6,7
7 READ (5,3)SCAN,ZBR,CBR,TBR
IF (SCAN.EQ.9999) GO TO 12
C   J COUNTS THE NUMBER OF LINES PER CAST.
J=J+1
Z=0.036621094*ZBR
Z=Z+COR
C=0.002441406*CBR
T=0.001220679*TBR-4.999208208
WRITE (7,5)J,SCAN,Z,C,T
GO TO 2
6 WRITE (6,4) I
WRITE(7,1)
C   THE FORMAT SECTION FOLLOWS
1 FORMAT("9999")
3 FORMAT (I4,1X,I5,1X,I5,1X,I5)
4 FORMAT ("*******",I6,"******=THE NUMBER OF CASTS NOW ON TAPE7.")
5 FORMAT (I4,1X,I2,1X,F6.2,1X,F6.3,1X,F5.2)
8 FORMAT("ENTER THE DEPTH CORRECTION FACTOR FOR THE CTD",/,
+    "IN THE FORMAT +X.XXX OR -X.XXX")
9 FORMAT(F6.3)
11 FORMAT (I2)
13 FORMAT (I4)
14 FORMAT ("9999",/,I4)
STOP
END
```

PROGRAM LAGFILT

```
PROGRAM LGFILT(LAG,OUTPUT,LATCH,TAPE5=LAG,TAPE6=OUTPUT,
+  TAPE7=LATCH)
C THIS PROGRAM READS D, C, AND T FROM LAG, COURSE FILTERS THE DATA,
C    CALCULATES THE TEMPERATURE SENSOR LAG, AND WRITES THE NEW DATA
C    SET ONTO A FILE DESIGNATED BY TAPE7.
INTEGER W,HEAD
REWIND 5
I=0
READ(5,10)W
GO TO 1
2 WRITE(6,19)HEAD,M
1 READ(5,10)HEAD
IF(EOF(5))4,5
5 WRITE(7,15)HEAD
M=0
C   I COUNTS THE NUMBER OF CASTS.
I=I+1
READ(5,12)J1,S1,D1,C1,T1
READ(5,12)J2,S2,D2,C2,T2
3 IF(EOF(5))4,23
23 READ(5,12)J3,S3,D3,C3,T3
IF(EOF(5))4,28
28 L=0
IF(J3.EQ.9999)GO TO 2
IF(D3.GE.D2+5.OR.D3.LE.D2-5)GO TO 30
IF(C3.GE.C2+0.8.OR.C3.LE.C2-0.8)GO TO 30
IF(T3.GE.T2+0.5.OR.T3.LE.T2-0.5)GO TO 30
T=.76341*(T3-T1)/(S2+1)+T2
WRITE(7,12)J2,S2,D2,C2,T
J1=J2$J2=J3$S1=S2$S2=S3$D1=D2$D2=D3$C1=C2$C2=C3$T1=T2$T2=T3
GO TO 3
30 READ(5,12)J4,S4,D4,C4,T4
IF(J4.EQ.9999)GO TO 2
IF(EOF(5))4,26
C   M COUNTS THE NUMBER OF LINES OF DATA REMOVED BY THE COURSE FILTER.
26 M=M+1
L=L+1 $ IF(L.EQ.5)GO TO 33
IF(D4.GE.D2+5.OR.D4.LE.D2-5)GO TO 30
IF(C4.GE.C2+0.8.OR.C4.LE.C2-0.8)GO TO 30
IF(T4.GE.T2+0.5.OR.T4.LE.T2-0.5)GO TO 30
31 READ(5,12)J5,S5,D5,C5,T5
IF(J5.EQ.9999)GO TO 2
IF(EOF(5))4,27
27 IF(D5.GE.D4+5.OR.D5.LE.D4-5)GO TO 32
IF(C5.GE.C4+0.8.OR.C5.LE.C4-0.8)GO TO 32
IF(T5.GE.T4+0.5.OR.T5.LE.T4-0.5)GO TO 32
J1=J4$J2=J5$S1=S4$S2=S5$D1=D4$D2=D5$C1=C4$C2=C5$T1=T4$T2=T5
GO TO 23
32 L=0 $ GO TO 30
33 IF(D4.GE.D2+20.OR.D4.LE.D2-20)GO TO 32
GO TO 31
4 WRITE(7,16)
WRITE(6,17)I
C      FORMATS ARE AS FOLLOWS:
10 FORMAT(I4)
12 FORMAT(I4,1X,I2,1X,F6.2,1X,F6.3,1X,F5.2)
15 FORMAT("9999",/,I4)
16 FORMAT("9999")
17 FORMAT(/,"**",I6,"**=THE NUMBER OF CASTS NOW ON TAPE7.")
19 FORMAT("CAST",I4," LOST",I4," DATA PTS. THRU COURSE FILTERING.")
STOP
END
```

PROGRAM BROENK

```
PROGRAM BROE (INPUT,AVE,OUTPUT,SGSA,TAPE4=INPUT,
+ TAPE5=AVE,TAPE6=OUTPUT,TAPE7=SGSA)
C THIS PROGRAM READS D, C, AND T FROM AVE, CALCULATES SALINITY
C   AND SIGMAT, AND WRITES THOSE PARAMETERS ONTO A FILE
C   DESIGNATED BY TAPE7.  THE SALINITY CALCULATION IS FROM
C   BROENKOW.
INTEGER W,HEAD
C1=.03895414
C2=-2.2584586
REWIND 5
WRITE(6,37)
READ(4,36)COR
I=0
READ (5,12)W
13 READ (5,12)HEAD
IF(EOF(5))5,4
C I COUNTS THE NUMBER OF CASTS.
4 I=I+1
WRITE (7,21)HEAD
7 IF(EOF(5))5,9
9 READ(5,10)J,SCAN,D2,CSTP,T,M
IF (J.EQ.9999) GO TO 13
K=0
AT=(676547+20131.5*T+99.89*T**2-0.1943*T**3-0.00672*T**4)*1.0E-6
RT=CSTP/(AT*42.896)
100 D15=RT*(RT-1)*(T-15)*(96.7-72.0*RT+37.3*RT**2-
+(0.63+0.21*RT**2)*(T-15))*1.0E-5
R15=RT+D15
S=-0.08996+28.29720*R15+12.80832*R15**2-10.67869*R15**3+
+5.98624*R15**4-1.32311*R15**5
IF(K.EQ.1)GO TO 101
RZ=1.0+0.01*(1.551-0.0453*T+0.00059*T**2+0.25*(35-S)*(0.043-0.0017*T
+  +2.3E-5*T**2))*(1.037E-3*D2-3.2E-8*D2**2)
RT=CSTP/(RZ*AT*42.896)
K=1 $ GO TO 100
C   A CORRECTION FACTOR FOR SALINITY(BOTTLE)-SALINITY(CTD) IS ADDED
C    TO ALL SALINITY VALUES.
C       (IT MUST BE CALCULATED FOR EVERY CRUISE)
101 S=S+COR
F1=((T-3.98)**2)*(T+283.)/((503.57)*(T+67.26))
F2=(T**3)*(1.0843E-6)-(T*T)*(9.8185E-5)+T*4.7867E-3
F3=(T**3)*(1.667E-8)-(T*T)*(8.164E-7)+T*1.803E-5
FS=(S**3)*(6.76786136E-6)-(S*S)*(4.8249614E-4)+S*.814876577
SIG=-F1+(FS+C1)*(1.-F2+(F3)*(FS+C2))
WRITE (7,20)J,SCAN,D2,CSTP,T,M,S,SIG
6 GO TO 7
5 WRITE(6,38)I
WRITE(7,39)
C THE FORMAT SECTION FOLLOWS
3 FORMAT (3X,I4,2X,F6.2,6X,F6.3,8X,F5.2,6X,F6.3)
10 FORMAT(I4,1X,I2,1X,F6.2,1X,F6.3,1X,F5.2,1X,I4)
12 FORMAT (I4)
15 FORMAT (/,"HEADER NUMBER=",I4,/)
21 FORMAT ("9999",/,I4)
20 FORMAT (I4,1X,I2,1X,F6.2,1X,F6.3,1X,F5.2,1X,I4,2X,F6.3,1X,F5.2)
36 FORMAT(F6.3)
37 FORMAT("A SALINITY CORRECTION FACTOR FOR SAL(BOTTLE)-SAL(CTD)",/,
+  "SHOULD BE ENTERED IN THE FORMAT +X.XXX OR -X.XXX")
38 FORMAT("***",I6,"***=THE NUMBER OF CASTS NOW ON TAPE7.")
39 FORMAT("9999")
50 STOP
END
```

PROGRAM DLATCH

```
PROGRAM DLATC (LATCH,OUTPUT,CTDATA,TAPE5=LATCH,TAPE6=OUTPUT,
+  TAPE7=CTDATA)
C THIS PROGRAM READS D, C, AND T FROM LATCH, REMOVES LINES HAVING
C    ASCENDING DEPTHS, AND WRITES THE NEW DATA SET ONTO A FILE
C    DESIGNATED BY TAPE7.
DIMENSION J(6000),S(6000),D(6000),C(6000),T(6000)
INTEGER HEAD,W
REWIND 5
I=0
READ(5,10)W
2 READ(5,10)HEAD
IF(EOF(5))3,4
4 WRITE(7,15)HEAD
C   I COUNTS THE NUMBER OF CASTS.
I=I+1
READ(5,12)JOUT,SCAN,DOUT,COUT,TOUT
READ(5,12)J1,S1,D1,C1,T1
DO 1,K=1,6000
READ(5,12)J(K),S(K),D(K),C(K),T(K)
IF(J(K).EQ.9999)GO TO 2
IF(EOF(5))3,5
5 IF(D(K).LE.D1)GO TO 1
WRITE(7,12)J1,S1,D1,C1,T1
J1=J(K)$S1=S(K)$D1=D(K)$C1=C(K)$T1=T(K)
1 CONTINUE
WRITE(6,18)HEAD $ GO TO 222
3 WRITE(7,16)
WRITE(6,17)I
C    FORMATS ARE AS FOLLOWS:
10 FORMAT(I4)
12 FORMAT(I4,1X,I2,1X,F6.2,1X,F6.3,1X,F5.2)
15 FORMAT("9999",/,I4)
16 FORMAT("9999")
17 FORMAT("*",I6,"*=THE NUMBER OF CASTS NOW ON TAPE7.")
18 FORMAT("STATION",I6," HAS OVER 6000 LINES:THE PROG. STOPPED.")
222 STOP
END
```

PROGRAM CTDAVE

```
 PROGRAM CTDAV (CTDATA,AVE,OUTPUT,TAPE5=CTDATA,TAPE7=AVE,
+  TAPE6=OUTPUT)
C THIS PROGRAM READS D, C, AND T FROM CTDATA, CALCULATES THE AVERAGE
C    VALUES FOR POINTS FROM _.5 TO _.5 METERS, AND WRITES THE NEW
C    DATA SET ONTO A FILE DESIGNATED BY TAPE7.
 DIMENSION J(100),S(100),D(100),C(100),T(100)
 INTEGER HEAD,W,S,Q,R
 REWIND 5
 I=0
 READ(5,1)W
 17 READ(5,1)HEAD
 IF(EOF(5))18,15
 15 WRITE(7,2)HEAD
C   I COUNTS THE NUMBER OF CASTS.
 I=I+1
 DX=1.5
 13 N=0 $ P=0 $ F=0 $ G=0
 DO 10 K=1,100
 READ(5,3)J(K),S(K),D(K),C(K),T(K)
 IF(EOF(5))11,12
 12 Q=J(K) $ R=S(K)
 IF(D(K).GE.DX)GO TO 11
 IF(Q.EQ.9999)GO TO 11
 M=Q
C   N COUNTS THE NUMBER OF POINTS TO BE AVERAGED.
 N=N+1
 P=P+D(K) $ F=F+C(K) $ G=G+T(K)
 10 CONTINUE
 11 IF(N.EQ.0)GO TO 22
 A=P/N $ B=F/N $ E=G/N
 GO TO 23
 22 IF(Q.EQ.9999)GO TO 17
 A=D(K) $ B=C(K) $ E=T(K)
 M=Q
 N=1
 23 WRITE(7,3)M,R,A,B,E,N
 IF(Q.EQ.9999)GO TO 17
```

```
C   DX STEPS TO THE NEXT DEPTH FOR AVERAGING.
DX=DX+1
IF(DX.EQ.102.5)GO TO 30
GO TO 13
30 DX=DX+5
N=0 $ P=0 $ F=0 $ G=0
DO 31 K=1,100
READ(5,3)J(K),S(K),D(K),C(K),T(K)
IF(EOF(5))32,33
33 Q=J(K) $ R=S(K)
IF (D(K).GE.DX)GO TO 32
IF(Q.EQ.9999)GO TO 32
M=Q
N=N+1
P=P+D(K) $ F=F+C(K) $ G=G+T(K)
31 CONTINUE
32 IF(N.EQ.0)GO TO 34
A=P/N $ B=F/N $ E=G/N
GO TO 35
34 IF(Q.EQ.9999)GO TO 17
A=D(K) $ B=C(K) $ E=T(K)
M=Q
N=1
35 IF(Q.EQ.9999)GO TO 17
WRITE(7,3)M,R,A,B,E,N
GO TO 30
18 WRITE(7,4)
WRITE(6,5)I
C  FORMAT SECTION:
1 FORMAT(I4)
2 FORMAT("9999",/,I4)
3 FORMAT(I4,1X,I2,1X,F6.2,1X,F6.3,1X,F5.2,1X,I4)
4 FORMAT("9999")
5 FORMAT("**",I6,"**=THE NUMBER OF CASTS NOW ON TAPE7.")
STOP
END
```

```
PROGRAM NODCFO(SGSA,OUTPUT,NODC,TAPE5=SGSA,TAPE6=OUTPUT,
+   TAPE7=NODC)
C THIS PROGRAM READS D,T AND S FROM THE CRUISE DATA FILE AND
C    REWRITES THEM IN NODC FORMAT ON A FILE DESIGNATED BY TAPE7.
INTEGER W,HEAD,X
REWIND 5
I=0 $ N=0
READ(5,1)W
10 READ(5,1)HEAD
IF(EOF(5))20,21
21 WRITE(7,2)HEAD
WRITE(6,1)HEAD
N=N+1
X=0
11 READ(5,3)J,D,T,S
IF(J.EQ.9999)GO TO 10
IF(D.GE.INT(D)+0.5)GO TO 24
IF(T*10.GE.INT(T*10)+0.5)GO TO 25
IF(S*100.GE.INT(S*100)+0.5)GO TO 26
K=D $ L=T*100 $ M=S*100
GO TO 23
26 K=D $ L=T*100 $ M=S*100+1
GO TO 23
25 IF(S*100.GE.INT(S*100)+0.5)GO TO 27
K=D $ L=T*100+1 $ M=S*100
GO TO 23
27 K=D $ L=T*100+1 $ M=S*100+1
GO TO 23
24 IF(T*10.GE.INT(T*10)+0.5)GO TO 28
IF(S*100.GE.INT(S*100)+0.5)GO TO 29
K=D+1 $ L=T*100 $ M=S*100
GO TO 23
29 K=D+1 $ L=T*100 $ M=S*100+1
GO TO 23
28 IF(S*100.GE.INT(S*100)+0.5)GO TO 30
K=D+1 $ L=T*100+1 $ M=S*100
GO TO 23
30 K=D+1 $ L=T*100+1 $ M=S*100+1
23 IF(K.EQ.X)GO TO 11
WRITE(7,4)K,L,M
I=I+1
X=K
GO TO 11
20 WRITE(6,5)N
WRITE(7,6)
C  THIS IS THE FORMAT SECTION:
1 FORMAT(I4)
2 FORMAT("9999",/,I4)
3 FORMAT(I4,4X,F6.2,8X,F5.2,7X,F6.3)
4 FORMAT(26X,I5,I5,I5)
5 FORMAT("***",I4,"***=THE NUMBER OF CASTS NOW ON TAPE7.")
6 FORMAT("9999")
STOP
END
```

PROGRAM NUTMERG

```
PROGRAM MERGEIT(INPUT,NOD,HEA,OUTPUT,FINAL,TAPE4=INPUT,
+  TAPE5=NOD,TAPE6=OUTPUT,TAPE7=FINAL,TAPE8=HEA)
+ THIS PROGRAM MERGES HEADER AND NUTRIENT DATA TO CAST DATA IN NODC FORMAT.
DIMENSION IH(10)
INTEGER W,HEAD,X,CT,Z
REWIND5 $ REWIND8
I=0 $ N=0
READ(5,1)W
41 BACKSPACE 8
10 READ(5,1)HEAD
IF(EOF(5))20,21
21 READ(8,6)(IH(I),I=1,9),IP,IHEAD,IR
IF(EOF(8))20,29
29 CONTINUE
22 WRITE(7,6)(IH(I),I=1,9),IP,IHEAD,IR
N=N+1
12 READ(8,9)Z
IF(EOF(8))13,14
14 IF(Z.EQ.31)GO TO 13
BACKSPACE 8
READ(8,7)KK,ISAL,O2,PO4,NO3,SIO3,CT
GO TO 11
13 KK=999
11 READ(5,3)J,K,L,M
IF(J.EQ.9999)GO TO 40
IF(K.GT.100.)GO TO 60
IF(KK.EQ.2)GO TO 43
IF(KK.LE.K)GO TO 43
GO TO 44
60 IF(KK.LT.K+2.5)GO TO 43
44 WRITE(7,4)K,L,M
GO TO 11
43 IF(ISAL.EQ.0)GO TO 48
WRITE(7,51)K,L,ISAL,O2,PO4,NO3,SIO3,CT
GO TO 12
48 WRITE(7,8)K,L,M,O2,PO4,NO3,SIO3,CT
GO TO 12
40 IF(KK.EQ.999)GO TO 41
IF(J.EQ.9999)WRITE(7,8)KK,L,M,O2,PO4,NO3,SIO3,CT
GO TO 47
45 WRITE(7,7)KK,ISAL,O2,PO4,NO3,SIO3,CT
47 CONTINUE
READ(8,9)Z
IF(EOF(8))10,46
46 IF(Z.EQ.31)GO TO 41
BACKSPACE 8
READ(8,7)KK,ISAL,O2,PO4,NO3,SIO3,CT
GO TO 45
20 WRITE(6,5)N
C  THIS IS THE FORMAT SECTION:
1 FORMAT(I4)
2 FORMAT("9999",/,I4)
3 FORMAT(I4,22X,I5,A5,A5)
4 FORMAT(26X,I5,A5,A5,38X,"3")
5 FORMAT("***",I4,"***=THE NUMBER OF CASTS NOW ON TAPE7.")
6 FORMAT(9A8,A4,I3,A1)
7 FORMAT(26X,I5,5X,I5,9X,A3,A3,6X,A3,A3,11X,I1)
8 FORMAT(26X,I5,A5,A5,9X,A3,A3,6X,A3,A3,11X,I1)
9 FORMAT(I2)
51 FORMAT(26X,I5,A5,I5,9X,A3,A3,6X,A3,A3,11X,I1)
52 FORMAT(30X,I3)
STOP
END
```

PROGRAM CEMLIST

```
PROGRAM CEMLIST(PIERC,TEC,OUTPUT,INPUT,TAPE5=PIERC,TAPE6=TEC,
+   TAPE8=OUTPUT,TAPE7=INPUT)
C
C   MODIFIED FEB. 1978 FOR CI-12 (DEC 76) CRUISE AND ON.  W.S.C.
C
C THIS PROGRAM CREATES OUTPUT FROM NATIONAL OCEANOGRAPHIC DATA CENTER
C INPUT FROM DIRECT ACCESS FILES. INPUT MUST BE NODC FORMATTED
C 80 CHARACTER CARD IMAGES.  OUTPUT IS A COMPLETE LIST OF THE DATA
C IN TECHNICAL REPORT FORMAT. L.P.ATKINSON
REAL NO3,RLAT(2),RLONG(2)
INTEGER PO41,PO42,NO31,NO32,SI1,SI2
REWIND5
DATA C1,C2,C3,C4,D1,D2,D3/-173.4292,249.6339,143.3483,-21.8492
+,-.033096,.014259,-.0017/
DATA AS1,AS2,AS3,AS4/1D-09,4886.,1.83E-05,.001/
DATA A31,A32,A33,A34,A35,A36/.97264298,1E-09,4886.,1.83E-05,
+.01059094,-228.86167/
DATA A1,A3,A3,A4,A5,A6,A7,A8,A9/1E-04,105.5,9.5,-.158,-1.5E-04,227.,
+28.33,-.551,.004/
DATA B1,B2,B3,B4,B5,B6,B7,B8,B9,B10,B11,B12/10.,147.3,2.72,.04,
+.0001,32.4,.87..02,4.5,0.1,1.8,.06/
DATA O/-28.1324/
DATA FS1,FS2,FS3/6.76786136E-06,-4.8249614E-04,8.14876577E-01/
WRITE(8,10)
10 FORMAT("ENTER CRUISE HEADER, 20 SPACES MAX")
READ(7,11)HEAD1,HEAD2
11 FORMAT(A10,A10)
WRITE(8,12)
12 FORMAT("IF YOU WANT SIGMA CALCULATED TYPE YES OR NO")
READ(7,13)SIGCAL
13 FORMAT(A3)
READ(5,79)NCONS
79 FORMAT(T76I4)
BACKSPACE 5 $ IF(NCONS.EQ.1)GO TO 60
WRITE(8,72)
72 FORMAT("ENTER THE LAT. AND LONG. (DEG. & MIN.) OF THE LAST STATION ",
+  " IN NODC FORMAT:",/,"    XXXXXXXXXX (4X,I2,I3,I3,I3)")
READ(7,73)NLAT,NLATD,NLONG,NLONGD
73 FORMAT(4X,I2,3(I3))
ALAT=NLATD/10. $ ALONG=NLONGD/10.
RLAT(2)=NLAT+ALAT/60. $ RLONG(2)=NLONG+ALONG/60.
60 IPG=IPG+1
IF(ISEC.EQ.0)GO TO 83
IF(IPG.LT.50)GO TO 61
83 IF(IPG.LT.42)GO TO 61
WRITE(6,62)NSTA,NLTR,NDY,MONTH,NYR,AHR,NCONS $ IPG=0 $ ISEC=ISEC+1
62 FORMAT(/,/,/,12X," STA ",I3,A1,1X,I2"/",A4,"/",I2,2X,F4.1," GMT",1X,
+ "CONSEC STA",I4,"  [CONTINUED]",/,/,38X,"OBSERVATIONS",/,
```

```
+ T14"Z",T19"T",T25"S",T31"D",T36"SVA",T42"O2",T48"O2'",T53"AOU",
+ T59"PO4",T65"NO3",T72"SI")
 61 READ(5,1)LD
 IF(EOF(5))70,71
 71 CONTINUE
 IF(LD.EQ.4)GO TO 70$IF(LD.EQ.1)GO TO 80$IF(LD.EQ.6)GO TO 60
 IF(LD.EQ.3)GO TO 50
 80 BACKSPACE 5
 IPG=0 $ ISEC=0
 READ(5,2)NLAT,NLATD,NLONG,NLONGD,NYR,NMN,NDY,NHR,NCRU,NSTA,NZ
+,NWAD,NWHGT,NWID,NWFO,NBAR,NAT2,NAT1,NWC,NCT,NCA,NVIS,NLTR,NCONS
 ALAT=NLATD/10.$ALONG=NLONGD/10.$AHR=NHR/10.
C WIND SPEED IS AS SPEED
C BAROMETER CALCULATION
 BAR=NBAR/10.
 IF(BAR.GE.0)GO TO 700
 BAR=BAR+900.$GO TO 701
 700 BAR=BAR+1000.
 701 CONTINUE
C WEATHER CODE IS AS IS
C CLOUD TYPE AS IS
C VISIBILITY AS IS
C MONTH TO ROMAN NUMERAL
 GOTO(751,752,753,754,755,756,757,758,759,760,761,762),NMN
 751 MONTH=#   I#$GO TO 770
 752 MONTH=#  II#$GO TO 770
 753 MONTH=# III#$GO TO 770
 754 MONTH=#  IV#$GO TO 770
 755 MONTH=#   V#$GO TO 770
 756 MONTH=#  VI#$GO TO 770
 757 MONTH=# VII#$GO TO 770
 758 MONTH=#VIII#$GO TO 770
 759 MONTH=#  IX#$GO TO 770
 760 MONTH=#   X#$GO TO 770
 761 MONTH=#  XI#$GO TO 770
 762 MONTH=# XII#$GO TO 770
 770 CONTINUE
C CLOUD AMOUNT CODE 9
 IF(NCA.EQ.9)NCA=1H*
C
C
C ******HEADER PRINTOUTS******
 RLAT(1)=NLAT+ALAT/60.$RLONG(1)=NLONG+ALONG/60.
 IF(NCONS.GT.1)GO TO 2000
 DIST=0.$GO TO 2001
 2000 DELLAT=ABS(RLAT(1)-RLAT(2))
 DELLON=ABS(RLONG(1)-RLONG(2))
 P=DELLON*COS((RLAT(1)+RLAT(2))*.0087265)
 DIST=111.2*(P*P+DELLAT*DELLAT)**.5
 2001 RLAT(2)=RLAT(1)$RLONG(2)=RLONG(1)
 WRITE(6,550)HEAD1,HEAD2,NSTA,NLTR,NDY,MONTH,NYR,AHR,NCONS
```

```
01010 550 FORMAT(///10X,A10,A10,1X," STA ",I3,A1,1X,I2"/",
01020+A4,"/",I2,1X,F4.1," GMT",1X,"CONSEC STA",I4)
01025 INO=INO+1
01030 WRITE(6,551)NLAT,ALAT,NLONG,ALONG,NZ,DIST
01040 551 FORMAT(/10X,"LAT ",I2,1X,F4.1,"N",2X,"LONG ",I2,1X,F4.1,"W",
01050+2X,"DEPTH =",I3,"M",2X,"DIST LAST STA = ",F5.1,"KM")
01055 IF(NWFO.EQ.0)WRITE(6,549)NWHGT
01060 IF(NWFO.NE.0)WRITE(6,552)NWFO,NWHGT
01070 552 FORMAT(/,10X,"WEATHER DATA",/,12X,"WIND SPEED     = ",I2,1X,"KTS",16X
01071+"SEA STATE      = ",A2)
01074 549 FORMAT(/,10X,"WEATHER DATA",/,12X,"WIND SPEED     = CALM",
01075+ 18X,"SEA STATE      = ",A2)
01077 IF(NWID.EQ.2H00)WRITE(6,74)
01078 74 FORMAT(12X,"WIND DIRECTION =          ",14X,"WAVE DIRECTION = ")
01081 IF((NWID.EQ.2H99).AND.(NWAD.EQ.2H  ))WRITE(6,75)
01082 75 FORMAT(12X,"WIND DIRECTION = VARIABLE",14X,"WAVE DIRECTION =")
01083 IF((NWID.EQ.2H99).AND.(NWAD.NE.2H  ))WRITE(6,76)
01084 76 FORMAT(12X,"WIND DIRECTION = VARIABLE",14X,"WAVE DIRECTION = ",
01085+  A2,"0 DEGR")
01090 IF((NWID.EQ.2H  ).AND.(NWAD.EQ.2H  ))WRITE(6,1002)
01100 1002 FORMAT(12X,"WIND DIRECTION = ",22X,"WAVE DIRECTION = ")
01110 IF((NWID.NE.2H  ).AND.(NWAD.EQ.2H  ).AND.(NWID.NE.2H99))WRITE(6,1003)NWID
01120 1003 FORMAT(12X,"WIND DIRECTION = ",A2,"0",19X,"WAVE DIRECTION = ")
01130 IF((NWID.NE.2H  ).AND.(NWAD.NE.2H  ).AND.(NWID.NE.2H99))WRITE(6,1004)
01135+NWID,NWAD
01140 1004 FORMAT(12X,"WIND DIRECTION = ",A2,"0"," DEGR",13X,
01145+"WAVE DIRECTION = ",A2,"0"," DEGR")
01150 IF((NWID.EQ.2H  ).AND.(NWAD.NE.2H  ))WRITE(6,1005)NWAD
01160 1005 FORMAT(12X,"WIND DIRECTION = ",22X,"WAVE DIRECTION = ",
01165+A2,"0 DEGR")
01170 553 CONTINUE
01300 WRITE(6,554)NAT2,NAT1,NCT
01310 554 FORMAT(12X,"AIR TEMP       = ",A2,1H.,A1,"C",17X,"CLOUD TYPE     = ",
01320+A1)
01330 WRITE(6,555)NWC,NCA
01340 555 FORMAT(12X,"WEATHER CODE   = ",A2,20X,"CLOUD AMOUNT   = ",A2)
01347C  IF THERE IS VISABILITY DATA, PUT ",NVIS" AFTER BAR IN LINE 1350
01350 WRITE(6,556)BAR
01360 556 FORMAT(12X,"BAROMETRIC PRESSURE = ",F6.1," MB",8X,
01370+"VISIBILITY CODE = ",A1,"/10")
01380C WRITE OBSERVED HEADER CARD
01390 WRITE(6,3)
01400 3 FORMAT(/,38X,"OBSERVATIONS",/,T14"Z",T19"T",T25"S",T31"D",T36"SVA",
01410+T42"02",T48"02%",T53"AOU",T59"PO4",T65"NO3",T72"SI")
01420 GO TO 60
01430 50 BACKSPACE 5
01440 READ(5,4)NDEPTH,NDEP,NTEMP,NSAL,NSIGMA,NOXY,PO41,PO42,NO31,NO32,SI1,SI2
01450 TEMP=NTEMP/100.$SAL=NSAL/100.$SIGMA=NSIGMA/100.
01460+$TK=TEMP+273.18$OXY=NOXY/100.
01470C***CALCULATE SIGMA T***
01480 IF(SIGCAL.NE.3HYES)GO TO 3000
```

```
T=TEMP$SIGF1=((T-3.98)**2)*(T+283.)/((503.57)*(T+67.26))
SIGF2=(T**3)*(1.0843E-6)-(T*T)*(9.8185E-5)+T*4.7867E-3
SIGF3=(T**3)*(1.667E-8)-(T*T)*(8.164E-7)+T*1.803E-5
SIGS=(SAL**3)*(6.767861E-6)-(SAL*SAL)*(4.82496E-4)+SAL*.814877
SIGMA=-SIGF1+(SIGS+.03895414)*(1.-SIGF2+(SIGF3)*(SIGS-2.258458))
3000 CONTINUE
C CALCULAT SVA(SPECIFIC VOLUME ANOMALY)
FS=FS1*SAL**3+FS2*SAL**2+FS3*SAL
A=NDEPTH*A1*(A2+A3*TEMP+A4*TEMP**2+A5*NDEPTH*TEMP)-
+(A6+A7*TEMP+A8*TEMP**2+A9*TEMP**3)
B=(((FS+0)/B1)*(B2-B3*TEMP+B4*TEMP**2-NDEPTH*B5*(B6-B7*TEMP+B8*
+TEMP**2)))*(-1.)+(((FS+0)/B1)**2)*(B9-B10*TEMP-(NDEPTH*B5)*
+(B11-B12*TEMP))
A350P=A31*(1.-NDEPTH*A32*(A33/(1.+A34*NDEPTH)+A35*NDEPTH+A36))
ASTP=(1.-NDEPTH*AS1*(AS2/(1.+AS3*NDEPTH)+(A+B)))/(1.+SIGMA*AS4)
SVA=ASTP-A350P
SVA=SVA*100000.
NSVA=SVA
OXYSAT=EXP(C1+C2*(100./TK)+C3*ALOG(TK/100.)+C4*TK/100.
++SAL*(D1+D2*TK/100.+D3*(TK/100.)**2))
AOU=OXYSAT-OXY
IF(SAL.GT.0.00)GO TO 200
IF(TEMP.EQ.0.0)GO TO 311
IF(OXY.EQ.0.00)GO TO 250
WRITE(6,210)NDEPTH,NDEP,TEMP,OXY,PO41,PO42,NO31,NO32,SI1,SI2
210 FORMAT(10X,I3,1H.,I1,1X,F5.2,19X,F4.2,3X,1H.,5X,1H.,4X,A1,1H.,A2,2X,
+  A2,1H.,A1,2X,A2,1H.,A1)
GO TO 60
311 IF(OXY.EQ.0.0)GO TO 313
WRITE(6,312)NDEPTH,NDEP,OXY,PO41,PO42,NO31,NO32,SI1,SI2
312 FORMAT(10X,I3,1H.,I1,25X,F4.2,3X,1H. 5X,1H.,4X,A1,1H.,A2,2X,A2,1H..A1,
+ 2X,A2,1H..A1)
GO TO 60
313 WRITE(6,314)NDEPTH,NDEP,PO41,PO42,NO31,NO32,SI1,SI2
314 FORMAT(10X,I3,1H.,I1,26X,1H.,5X,1H.,5X,1H.,4X,A1,1H.,A2,2X,A2,1H.,A1,
+ 2X,A2,1H.,A1)
GO TO 60
250 WRITE(6,251)NDEPTH,NDEP,TEMP,PO41,PO42,NO31,NO32,SI1,SI2
251 FORMAT(10X,I3,1H.,I1,1X,F5.2,3X,1H.,5X,1H.,5X,1H.,4X,1H.,5X,1H.,5X,
+ 1H.,4X,A1,1H.,A2,2(2X,A2,1H.,A1))
GO TO 60
200 IF(OXY.EQ.0.00)GO TO 300
WRITE(6,5)NDEPTH,NDEP,TEMP,SAL,SIGMA,NSVA,OXY,OXYSAT,AOU,PO41,PO42,NO31,
+ NO32,SI1,SI2
GOTO 60
300 WRITE(6,6)NDEPTH,NDEP,TEMP,SAL,SIGMA,NSVA,PO41,PO42,NO31,NO32,SI1,SI2
6 FORMAT(10X,I3,1H.,I1,3(1X,F5.2),2X,I3,3X,1H.,5X,1H.,5X,1H.,4X,A1,1H.,
+ A2,2X,A2,1H.,A1,2X,A2,1H.,A1)
GO TO 60
1 FORMAT(79X,I1)
2 FORMAT(4X,I2,3I3,3X,3I2,I3,A3,I3,I4,8X,A2,A1,1X,A2,I2,I3,A2,A1,3X,A
```

```
+2,A1,A1,A1,A1,7X,I4)
 4 FORMAT(28X,I3,I1,I4,1X,I4,1X,I4,4X,I3,A1,A2,6X,A2,A1,A2,A1)
 5 FORMAT(10X,I3,1H.,I1,3(1X,F5.2),2X,I3.2X,F4.2,2(1X,F5.2),2X,A1,1H.,
+ A2,2X,A2,1H.,A1,2X,A2,1H.,A1)
 70 WRITE(8,77)IND
 77 FORMAT("###",I4,"###=THE NUMBER OF CASTS NOW ON TAPE7.")
 STOP
 END
```

APPENDIX IV.

HP Programs

The following programs are written for the HP 9825A desktop computer with the following options:

98214A 9862A Plotter - General I/O - Extended I/O ROM

98210A String-Advanced Programming ROM

98324A Systems Programming ROM

and

24K core

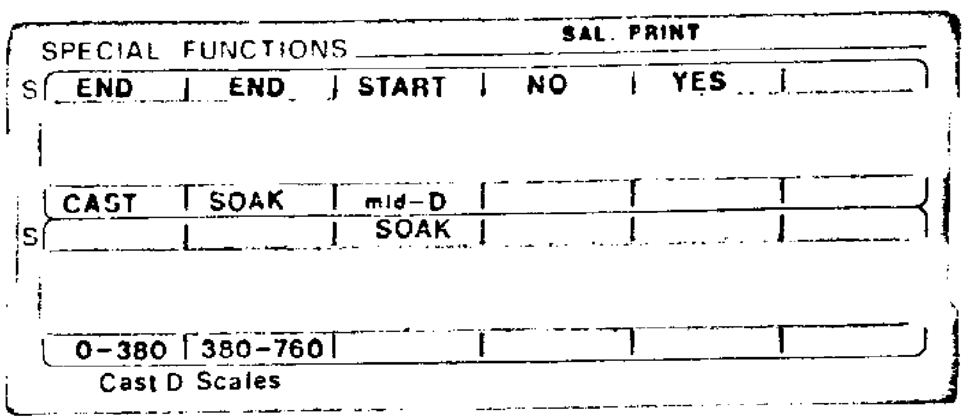
The 9825A internal printer is 16 characters wide. Using a RS-232C interface to a T.I. Silent 700 ASR terminal provides an 80 character printout. Some characters are not the same, such as:

HP	T.I.
→	}
Lower case	Little caps.
↑	^

The programs are stored by file on the internal cassette and are as follows:

File	Name
0	Master File
1	Special Function Keys
2	Taking a Cast
3	List D, C, T
4	Bottom Soak
5	Downcast Average
6	Mid-depth Soak
7	Upcast Average
8	Salinity Plot

The programs are stored on track 1, files 0-8. The preliminary data are stored on track 1 from file 10 on. The final data (filtered and meter averaged) is stored on track 0, file 0 on.



Overlay used for Special Function Keys

MASTER PROGRAM

```
0: PRT " MASTER PROGRAM";PRT "    ***********";GTO +2
1: SFG 1
2: PRT "TYPE PROGRAM #  AND PRESS        CONTINUE TO RUN"
3: IF FLG1=1;CFG ;GTO 17
4: PRT "ONE OF THESE:";SPC 1
5: PRT "0 THIS ONE          STOPS THE        MASTER PROGRAM"
6: PRT "1 THIS ONE          ALREADY LOADED  THE SPECIAL      FUNCTION KEYS"
7: PRT "2  TAKING A CAST"
8: PRT "3      LIST D,C,T"
9: PRT "4     BOTTOM SOAK"
10: PRT "5 DOWNCAST AVER."
11: PRT "6 MID-DEPTH SOAK"
12: PRT "7   UPCAST AVER."
13: PRT "8  SALINITY PLOT"
14: PRT "9  TEMP. PLOT"
15: PRT "10 1ST DATA FILE"
16: PRT "    ***********";SPC 2
17: ENT "PROGRAM #",P
18: IF P=0;GTO 20
19: TRK 1;LDK 1;LDP P
20: END
```

TAKING A CAST

```
0: dim A[3,799]
1: trk 1;ldk 1
2: if flg2=1;gto 24
3: spc 2;prt "Month Day Time"
4: red 720,W;fxd 0;int(W/1e8)→M;(W/1e8-int(W/1e8))*1e2→D
5: (W/1e6-int(W/1e6))*1e4→H
6: fmt 2,1x,f2.0,4x,f2.0,1x,f4.0
7: wrt 16.2,M,D,H
8: if Z#0;gto 16
9: ent "Depth freq. of CTD in air",Z
10: ent "Cond. freq. of CTD in air",E
11: ent "Station number=?",P
12: prt "Station number=",P;prt "D freq in air=",Z,"*"
13: prt "C freq in air=",E,"*"
14: prt "When the CTD     cast ends press Special FunctionKey f0.
15: prt "For Mid-Depth    soaking,press    Special FunctionKey f2."
16: prt "*";spc 1;dsp "Wait for axes plot."
17: scl 0,380,5,30
18: axe 0,5,20,5
19: dsp "press CONTINUE when it's all rdy";stp
20: 0→N;1→K
21: 1→M
22: gsb "READ"
23: for I=1 to 799;0→A[1,I]→A[2,I]→A[3,I];next I
24: gsb "READ"
25: gsb "CON"
26: D→P;C→Q;T→R
27: gsb "READ"
28: gsb "CON"
29: D→S;C→U;T→V→O
30: gsb "READ"
31: gsb "CON"
32: if flg1=1;gto "REC"
33: if flg3=1;cfg 3;pen;trk 1;ldf 6,0,0
34: D→W;C→X;T→Y
35: V+.35(Y-R)/.810→V
36: fxd 1;dsp "D=",S,"T=",V,M,K
37: fxd 3;plt S,V
38: S→A[1,M];U→A[2,M];V→A[3,M]
39: S→P;W→S;U→Q;X→U;O→R;Y→V→O
40: if M<799;M+1→M;gto 30
41: dsp "STOP WINCH (stopped at",S,"M)"
42: pen;trk 1;rcf K,A[*];K+1→K;gto 21
43: "CON":
44: (1/D-Z)*.38071→D
45: (1/C-E)*.02065→C
46: (1/T-2127)*.01791-2→T
47: ret
48: "READ":
49: wrt 719,"B1";wrt 718,"PF762T";wait 30;red 718,D
```

```
50: wrt 719,"B2";wrt 718,"PF7G2T";wait 30;red 718,C
51: wrt 719,"B3";wrt 718,"PF7G3T";wait 30;red 718,T
52: ret
53: "REC":
54: ren;trk 1;rcf K,A[*]
55: if flg2=1 or D<5;gto 57
56: dsp "Now do the calibration soak.";gto 60
57: fxd 0;prt "The first and last files of thiscast are       10 and";K
58: prt "    ***********";spc 2
59: if flg2=1 or D<5;cfg ;prt "Upcast Aver. is #7";trk 1;ldf 0,0,1
60: trk 1;ldf 4,0,0
61: end
```

LIST D,C,T

```
0: dim A[3,799]
1: dsp "Make sure data tape is in place!";wait 1000
2: ent "Station number=?",P
3: fxd 0;prt "Station number=",P
4: ent "Which tape track?",Q
5: prt "   D     C       T"
6: ent "Starting Data File=?",S
7: ent "Last Data File=?",N
8: for L=S to N
9: trk Q;ldf L,A[*]
10: for J=1 to 799
11: if A[2,J]=0;gto 18
12: if A[1,J]>99;gto 15
13: fmt 1,f4.1,f6.2,f6.2
14: wrt 16.1,A[1,J],A[2,J],A[3,J];gto 17
15: fmt 3,f4.0,f6.2,f6.2
16: wrt 16.3,A[1,J],A[2,J],A[3,J]
17: next J
18: prt " "
19: next L
20: dsp "D,C,T listed, what next?"
21: sfg 2;trk 1;ldf 0,0,1
22: end
```

BOTTOM SOAK

```
0: prt "****SOAKING****"
1: prt "Month Day Time"
2: red 720,W;int(W/1e8)→X;(W/1e8-int(W/1e8))*1e2→Y
3: (W/1e6-int(W/1e6))*1e4→Q
4: fmt 2,1x,f2.0,4x,f2.0,1x,f4.0
5: wrt 16.2,X,Y,Q
6: prt "  D     T      S"
7: 0→P
8: gsb "READ"
9: gsb "READ"
10: gsb "CON"
11: D→F;C→G;T→H
12: I+1→I
13: gsb "READ"
14: if flg2=1;gto 59
15: gsb "CON"
16: 0→J
17: if r3-Q=4;gsb "WARN"
18: if P>3;0→P;spc ;gto 9
19: if D>F+5 or D<F-5;P+1→P;gto 12
20: if C>G+.05 or C<G-.05;P+1→P;gto 12
21: if T>H+.05 or T<H-.05;P+1→P;gto 12
22: gsb "SAL"
23: fxd 1;dsp "D=",D,"T=",T,"S=",S,I,K
24: if I>=5;0→I;gto 26
25: gto 12
26: fmt 3,f3.0,f6.2,f7.3
27: wrt 16.3,D,T,S
28: gto 11
29: "WARN":
30: prt "*";prt "The CTD has soaked for 4 minutes**trip bottle**";prt "*"
31: prt "press Special   Function Key f1 after the trip. *"
32: ret
33: "SAL":
34: gto +3
35: 1→J;.01(1.551-.0453T+5.9e-4T^2+.25(35-S)(.043-.0017T+2.3e-5T^2))→B
36: 1+B*(1.037e-3D-3.2e-8D^2)→r4
37: (676547+20131.5T+99.89T^2-.1943T^3-.00672T^4)1e-6→U
38: if J=1;gto +2
39: C/42.896U→r1;gto +2
40: C/(r4*U*42.896)→r1
41: r1(r1-1)(T-15)(96.7-72r1+37.3r1^2-(.63+.21r1^2)(T-15))1e-5→r2
42: r1+r2→r3
43: -.092+28.3r3+12.808r3^2-10.679r3^3+5.986r3^4-1.323r3^5→S
44: if J=0;gto 35
45: ret
46: "CON":
47: (1/D-Z)*.38071→D
48: (1/C-E)*.02065→C
49: (1/T-2127)*.01791-2→T
```

```
50: INT(R0/1E8)→R1;(R0/1E8-INT(R0/1E8))*1E2→R2
51: (R0/1E6-INT(R0/1E6))*1E4→R3
52: RET
53: "READ":
54: WRT 719,"B1";WRT 718,"PF7G2T";WAIT 35;RED 718,D
55: WRT 719,"B2";WRT 718,"PF7G2T";WAIT 35;RED 718,C
56: WRT 719,"B3";WRT 718,"PF7G3T";WAIT 35;RED 718,T
57: RED 720,R0
58: RET
59: PRT "    ***********";SPC 1;FXD 0
60: PRT "THE FIRST AND LAST FILES OF THISCAST ARE       10 AND ",K;SPC 1
61: TRK 1;LDP 5,0,0
62: END
```

DOWNCAST AVERAGING

```
0: DIM A[3,799]
1: DIM B[3,80]
2: SPC 1;PRT "*DOWNCAST AVER.*"
3: ENT "LAST FILE OF PRELIM. DATA SET?",K
4: PRT "YOU TYPED",K
5: ENT "NEXT FILE FOR DATA STORAGE?",U;U→V
6: PRT "YOU TYPED",U
7: 1.5→E
8: 1→J
9: PRT "  D     C     T"
10: FOR L=10 TO K
11: TRK 1;LDF L,A[*]
12: 0→P
13: FOR M=3 TO 799
14: P+1→Q
15: IF P=3;0→P
16: IF A[1,M]>A[1,M-Q]+5 OR A[1,M]<A[1,M-Q]-5;P+1→P;GTO 24
17: IF A[2,M]>A[2,M-Q]+.8 OR A[2,M]<A[2,M-Q]-.8;P+1→P;GTO 24
18: IF A[3,M]>A[3,M-Q]+.5 OR A[3,M]<A[3,M-Q]-.5;P+1→P;GTO 24
19: IF A[1,M]<E-1;GTO 24
20: IF A[1,M]>=E;GSB "STOR"
21: IF L=K AND A[1,M]=0 AND A[3,M]=0;GSB "STOR"
22: F+A[1,M]→F;G+A[2,M]→G;H+A[3,M]→H
23: I+1→I;0→P
24: NEXT M
25: SPC 1;NEXT L
26: REW;TRK 0;RCF U,B[*]
27: FXD 0;PRT "THE FIRST AND   LAST FILES OF   SAVED DATA ARE",V," AND",U
28: DSP "NOW DO THE UPCAST";WAIT 1000
29: SPC 2;PRT "FOR SOAKING WHILE A BOTTLE TRIPSPRESS S.F.K. F2."
30: TRK 1;LDF 2,0,0
31: "STOR":
32: IF F=0;GTO 45
33: F/I→F;G/I→G;H/I→H
34: IF F<99.5;GTO +4
35: FMT 5,F3.0,F7.2,F6.2
36: WRT 16.5,F,G,H
37: GTO +3
38: FMT 1,F4.1,F6.2,F6.2
39: WRT 16.1,F,G,H
40: F→B[1,J];G→B[2,J];H→B[3,J]
41: IF J=80;GSB "REC"
42: J+1→J
43: INT(F+.5)+1.5→E
44: GTO 46
45: E+1→E
46: 0→F→G→H→I
47: RET
48: "REC":
49: TRK 0;RCF U,B[*]
50: FOR N=1 TO 80;0→B[1,N]→B[2,N]→B[3,N];NEXT N
51: 0→J;U+1→U
52: RET
53: END
```

MID-DEPTH SOAK

```
0: spc 1;prt "****SOAKING****"
1: prt "WHEN THE UPCAST IS TO BE RESUMEDPRESS SPECIAL   FUNCTION KEY F1.*"
2: prt "  D     T      S"
3: 0→P
4: gsb "READ"
5: gsb "READ"
6: gsb "CON"
7: D→F;C→G;T→H
8: I+1→I
9: gsb "READ"
10: if flg2=1;gto 47
11: gsb "CON"
12: 0→J
13: if P>3;0→P;spc ;gto 5
14: if D>F+5 or D<F-5;P+1→P;gto 8
15: if C>G+.05 or C<G-.05;P+1→P;gto 8
16: if T>H+.05 or T<H-.05;P+1→P;gto 8
17: gsb "SAL"
18: fxd 1;dsp "D=",D,"T=",T,"S=",S,I,K
19: if I>=5;0→I;gto +2
20: gto 8
21: fmt 3,f3.0,f6.2,f7.3
22: wrt 16.3,D,T,S
23: gto 7
24: "SAL":
25: gto +3
26: 1→J;.01(1.551-.0453T+5.9e-4T^2+.25(35-S)(.043-.0017T+2.3e-5T^2))→B
27: 1+B*(1.037e-3D-3.2e-8D^2)→r4
28: (676547+20131.5T+99.89T^2-.1943T^3-.00672T^4)1e-6→U
29: if J=1;gto +2
30: C/42.896U→r1;gto +2
31: C/(r4*U*42.896)→r1
32: r1(r1-1)(T-15)(96.7-72r1+37.3r1^2-(.63+.21r1^2)(T-15))1e-5→r2
33: r1+r2→r3
34: -.092+28.3r3+12.808r3^2-10.679r3^3+5.986r3^4-1.323r3^5→S
35: if J=0;gto 26
36: ret
37: "CON":
38: (1/D-Z)*.38071→D
39: (1/C-E)*.02065→C
40: (1/T-2127)*.01791-2→T
41: ret
42: "READ":
43: wrt 719,"B1";wrt 718,"PF762T";wait 30;red 718,D
44: wrt 719,"B2";wrt 718,"PF762T";wait 30;red 718,C
45: wrt 719,"B3";wrt 718,"PF763T";wait 30;red 718,T
46: ret
47: prt "    ***********";spc 1
48: cfg 1,3;trk 1;ldf 2,0,1
49: end
```

UPCAST AVERAGING

```
0: dim A[3,799]
1: dim B[3,80]
2: spc 1;prt "**UPCAST AVER.**"
3: ent "Last file of prelim. data set?",K
4: prt "you typed",K
5: ent "Next file for data storage?",U;U→V
6: prt "you typed",U
7: 500→E
8: 1→J
9: prt "   D      C      T"
10: for L=10 to K
11: trk 1;ldf L,A[*]
12: 0→P
13: for M=3 to 799
14: P+1→Q
15: if P=3;0→P
16: if A[1,M]>A[1,M-Q]+5 or A[1,M]<A[1,M-Q]-5;P+1→P;gto 24
17: if A[2,M]>A[2,M-Q]+.8 or A[2,M]<A[2,M-Q]-.8;P+1→P;gto 24
18: if A[3,M]>A[3,M-Q]+.5 or A[3,M]<A[3,M-Q]-.5;P+1→P;gto 24
19: if A[1,M]>E+1;gto 24
20: if A[1,M]<=E;gsb "STOR"
21: if L=K and A[1,M]=0 and A[3,M]=0;gsb "STOR"
22: F+A[1,M]→F;G+A[2,M]→G;H+A[3,M]→H
23: I+1→I;0→P
24: next M
25: spc 1;next L
26: rew;trk 0;rcf U,B[*]
27: dsp "Next..plot salinity, up or down."
28: fxd 0;prt "The first and   last files of   saved data are",V,"and",U
29: prt "   ***********";spc 2
30: prt "Sal. Plot is    #8"
31: trk 1;ldf 0,0,1
32: "STOR":
33: if F=0;gto 45
34: F/I→F;G/I→G;H/I→H
35: if F<99.5;gto +4
36: fmt 5,f3.0,f7.2,f5.2
37: wrt 16.5,F,G,H
38: gto +3
39: fmt 1,f4.1,f6.2,f6.2
40: wrt 16.1,F,G,H
41: F→B[1,J];G→B[2,J];H→B[3,J]
42: if J=80;gsb "REC"
43: J+1→J
44: int(F+.5)-1.5→E
45: 0→F→G→H→I
46: ret
47: "REC":
48: rew;trk 0;rcf U,B[*]
49: for N=1 to 80;0→B[1,N]→B[2,N]→B[3,N];next N
50: 0→J;U+1→U
51: ret
52: end
```

SALINITY PLOT

```
0: dim K[3,80];scl 0,380,32,37
1: dsp "DO YOU WANT THE PRINTOUT?";stp
2: sfg 4
3: ent "FIRST FILE?",A
4: ent "LAST FILE?",Z
5: for L=A to Z
6: trk 0;ldf L,K[*]
7: if flg4=1;gto +2
8: fxd 0;spc 1;prt "***FILE*** ",L;prt "  D     T       S";fxd 2
9: for I=1 to 80
10: 0→J
11: K[1,I]→D;K[2,I]→C;K[3,I]→T
12: if D=0 and C=0;gto 35
13: gto +3
14: 1→J;.01(1.551-.0453T+5.9e-4T^2+.25(35-S)(.043-.0017T+2.3e-5T^2))→B
15: 1+B*(1.037e-3D-3.2e-8D^2)→r4
16: (676547+20131.5T+99.89T^2-.1943T^3-.00672T^4)1e-6→Z
17: if J=1;gto +2
18: C/42.896Z→r1;gto +2
19: C/(r4*Z*42.896)→r1
20: r1(r1-1)(T-15)(96.7-72r1+37.3r1^2-(.63+.21r1^2)(T-15))1e-5→r2
21: r1+r2→r3
22: -.092+28.3r3+12.808r3^2-10.679r3^3+5.986r3^4-1.323r3^5→S
23: if J=0;gto 14
24: if D>99;gto 30
25: fmt 1,f4.1,f6.2,f6.2
26: if flg4=1;gto +2
27: wrt 16.1,D,T,S
28: plt D,S
29: gto 34
30: fmt 2,f4.0,f6.2,f6.2
31: if flg4=1;gto +2
32: wrt 16.2,D,T,S
33: plt D,S
34: next I
35: next L
36: prt "   ***********";spc ;prt "PREP. FOR        NEXT STATION";spc
37: pen;cfg 4;trk 1;ldf 0,0,1
38: end
```

APPENDIX V.

Sample HP-CTD Cast Printout

The following is a sample listing of an HP-CTD cast. The various sections of the printout are as follows:

1. The Master Program (TRK1, FILE 0) provides access to the other programs. It also loads the special function keys.

2. Program 2 reads the clock and prints the month, day, and hour. It then asks for the station number followed by depth and conductivity zero frequencies.

*During the cast, both depth and temperature are displayed on the LED display. Special function key f0 ends the cast and puts the 9825A into a soak routine. The 9825A times the soak and after 4 minutes prints the time and continues. During the soak, 5 consecutive temperature values are averaged and printed unless one of the values varies by more than 0.05^{o}C from others, in which case a space is printed. This visually displays the quality of the soak for calibration purposes.

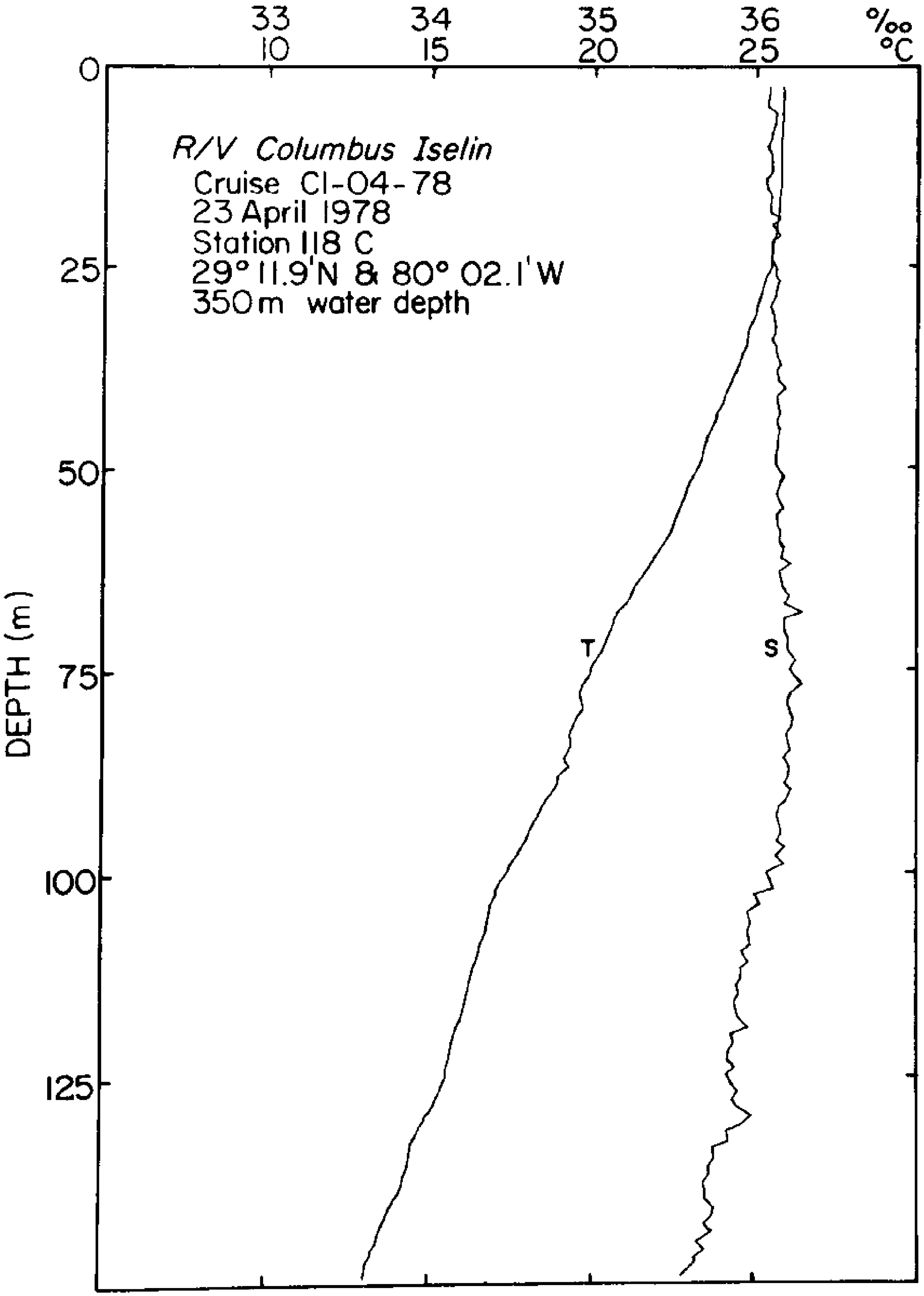
*After the soak, program 4 prints the first and last preliminary data files, in this case files 10 and 13.

3. Program 4 loads and runs program 5 which prints the downcast one meter averaged data and asks where to store that data (files 8 and 9 in this case).

4. The upcast is similar to the downcast with final data stored on files 10 and 11.

5. Program 8 simultaneously prints and plots salinity values for the up and down cast if requested.

```
MASTER PROGRAM
  **********
Type program #
and press
CONTINUE to run
one of these:

0 this one
  stops the
 Master Program
1 this one
  already loaded
  the special
  function keys
2  Taking a Cast
3     List D,C,T
4    Bottom Soak
5 Downcast Aver.
6 Mid-Depth Soak
7   Upcast Aver.
8  Salinity Plot
10 1st data file
   **********


Month Day Time
  4    23 1046
Station number=
             118
D freq in air=
            9712
*
C freq in air=
            5005
*
When the CTD
cast ends press
Special Function
Key f0.
*
For Mid-Depth
soaking, press
Special Function
Key f2.
*

****SOAKING****
Month Day Time
  4    23 1107
  D     T     S
145 13.40 35.600
145 13.42 35.601
145 13.46 35.610
144 13.50 35.602

142 13.64 35.627
142 13.64 35.619
144 13.50 35.629

146 13.26 35.627
    **********

The first and la
st files of this
cast are       10
 and           13



*DOWNCAST AVER.*
you typed      13
you typed       8
  D     C     T
 2.7 55.38 25.81
 3.8 55.37 25.82
 5.0 55.36 25.82
  .
  .
  .

147  41.87 13.19

148  41.77 13.10
149  41.65 13.06

The first and
last files of
saved data are 8
 and           9


For soaking whil
e a bottle trips
press S.F.K. f2.


Month Day Time
  4    23 1111
Station number=
             118
D freq in air=
            9712
*
C freq in air=
            5005
*
When the CTD
cast ends press
Special Function
Key f0.
*
For Mid-Depth
soaking,press
Special Function
Key f2.
*
****SOAKING****
When the upcast
is to be resumed
press Special
Function Key f1.
*
  3 25.00 36.092
  4 25.80 36.097
  4 25.80 36.086


  4 25.80 36.132

  4 25.80 36.093


  4 25.80 36.085
  3 25.80 36.084
   **********


The first and la
st files of this
cast are       10
 and           12
   **********



Upcast Aver. is
#7
Type program #
and press
CONTINUE to run

**UPCAST AVER.**
you typed      12
you typed      10
  D     C     T
157  40.85 12.34
156  40.86 12.36
155  40.98 12.48
  .
  .
  .

3.3  44.38 25.80
1.8  55.39 25.80
1.1  55.32 25.80

The first and
last files of
saved data are
               10
and            11
   **********
Sal. Plot is
#8
Type program #
and press
CONTINUE to run
   **********



***File***     8
  D     T     S
2.7 25.81 36.09
3.8 25.82 36.07
5.0 25.82 36.07
 .
 .
 .

80.9 19.53 36.24
81.9 19.41 36.23

***File***     9
  D     T     S
82.9 19.30 36.21
 .
 .
 .

147 13.19 35.64
148 13.10 35.63
149 13.06 35.56
  **********

prep. for
NEXT STATION

Type program #
and press
CONTINUE to run
```


33
10
34
15
35
20
36
25
‰
°C
0
25
50
75
100
125
DEPTH (m)
R/V Columbus Iselin
Cruise CI-04-78
23 April 1978
Station 118 C
29° 11.9'N & 80° 02.1'W
350m water depth
T
S

APPENDIX VI.

Data Logging Forms

DATA CASSETTE LOG

Cruise__________ Date__________

Station	Time	Data Acquiring Program	*Data Files*	Remarks

CRUISE SECTION LOG

Cruise__________ Date__________ Section__________

Distance Offshore to 1st Station = __________ Nautical Miles x 1.853 = __________ KM

Station	Depth	Latitude	Longitude	Data Files	Time	Date	Remarks

Country = 31
Ship = CI
C = CTD
X = XBT

CRUISE:__________

Page____of____

XBT - CTD BRIDGE LOG

Station#	Lat.	Long.	Loran C	Day	Time	Depth	Waves Dir.	Waves Ht.	Wind Dir.	Wind Spd.	Bar. Pres.	Air Temp.	WMO 4501 Weather
													X
													X
													X
													X
													X
													X
													X
													X
													X
													X
													X
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													X
													X
													X
													X
													X
													X
													X

PINGER LOG

Cruise Dates	Total Time Submerged	Total Time Submerged To Date

SALINITY LOG SHEET

Cruise	Operators Name	Analysis Date	STANDARD Sea water Stock # and Year

STA/DEPTH	SAMPLE BOTTLE	SAMPLE TEMP. DIAL READING	COND. RATIO BRIDGE READING	DRIFT READING	CORRECTED SALINITY
Standard	----				
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40

CTD - SALINITY AND TEMPERATURE CALIBRATION DATA

CRUISE__________

DATES__________

DATA SOURCE:

Mag Tape
HP
XYY

Consec. Sta. Number	Station Number	Bottle °/oo	615 660 CTD °/oo	Diff.	Therm(Rev.) °C		720 737 CTD °C	Diff.	
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CTD - SALINITY EQUATION USED:__________________

MEAN °/oo DIFFERENCE__________________ STANDARD DEV.__________

MEAN °C DIFFERENCE__________________ STANDARD DEV.__________

°/oo Equation for depth effect__________________

CTD-SALINITY ERROR ANALYSIS

SENSOR (Accuracy)	Maximum °/oo Error	
	Shallow	Deep
Conductivity (± .03 mmho/cm)		
Temperature (± .02°C)		
Depth (± 1.5 m)		
°/oo Equation:____________		
Total		

DIGITIZING (RESOLUTION)	Maximum °/oo Error	
	Shallow	Deep
Conductivity (± .01 mmho/cm)		
Temperature (± .005°C)		
Depth (± .10 m)		
Total		

(Values used for error analysis) SHALLOW	DEEP
Cond.____________	Cond.____________
Temp.____________	Temp.____________
Depth____________	Depth____________

NOAA FORM 81-3
(12-75)
FORM APPROVED
O.M.B. NO. 41-R2655

NATIONAL O

PHYSICAL AND CHEMICAL DATA FORM FOR OCEANOGRAPHIC STATIONS (NODC 3-64)

SURFACE ENVIRONMENTAL INFORMATION (MASTER CARD)

	COUNTRY		SHIP		LATITUDE						LONGITUDE							MARSDEN SQUARE			DATE						TIME GMT			SHIP'S CRUISE NO			SHIP'S STATION NO			DEPTH TO BOTTOM (M)				MAX SAMPLE	
					S = X8						E = X14										YEAR		MONTH		DAY		HR		1/10												
COL	1	2	3	4	5	6	7	8	9	N S	10	11	12	13	14	15	E W	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
									1/10							1/10																									

	ADD OBS CODE		WATER				WAVE				WIND				BAR (MBS)			AIR TEMPERATURE °C						WEATHER WW or W		CLOUD		VIS	SPECIAL OBS					PROCESSING NOS							C T
			COLOR		TRANS		DIR		H/A	P	DIR		SPEED/FORCE					DRY B			WET B					T	A							REF ID NO			CONSEC NO				
COL	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

SUBSURFACE OBSERVATIONS—(DETAIL CARDS)

	MESSENGER TIME			DEPTH (M)					TEMP °C					SAL ‰					O_2			PO_4—P			TOTAL—P			NO_2—N			NO_3—N			SiO_3—Si			pH				C T
	HR		1/10					I					I					I				OPTIONAL CHEMISTRY																			
COL	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	80

SPECIF

Page ___

MAGNETIC TAPE LOG

Tape No.	Date Used	Where Used	Keyword VSN	Date Mailed	Date Returned	Cleaned/Inspect Yes/No	Comments