A Hydroacoustic Data Acquisition System (HYDAS) for the Collection of Acoustic Data from Fish Stocks

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ABSTRACT

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The Science Branch, Newfoundland Region (SB) has developed a hydroacoustic data acquisition system (HYDAS) for the collection of acoustic data required to estimate fish stock abundance and/or biomass. The system digitizes the real time, analog signal produced by its vertical echo sounding subsystem and stores all the digitized samples which have magnitudes equal to or greater than an operator defined threshold, on 9-track computer tape. HYDAS has been used successfully by SB during many surveys and studies designed to collect acoustic data for fish stock biomass estimations.

Details of the configuration and design of the instrumentation used in the system are presented. In addition, a complete description of system operating procedures is provided and the formats used to write data on the 9-track tapes are described.

RÉSUMÉ

Stevens, C. R. 1986. A hydroacoustic data acquisition system (HYDAS) for the collection of acoustic data from fish stocks. Can. Tech. Rep. Fish. Aquat. Sci. 1520: v + 73 p.

La Direction des Sciences de la Région de Terre-Neuve a mis au point un système d'acquisition de données hydroacoustiques (HYDAS) pour la collecte des données acoustiques nécessaires à l'estimation de l'abondance ou de la biomasse des stocks de poisson. Le système convertit en valeur numérique le signal analogique en temps réel produit par son sous-système d'échosondage vertical et mémorise sur bande à neuf pistes, tous les échantillons numérisés dont la grandeur est égale on supérieure au seuil défini par l'opérateur. Le système HYDAS a été utilisé avec succès par la Direction des Sciences au cours de nombreux relevés et études visant la collecte de données acoustiques pour les estimations de la biomasse d'un stock de poisson.

On présente des détails sur la composition et la conception des appareils du système. De plus, on fournit une description complète des procédures d'exploitation du système et on décrit la structure de présentation des fichiers sur bandes à neuf pistes.

1. INTRODUCTION

1.1. RATIONALE FOR THE DEVELOPMENT OF HYDAS

Science Branch, Newfoundland Region (SB), started to use the Computerized Echo Integration System (CEIS) to conduct hydroacoustic surveys to determine capelin (Mallotus villosus) abundance in 1977 (Miller et al. MS 1978). The CEIS was quite similar to the Computerized Echo Counting System (CECS) (Shotton and Dowd MS 1975). The two systems used the same hardware (i.e. Honeywell minicomputer, Model 316, Simrad echo sounder, Model EK50, Fathom Oceanology underwater towed vehicle, Model 4.5 ft. Tow Fish, and Ametek/Straza transducer, Model SP187LT) but had different software packages. The CECS executed a data acquisition and an echo counting program while the CEIS executed a data acquisition and an echo integration program.

SB personnel experienced major problems with the computer in the CEIS. The hardware and software of the computer imposed serious limitations on the acquisition and analysis of the hydroacoustic data. The program contained mistakes and omissions that caused the real time density estimates to be inaccurate and biased. Also, the program did not record raw data (i.e. the digital value of the converted signal from the demodulated output of the echo sounder) on the 9-track magnetic tape. Instead, the digital values were squared, summed, and averaged over layers of from one to ten meters in thickness before being recorded on the tape. Therefore, the data stored on the tapes could not be adjusted to compensate for errors in the time varied gain (TVG) amplifier of the echo sounder receiver. As a result, the estimates obtained by integrating the data stored on the tapes contained unknown errors. In addition, many computer hardware failures were experienced which resulted in the loss of survey vessel time. The remaining instrumentation in the CEIS (i.e. transducer, underwater towed vehicle, echo sounder, etc.) performed in an acceptable manner.

To overcome the computer problems, the SB decided to develop a dedicated computer for the acquisition and storage of hydroacoustic data and to use general purpose mini and mainframe computers for the development and execution of hydroacoustic data analysis software. The project for the development of the hydroacoustic acquisition computer was started in 1979. The project gradually expanded to permit other parts of the data acquisition system to be improved. The resultant product is called HYDAS - an acronym for Hydroacoustic Data Acquisition System.

2. HYDAS TECHNICAL DESCRIPTION

2.1 SYSTEM CONFIGURATION

The organization of the major components which make up HYDAS is shown in Fig. 1. For ease of explanation, the components in the system have been divided into two groups called the Analog Subsystem and the Digital Subsystem.

2.2 THE ANALOG SUBSYSTEM

The equipment in the Analog Subsystem which is exposed to the elements is known as the Wet End equipment. The Wet End is composed of the transducer, the underwater towed vehicle (towed body), the towing cable, and the towed body deployment and retrieval equipment.

The remainder of the equipment in the Analog Subsystem is known as Dry End equipment. The Dry End consists of the echo sounder equipment and the test and measurement instrumentation.

2.2.1 Analog Subsystem - Wet End

The configuration of the equipment in the Wet End of the Analog Subsystem is shown in Fig. 1. The following is a description of that equipment.

Transducer - Ametek/Straza Model SP187LT: The transducer can be configured to provide either a six-degree or a twelve-degree, full angle, conical beam pattern. The unit can be deployed to a maximum depth of 180 meters.

Towed Body - Fathom Oceanology Model 4.5 ft. Tow Fish: The towed body is designed for dead weight operation (i.e. there are no steering or depressing fins or plates). The unit is designed to house the transducer for downward looking operation. The combined weight of the towed body and the transducer in air is approximately 120 kilograms.

Tow Termination - Braincon Type 275: The tow termination provides a mechanical link between the armour wires of the towing cable and the tow point of the towed body. Also, it provides an electrical link between the electrical conductors of the towing cable and the transducer.

Towing Cable: The towing cable has an armour which is composed of two layers of wires wound about the core of the cable. The armour wires provide the cable with the mechanical strength required to deploy, tow and retrieve the towed body. In addition, they protect the core from damage. The core is composed of electrical conductors covered with waterproof material. Two conductors are needed to provide the communications link between the transducer and the transceiver of the echo sounder.

Towed Body Deployment and Retrieval Equipment: The deployment and retrieval equipment is composed of a Hiab articulating crane, Model 1165AW, fitted with two InterOceans Systems snatch block pulleys, Model 712-16, and a Hydrauuk Brattvaag winch, Model UMG164. The crane and winch are part of the equipment provided by the research vessel GADUS ATLANTICA. The towing cable is stored on the drum of

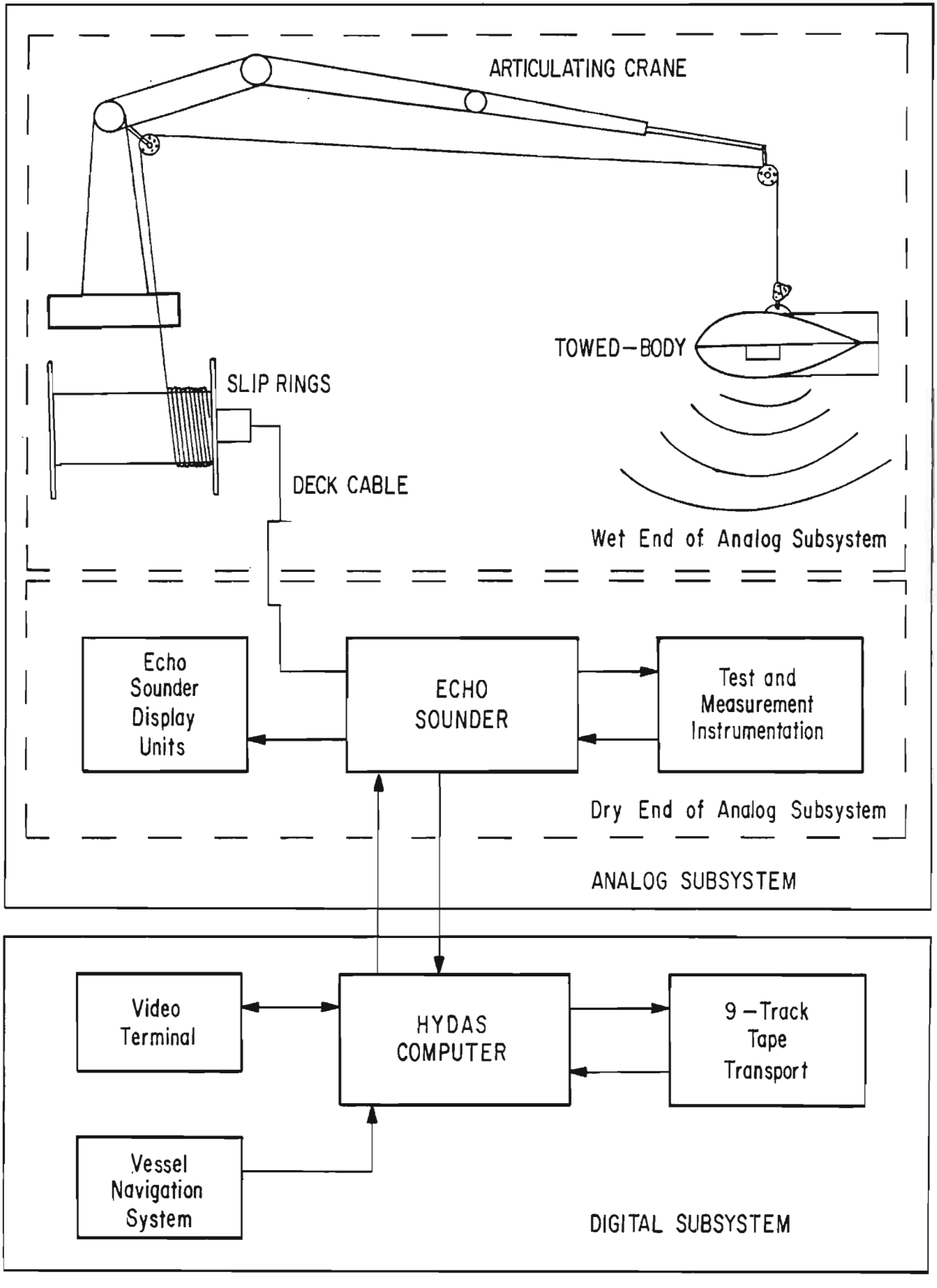


Figure 1. Configuration of the Major Components for HYDAS.

the winch. The cable is passed through the snatch block pulleys fixed on the articulating arms of the crane. The towed body can be raised, lowered, and moved horizontally by the crane.

Slip Ring Assembly: The slip ring assembly provides electrical continuity between the conductors of the towing cable stored on the rotating winch drum and the deck lead-in cable. The conductors of the towing cable are connected to the rotor unit of the slip ring assembly which is mounted on the rotating axis of the drum. The conductors of the deck cable are connected to the stator unit of the slip ring assembly which is mounted on the stationary winch frame.

Deck Lead-in Cable: The deck lead-in cable provides electrical continuity between the stator unit of the slip ring assembly and the Transducer Test and Selector Unit of the echo sounder located in the laboratory of the research vessel. The deck cable is housed in conduit to provide it with mechanical and electrical protection.

2.2.2 Analog Subsystem - Dry End

The configuration of the equipment in the Dry End of the Analog Subsystem is shown in Fig. 2. The major component in the Dry End is a customized, 49 kilohertz (KHz) Simrad echo sounder, Model EK400. The echo sounder is composed of the following units.

Transceiver Unit - Simrad Model TR101: The transmitter section of the Transceiver Unit has been fitted with the printed circuit boards (PCBs) required to provide it with a maximum output power of 5,000 watts.

The receiver section contains the 20 log R + 2 α R and 40 log R + 2 α R TVG amplifiers. The signals from the outputs of these amplifiers are routed to the Control Unit and then to the Test Panel for distribution to other parts of HYDAS.

The operation of the Transceiver Unit is controlled by the Control Unit.

The Transceiver Control PCB of the Transceiver Unit was modified to provide transmit pulse lengths of 0.3 milliseconds (msec), 0.6 msec, and 1.2 msec. The Input Circuit, 20 log R TVG Amplifier, and 40 log R TVG Amplifier PCBs were modified to provide receiver bandwidths of 6.7 KHz, 3.3 KHz and 1.7 KHz. The modifications were performed by Simrad under a contract funded by SB.

It was observed that ship vibrations caused changes in the conductivity of the relay contacts on the Transducer Selector PCB (i.e. the contacts were not remaining completely closed). Therefore, the performance of the receiver amplifiers was unpredictable. To overcome this problem, wires were installed to provide a direct signal path from the transceiver input/output point (i.e. the Dual Transmitter Output PCB) to a custom built Transducer Test and Selector Unit (TTSU). A description of the TTSU is given later in this section. The modification to the Transducer Selector PCB was performed by the Hydroacoustic Section of FRB.

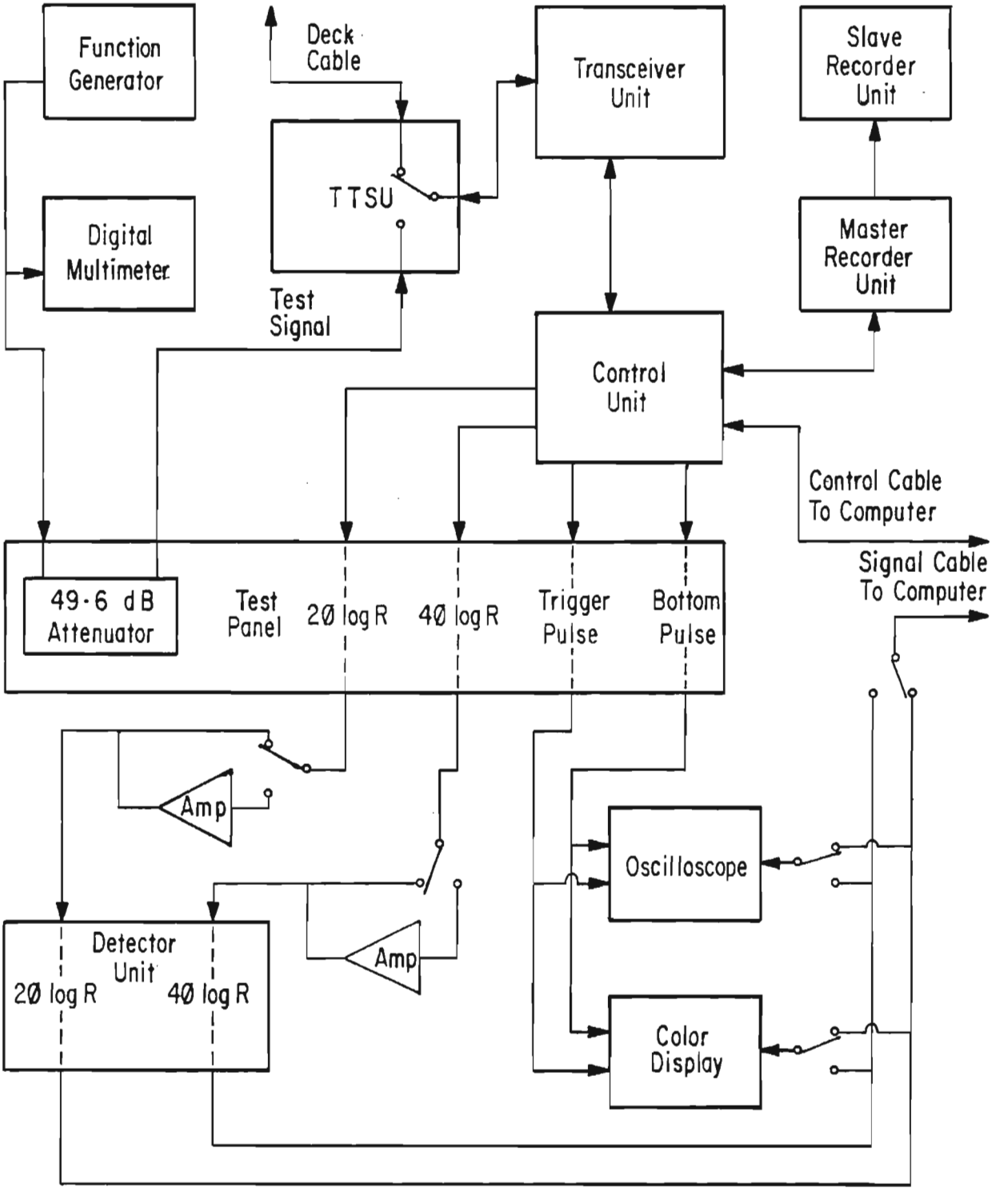


Figure 2. Analog Subsystem, Dry End Equipment Configuration.

Control Unit - Simrad Model MV101: The selection of the operating parameters for the echo sounder is done by the operator via the keyboard of the Control Unit. A description of the parameters is given in Section 3.3 of the Simrad EK400 Instruction Manual.

The Control Unit develops all the signals required to control the operation of the Transceiver Unit and the Recorder Units. In addition, it provides the trigger pulse signal and the bottom pulse signal. These signals are routed to the Test Panel for distribution to other parts of HYDAS.

A multiconductor cable is used to transfer control signals to and from the Control Unit and the HYDAS computer. The cable is connected to the General Access connector (J106) of the Control Unit and to a 25-pin DP connector mounted on the rear panel of the computer. The conductors in the cable are used to:

(1) send the trigger pulse and bottom pulse signals from the Control Unit to the computer,

(2) send the signals which indicate the positions of the Tape/Normal and the Meter/Fathom switches, located on the front panel of the Control Unit, to the computer, and

(3) send the signal from the Event Marker button, located on the front panel of the computer, to the Control Unit (MV101 signal Log Marker I).

Read only memory (ROM) integrated circuits (chips) containing customized software have been installed on the Processor Unit PCB of the Control Unit. The software changes allow the customized pulse lengths and bandwidths of the Transceiver Unit to be presented and selected via the display and the keyboard of the Control Unit. The software modifications and the preparation of the ROM chips were carried out by Simrad under a contract funded by SB.

Test Panel - Simrad Model EK400: The Test Panel functions as a distribution point for signals from the Transceiver Unit and the Control Unit that are needed by other parts of HYDAS. The signals from the outputs of the TVG amplifiers of the receiver section are routed, via the Control Unit, to the BNC connectors on the Test Panel labelled Transceiver I, 20 log R and 40 log R. The trigger pulse signal and the bottom pulse signal from the Control Unit are routed to the BNC connectors on the Test Panel labelled Trigger Pulse and Bottom Pulse.

The Test Panel also provides connectors for the injection of test signals into the front end of the receiver section of the Transceiver Unit. Test signals can be injected into the BNC connectors on the Test Panel labelled Transceiver I, Test Input and Tx Output. A passive network providing 49.6 dB of attenuation is connected between the Test Input and the Tx Output BNC connectors. Test signals are routed from the Tx Output, via the Transducer Test and Selector Unit, to the input of the receiver section of the Transceiver Unit.

The BNC connectors on the Test Panel labelled Transceiver II are not used by HYDAS.

Transducer Test and Selector Unit (TTSU) - Custom Built: The TTSU provides electrical continuity between selected units in the Dry End of the Analog Subsystem. It can be configured to allow:

(1) the Transceiver Unit to send transmit pulses to the transducer and receive signals from the transducer,

(2) the Transceiver Unit to send transmit pulses to the resistive (dummy) load mounted in the TTSU,

(3) test signals from the Tx Output of the Test Panel to be injected into the input of the receiver section of the Transceiver Unit, and

(4) test signals from the output of the Function Generator to be injected into the transducer.

The operator can configure the TTSU for a specific task by setting the toggle switches located on the front panel of the unit. The diagram presented in Fig. 3 shows the units connected to the TTSU and the electrical paths which can be configured with the switches. For example, if switch S1 and switch S3 are both set in the 'Oper.' position, the Transceiver Unit will be connected to the transducer. If switch S1 is set to the 'Test' position and switch S2 is set to the 'Rx Test' position, the signal from the Tx Output will be injected into the receiver section of the Transceiver Unit.

The TTSU can be configured to measure the magnitude of the transducer impedance via the following procedure.

(1) Set switch S3 to the 'Test' position and switch S4 to the 'Trans.' position.

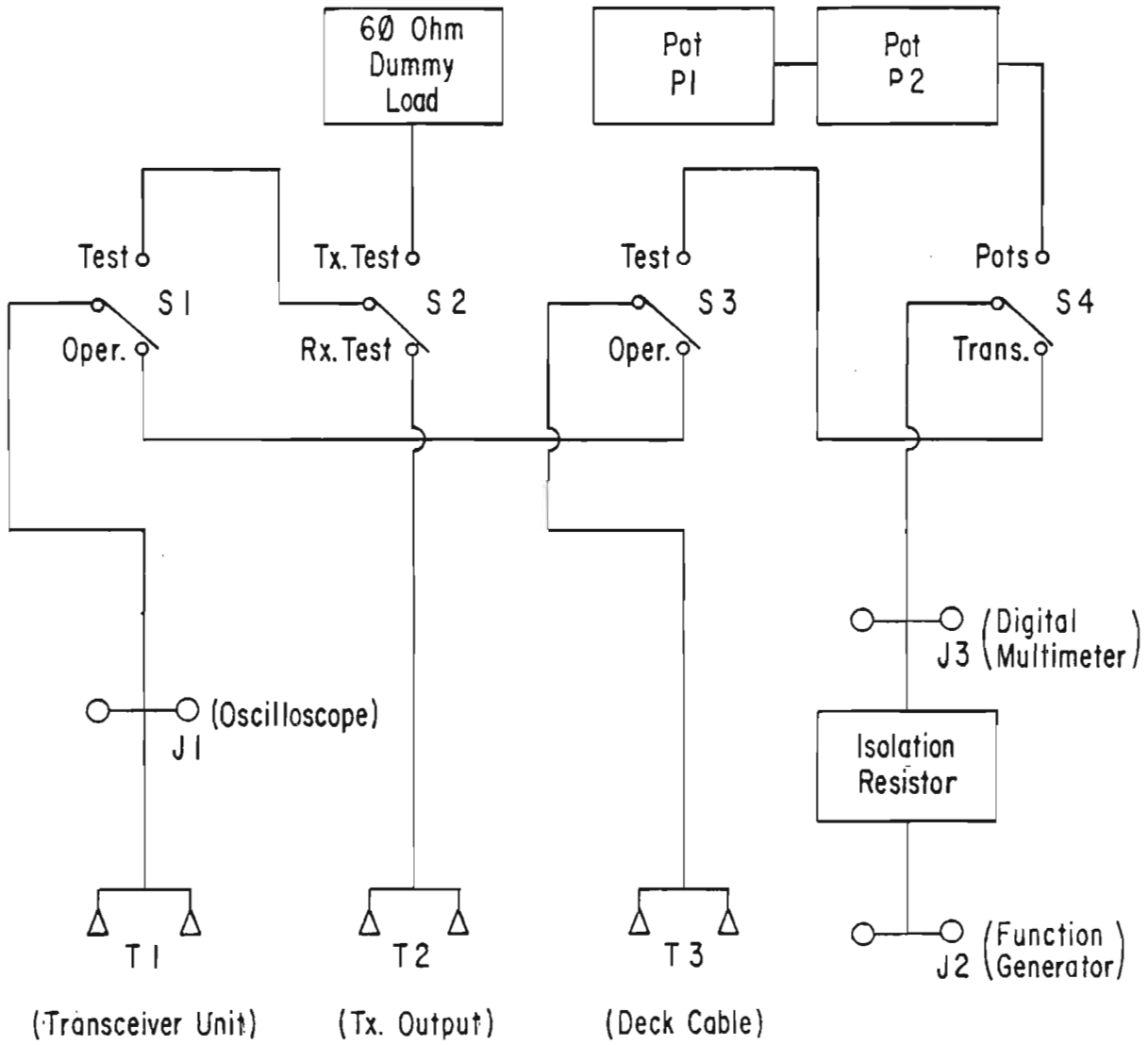
(2) Use the Function Generator to inject a 49 KHz signal into jack J2 and measure the amplitude of the signal with the Digital Multimeter via jack J3.

(3) Set switch S4 to the 'Pots' position and adjust the rotors of potentiometers P1 and P2 until the signal amplitude has the same value observed in the previous step.

(4) Disconnect the Function Generator from jack J3 and use the Digital Multimeter to measure the value of the resistance of the potentiometers.

The value of the resistance is equal to the magnitude of the transducer impedance (Boldholt and Brede MS 1982).

Signals going to or coming from the Transceiver Unit can be monitored via jack J1.



S1, S2, S3, S4 = Toggle Switches
J1, J2, J3 = Jack Connectors
T1, T2, T3 = Terminal Strips
P1, P2 = Potentiometers

Figure 3. TTSU Signal Path Diagram.

The TTSU was developed by the Hydroacoustic Section of SB.

Optional Amplifiers - Hewlett-Packard Model HP467A: If necessary, these fixed gain amplifiers can be used to increase the amplitudes of the signals from the outputs of the TVG amplifiers. The signals from the 20 log R and 40 log R BNC connectors on the Test Panel are routed to the inputs of the amplifiers. The signals from the outputs of the amplifiers are routed to the inputs of the Detector Unit.

Detector Unit - Simrad Custom Built: The Detector Unit contains three RMS signal detectors. Each detector has BNC connectors mounted on its front panel which function as signal input and signal output jacks. The signals from the 20 log R and 40 log R connectors on the Test Panel or from the outputs of the optional amplifiers are routed to the BNC input connectors. The RMS detected signals from the BNC output connector are routed to other parts of HYDAS.

The circuitry for the detectors is identical to the circuitry used for the detector in the Simrad QX Integrator Preprocessor Unit. The Detector Unit was developed by Simrad under a contract funded by SB.

Recorder Units - Simrad Model AR800: The echo sounder has two dry paper recorders configured as a master unit and a slave unit. The master recorder provides the key pulse signal used by the Control Unit to trigger the transmitter section of the Transceiver Unit.

Both recorders receive the information to be displayed from the Control Unit. The master recorder can be configured (via the Control Unit) to display the full range of features described in Section 3.3 of the Simrad EK400 Instruction Manual. The slave recorder can be configured (via the Control Unit) to display the basic and the phased ranges. The synchronization correction control (i.e. the button labelled 'Push;Sync.corr.') of both recorders must be used to initialize the slave recorder after the recorders have been powered up or the basic range has been changed.

Video Color Display - Simrad Model CF100: The Color Display can be configured to present the full water column (i.e. from the transducer to the ocean floor) or an expanded portion of the water column. The information presented by the display can be referenced to the transducer or to the ocean floor. The detected signal from either the 20 log R output or the 40 log R output of the Detector Unit can be displayed.

The Color Display receives the trigger pulse signal and the bottom pulse signal via cables connected to the Trigger Pulse and Bottom Pulse BNC connectors on the Test Panel.

The remaining instrumentation in the Dry End of the Analog Subsystem is described below.

Oscilloscope - Tektronix Model R7704 fitted with a Programmable Digitizer module - Tektronix Model 7D20: The oscilloscope (scope) can be configured to display the 20 log R or 40 log R detected signal from each echo sounder transmit/receive cycle (ping). Range (i.e. depth) is presented on the horizontal axis of the scope and the amplitude of the detected signal is presented on the

vertical axis. The vertical gain control of the scope can be adjusted to display very small or large amplitude signals. The trigger pulse signal or the bottom pulse signal from the Test Panel can be used to control the horizontal trigger of the scope. Therefore, the scope can display the detected signal referenced to the transducer or to the ocean floor. The horizontal time base control of the scope can be adjusted to display the full water column (i.e. from the transducer to the ocean floor) or to display any portion of the water column.

The operator can configure the scope to average or envelope the signals from contiguous pings. In addition, the signals from up to six pings can be stored in the memory of the scope for comparison purposes.

For information on the operation of the oscilloscope, the operator should refer to the Tektronix Model R7704 and 7D20 Instruction Manuals.

Function Generator - Tektronix Model FG5010: The Function Generator provides the test signals needed to:

(1) measure the characteristics (i.e. bandwidth, gain, etc.) of the receiver section of the Transceiver Unit,

(2) measure the receive sensitivity of the system, and

(3) measure the magnitude of the transducer impedance.

The digital display of the Function Generator can be used to indicate the frequency or the peak-to-peak amplitude of the test signals.

For information on the operation of the Function Generator, the operator should refer to the Tektronix Model FG5010 Instruction Manual.

Digital Multimeter - Tektronix Model DM5010: The Digital Multimeter monitors the amplitude of the signal from the Function Generator. It can be configured to display the amplitude value in decibel units (dBs) referenced to 1 volt RMS.

The multimeter also is used to measure the magnitude of the transducer impedance.

For information on the operation of the Digital Multimeter, the operator should refer to the Tektronix Model DM5010 Instruction Manual.

Note that both the Function Generator and the Digital Multimeter are mounted in a Tektronix Power Module, Model 5006.

2.3 THE DIGITAL SUBSYSTEM

The Digital Subsystem is divided into hardware and software parts. The hardware part is composed of the microcomputer, video terminal, and 9-track tape transport and formatter. The software part is comprised of the programs executed by the microcomputer.

2.3.1 Digital Subsystem - Hardware

The major hardware unit is the microcomputer, which is housed in a Tei Inc. chassis, Model RM-22. The chassis contains a high quality, constant voltage transformer power supply, a cooling fan, and an actively terminated, 22-slot, S-100 mother board.

The circuitry for the computer is contained on nine S-100 circuit cards which are fitted into slots on the mother board. A functional diagram of the computer hardware is shown in Fig. 4. The following is a description of the nine circuit cards.

Master Processing Card - Cromemco Model ZPU: The card contains the Z80A microprocessor which serves as the master processing unit (MPU) for the computer. The card has been configured to operate at 4.0 megahertz (MHz) with no wait states. The card contains no read-only-memory (ROM) or random access memory (RAM). The ROM and RAM are provided by other cards in the computer. Table 1 shows the allocation of the MPU memory space.

When the computer is powered up or the RESET button on the front panel of the computer chassis is depressed and released, the MPU generates the S-100 bus signals required to fetch the instruction stored at memory location 0000H (hexadecimal notation). The instruction stored at this address is the first instruction in the HYDAS-400 program.

For a detailed description of the card, the Cromemco ZPU Instruction Manual should be consulted.

First RAM Card - Dynabyte 16K Static Memory Module Model MSC-1625: The card has been configured to provide the first 14K (K = 1024) of RAM for the MPU. The RAM is positioned in the MPU address space from 4800H to 7FFFH. The first 2K of memory locations (bytes) provided by the card have been disabled. This was done to provide an MPU address space (4000H to 47FFH) for other cards in the computer.

For a detailed description of the card, the Dynabyte Model MSC-1625 Operating Manual should be consulted.

Second RAM Card - Industrial Micro Systems 32K Static RAM Memory Model 370: The Card provides the second part (32K) of RAM for the MPU. The RAM is positioned in the MPU address space from 8000H to FFFFH.

For a detailed description of the card, the Industrial Micro Systems Model 370 Operating Manual should be consulted.

EPROM and Serial Interface Card - Custom Built: The card contains 4, 4K-byte erasable programmable read-only-memory (EPROM) chips that are configured to occupy the MPU address space from 0000H to 3FFFH. The chips have been programmed with the executable code for the HYDAS-400 program. The MPU executes this program when the computer is powered up.

The card also contains a universal asynchronous receiver transmitter (UART) chip that is configured as a bidirectional serial port. The port provides the

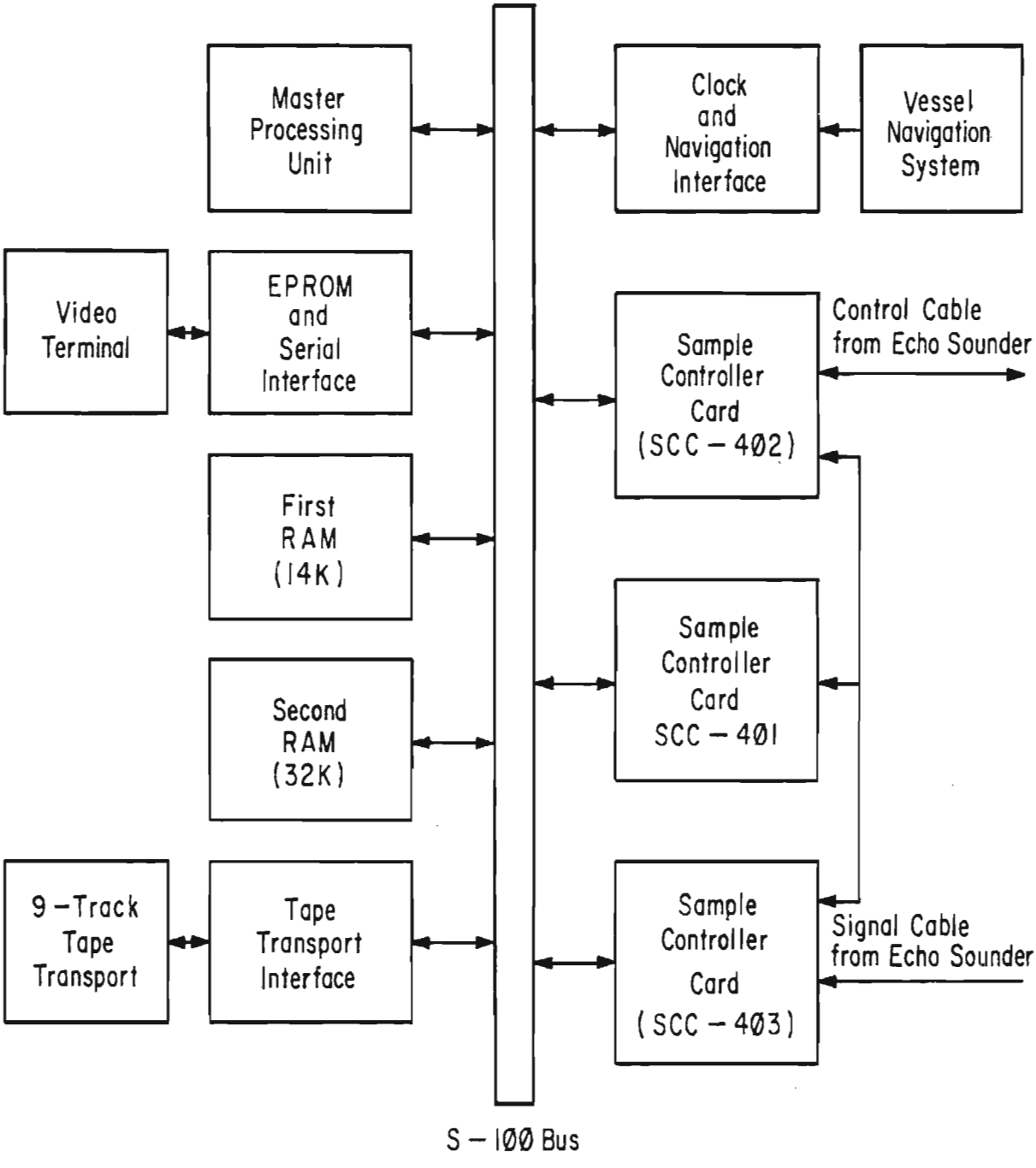


Figure 4. Block Diagram of HYDAS Computer.

Table 1. Allocation of the MPU Memory Area.

Address range	Description
0000H-3FFFH	- location of the HYDAS-400 program executed by the MPU - the program is contained in four EPROM chips mounted on the EPROM and Serial Interface card
4000H-43FFH	- dual-ported RAM used for the transfer of information between the MPU and the CPU of the Clock and Navigation Interface card - see Table 2 for a description of the allocation of the dual-ported RAM
4400H-4401H	- Sample Depth register - used to transfer the sample depth words from the Sample Controller cards to the MPU.
4402H-4403H	- Sample Amplitude register - used to transfer the sample amplitude words from the Sample Controller cards to the MPU
4404H-47FF	- unused
4800H-7FFFH	- first part of the RAM area for the MPU - provided by the Dynabyte Model MSC-1625 card
8000H-FFFFH	- second part of the RAM area for the MPU - provided by the Industrial Micro Systems Model 370 card

communication channel between the MPU and the video terminal. RS-232 signal levels are used to transfer the serial data. A ribbon cable carries the signals between a header connector mounted on the top edge of the card and a 25-pin DP connector mounted on the rear panel of the computer chassis. Only pins 2 (Receive Data), 3 (Transmit Data), and 7 (Signal Ground) of the DP connector are used. The remaining pins are not terminated. The data transfer rate is set at 9600 bits per second.

A block diagram of the card is shown in Fig. 5. The card was developed by the Hydroacoustic Section of SB.

Tape Transport Interface Card - Custom Built: The card allows the MPU to send commands and transfer data to the 9-track tape transport and formatter. Command and data bytes are transferred by the MPU to the transport and formatter via two parallel output ports located on the card. Transport and formatter status information is transferred to the MPU via a parallel input port and an interrupt requester and vector generator circuit located on the card.

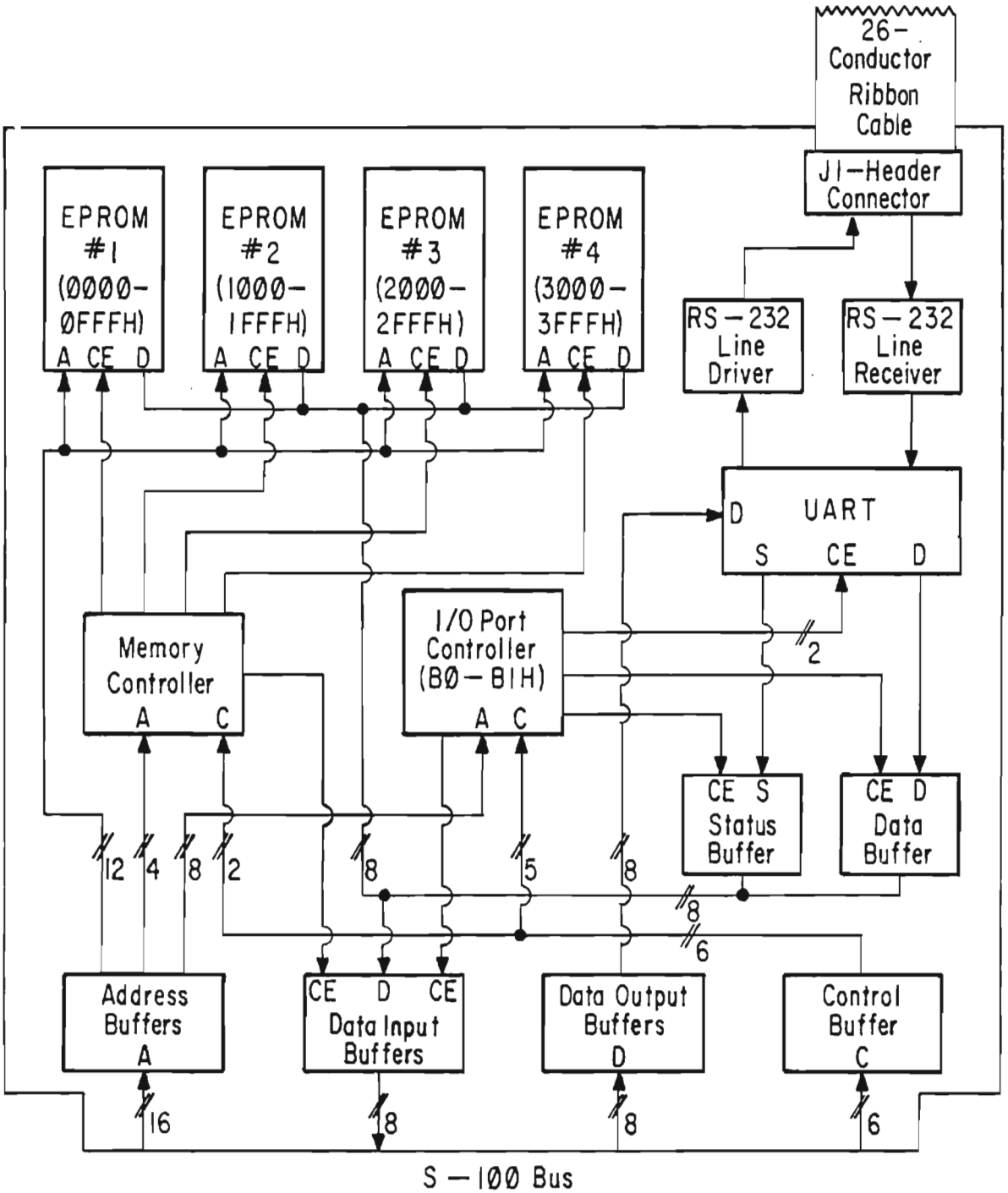
The information is transferred between the MPU and the transport and formatter in byte wide (i.e. 8-bits) format. Three ribbon cables carry the signals between three header connectors mounted on the top edge of the card and three 25-pin DP connectors mounted on the rear panel of the computer chassis.

A block diagram of the card is shown in Fig. 6. The card was developed by he Hydroacoustic Section of SB.

Clock and Navigation Interface (CLK-NAV) Card - Custom Built: The card functions as a calendar and a clock. It maintains the date in days, months, and years (minus 1900) and the time in hours, minutes, seconds, and milliseconds. The card also acquires positional information from the research vessel's navigation system via a serial input port. Both the date and time data and the navigational data are stored on the card in memory locations which are configured into the memory address space of the MPU. Therefore, the MPU can access these data via memory read operations.

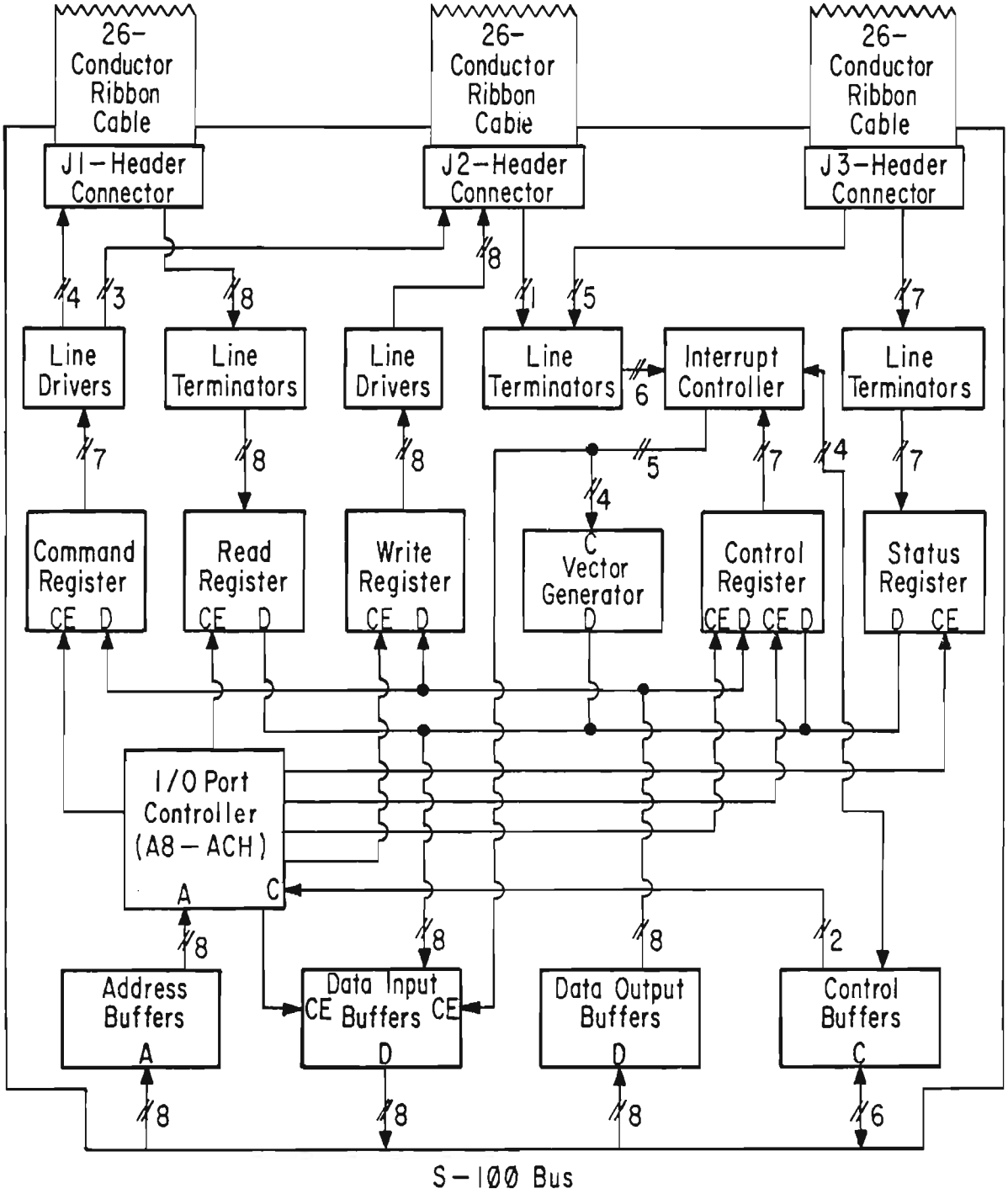
The card provides two timer channels for the MPU. One of the timer channels (Timer Channel #2) is used to measure the period of time between consecutive listings of the Interval Summary Data Table on the video terminal (see Section 4.4.4 for a description of the Interval Summary Data Table). The second timer channel (Timer Channel #3) is used to measure the period of time between the recording of consecutive Navigation records on the 9-track magnetic tape (see Section 4.4.6 for a description of the Navigation record).

The card contains a microcomputer which functions as a slave of the MPU. The microcomputer is composed of a Z80A CPU, a 4K-byte EPROM, a 1K-byte dual-ported RAM, and a serial input port. The card executes the program (called CNAV) stored in the EPROM chip. The memory locations of the RAM are configured into the address space of the MPU and the CLK-NAV CPU. Therefore, the RAM provides the data communication channel between the two microcomputers. The RAM is configured to occupy the MPU address space from 4000H to 43FFH. Table 2 shows the manner in which these memory locations are used by the MPU and the CLK-NAV CPU.



SYMBOL DEFINITIONS: A = Address Lines. C = Control Lines. CE = Chip Enable Lines. D = Data Lines. S = Status Lines. // = Multiple Lines.

Figure 5. Block Diagram of the EPROM and Serial Interface Card.



SYMBOL DEFINITIONS: A = Address Lines. C = Control Lines. CE = Chip Enable Lines. D = Data Lines. // = Multiple Lines.

Figure 6. Block Diagram of the Tape Transport Interface Card.

Table 2. Allocation of the Dual-Ported RAM Area.

MPU address range	CLK-NAV CPU address range	Description
4000H	1000H	- Clock Command register - the MPU writes to this register to request the CLK-NAV CPU to carry out specific functions
4001H	1001H	- Clock Status register - the MPU reads the contents of this register to determine the status of the CLK-NAV CPU
4002H-4009H	1002H-1009H	- Time and Date registers - the MPU writes to these registers to update the time and date - the MPU reads the contents of these registers to determine the current time and date
400AH-411FH	100AH-111FH	- Navigation record registers - the MPU reads the contents of these registers to acquire the current navigational data
4120H	1120H	- Timer Channel #2 Initialization register (TIME$2) - the MPU writes the value of the INTV parameter to this register (see Section for a description of the INTV parameter)
4121H	1121H	- Timer Channel #3 Initialization register (TIME$3) - the MPU writes the value used to time the period between the recording of consecutive Navigation records on the 9-track tape to this register
4122H-43FFH	1122H-13FFH	- unused by the MPU - work space for the CLK-NAV CPU

A UART chip functions as a serial input port for the reception of the data from the vessel's navigation system. The port receives RS-232 signals from the navigation computer (i.e. the Magnovox Model 1107L). A ribbon cable carries the signals from a 25-pin DP connector mounted on the rear panel of the computer chassis to a header connector mounted on the top edge of the card. Only pins 3 (Transmitted Data) and 7 (Signal Ground) of the DP connector are used. The remaining pins are not terminated. The data transfer rate is set at 600 bits per second.

A block diagram of the card is shown in Fig. 7. The card was developed by the Hydroacoustic Section of SB.

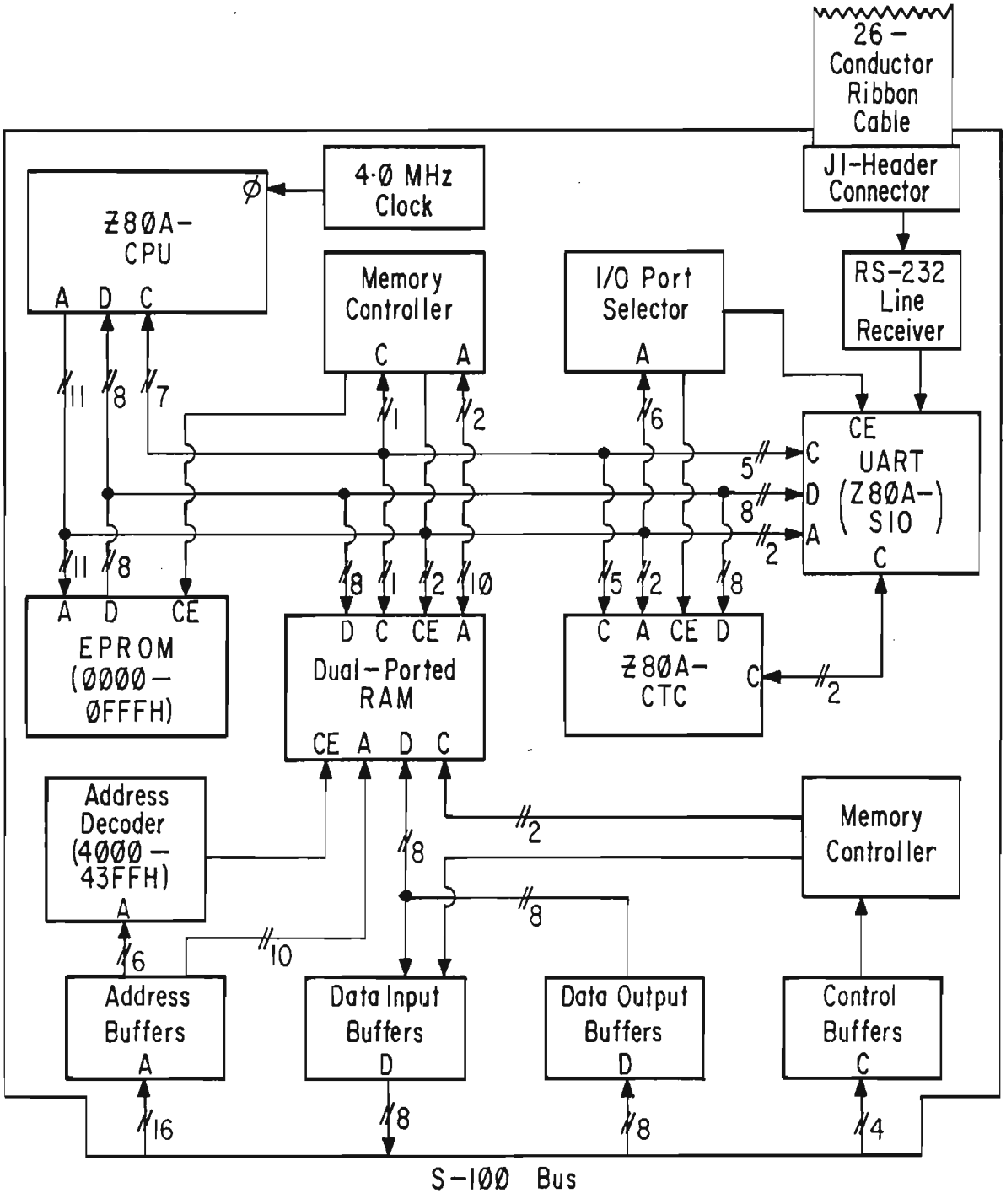
Sample Controller Cards (Three Cards) - Custom Built: The three cards function as the interface between the MPU and the echo sounder. The cards perform the following tasks.

(1) Determine the sampling period for each echo sounder ping.
The cards receive the trigger pulse and the bottom pulse signals from the echo sounder Control Unit and the depth to first sample (DTFS) value from the MPU (see Section 4.4.2 for a description of the DTFS parameter). The card uses this information to determine the period of time for each echo sounder ping (i.e. the sampling period) during which the signal from the output of the echo sounder Detector Unit should be digitized.

(2) Perform the analog to digital conversion of the signal from the output of the Detector Unit.
During the sampling period, the analog-to-digital converter components digitize the signal to twelve bits of resolution at the rate of 15,000 conversions per second. The 12-bit binary number produced by each conversion of the signal is placed in a 16-bit register called the Sample Amplitude register. Note that the most significant four bits in the Sample Amplitude register are always zeros. The Sample Amplitude register is configured to occupy the MPU address space from 4402H to 4403H.

(3) Compare the digitized signal values to the amplitude threshold (THRS) value.
The cards compare each sample amplitude word (i.e. the 12-bit binary number produced by the analog-to-digital converter) to the THRS value received from the MPU (see Section 4.4.2 for a description of the THRS parameter). If the magnitude of the sample amplitude word is equal to or greater than the THRS value, the cards notify the MPU via an interrupt request and an interrupt vector.

(4) Measure the depth at which each analog to digital conversion is performed and the maximum water depth for the ping.
The cards measure the water depth by using the output of the 15 KHz sample rate generator to increment a register from the time the trigger pulse signal is received until the bottom pulse signal is received. The 16-bit register is called the Sample Depth register and is configured to occupy the MPU address space from 4400H to 4401H. The



SYMBOL DEFINITIONS: A = Address Lines. C = Control Lines. CE = Chip Enable Lines. D = Data Lines. // = Multiple Lines. Ø = Clock

Figure 7. Block Diagram of the Clock and Navigation Interface Card.

Sample Depth register is cleared each time a trigger pulse is received.

(5) Track the ocean floor.
The cards use the DOFF value supplied by the MPU to compute a maximum sample depth (MSD) for each echo sounder ping (see Section 4.4.2 for a description of the DOFF parameter). Then, if the echo sounder fails to detect the ocean floor and generate a bottom pulse signal, the cards use the MSD to determine when sampling should be stopped for the ping.

The cards notify the MPU each time the echo sounder fails to generate a bottom pulse signal by setting a bit in a status register located on the cards. The status register is configured as an input port of the MPU.

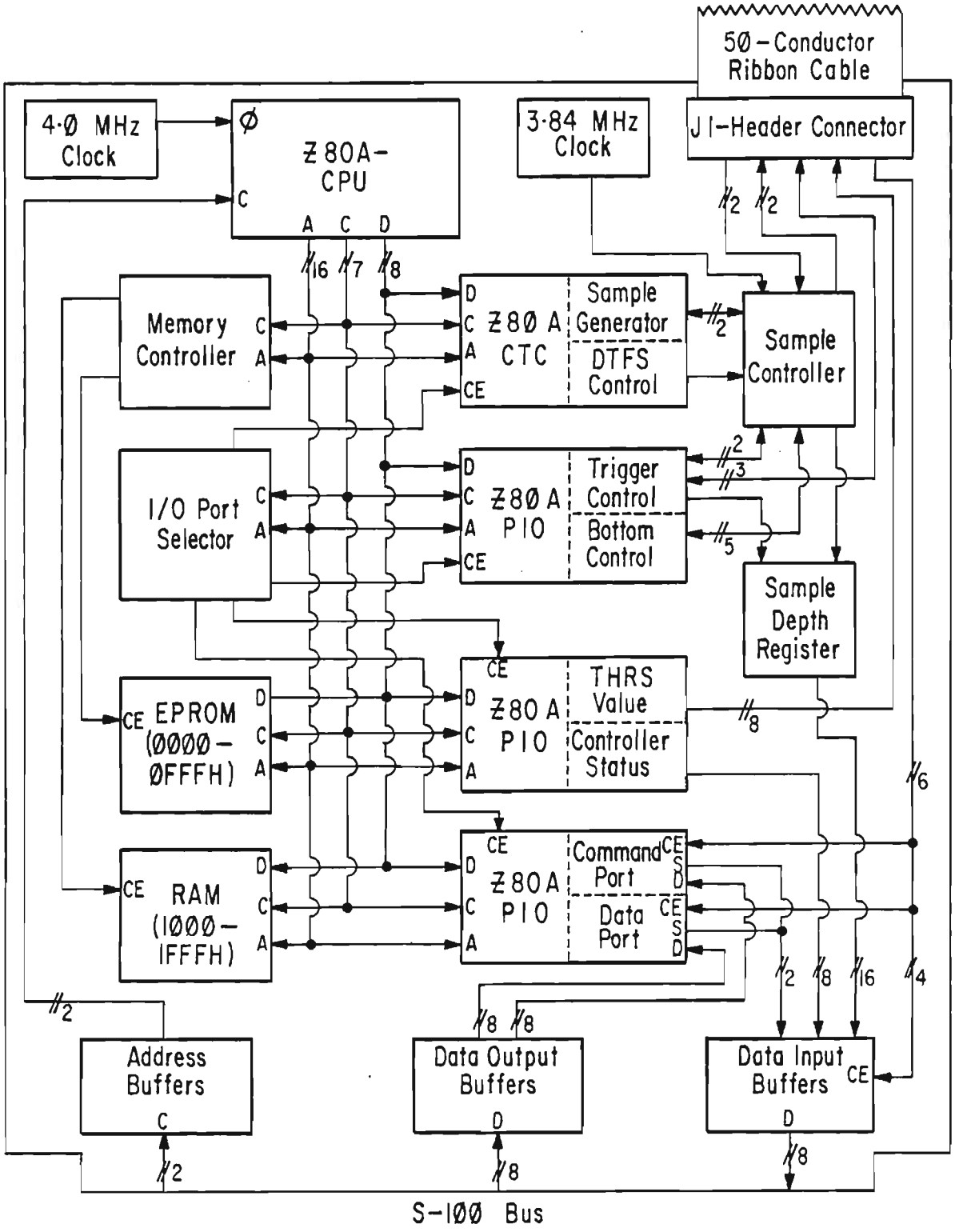
(6) Monitor the state of the Tape/Normal and the Meter/Fathom switches of the echo sounder.
The cards continuously check the state of the Tape/Normal and the Meter/Fathom switches located on the front panel of the echo sounder Control Unit. For proper operation of the system, the Tape/Normal switch should be set in the 'Normal' position and the Meter/Fathom switch should be set in the 'Meter' position. If a switch is incorrectly set, the cards notify the MPU by setting a bit in a status register located on the cards. The status register is configured as an input port of the MPU.

The three Sample Controlled cards contain a microcomputer which functions as a slave of the MPU. The microcomputer is composed of a Z80A CPU, a 4K-byte EPROM, a 2K-byte RAM, peripheral interface (PIO) chips, counter-timer (CTC) chips, and an analog-to-digital converter (ADC). The CPU executes the program (called SCC-400) stored in the EPROM chip. The PIO chips provide the CPU with the input/output (I/O) ports it needs to control the sampling of the analog signal from the echo sounder and to communicate with the MPU. The CTC chips generate the 15 KHz sample rate and provide the other timing functions needed by the CPU.

The cards transfer information among themselves via a fifty conductor ribbon cable which is connected to a header connector mounted on the top edge of each card. The cards receive control and status signals from the echo sounder through two parallel ports (one PIO chip). The signals are carried by a ribbon cable attached to a 25-pin DP connector mounted on the rear panel of the computer chassis and to a header connector mounted on the top edge of one of the cards (i.e card SCC-402). The signal from the output of the Detector Unit is carried directly to the card containing the ADC (i.e. card SCC-403) by a cable containing a twisted pair of shielded conductors.

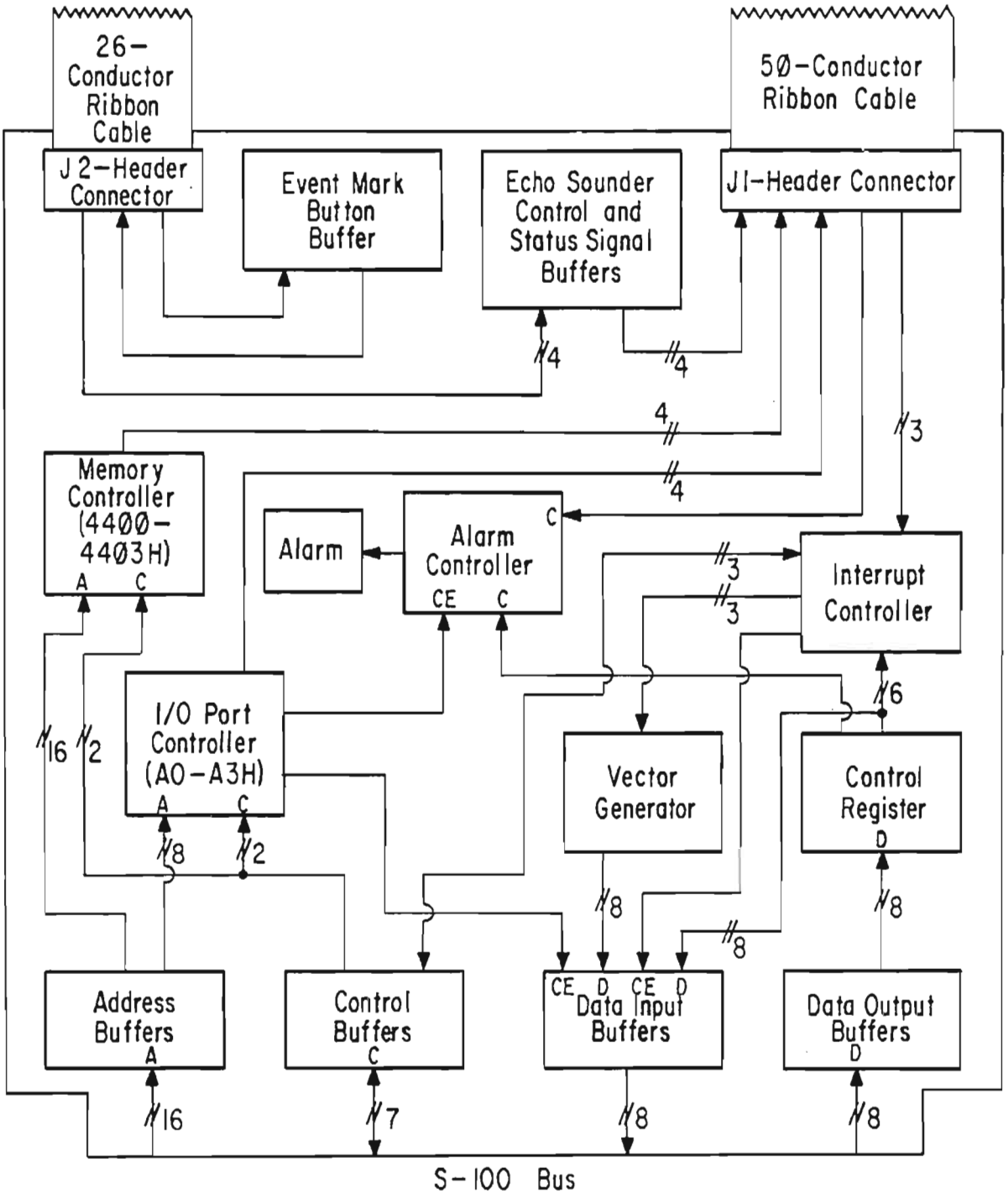
Block diagrams of the cards are shown in Fig. 8, 9, and 10. The cards were developed by the Hydroacoustic Section of SB.

Copies of the schematic diagrams for the six custom built cards are available from the Hydroacoustic of SB.



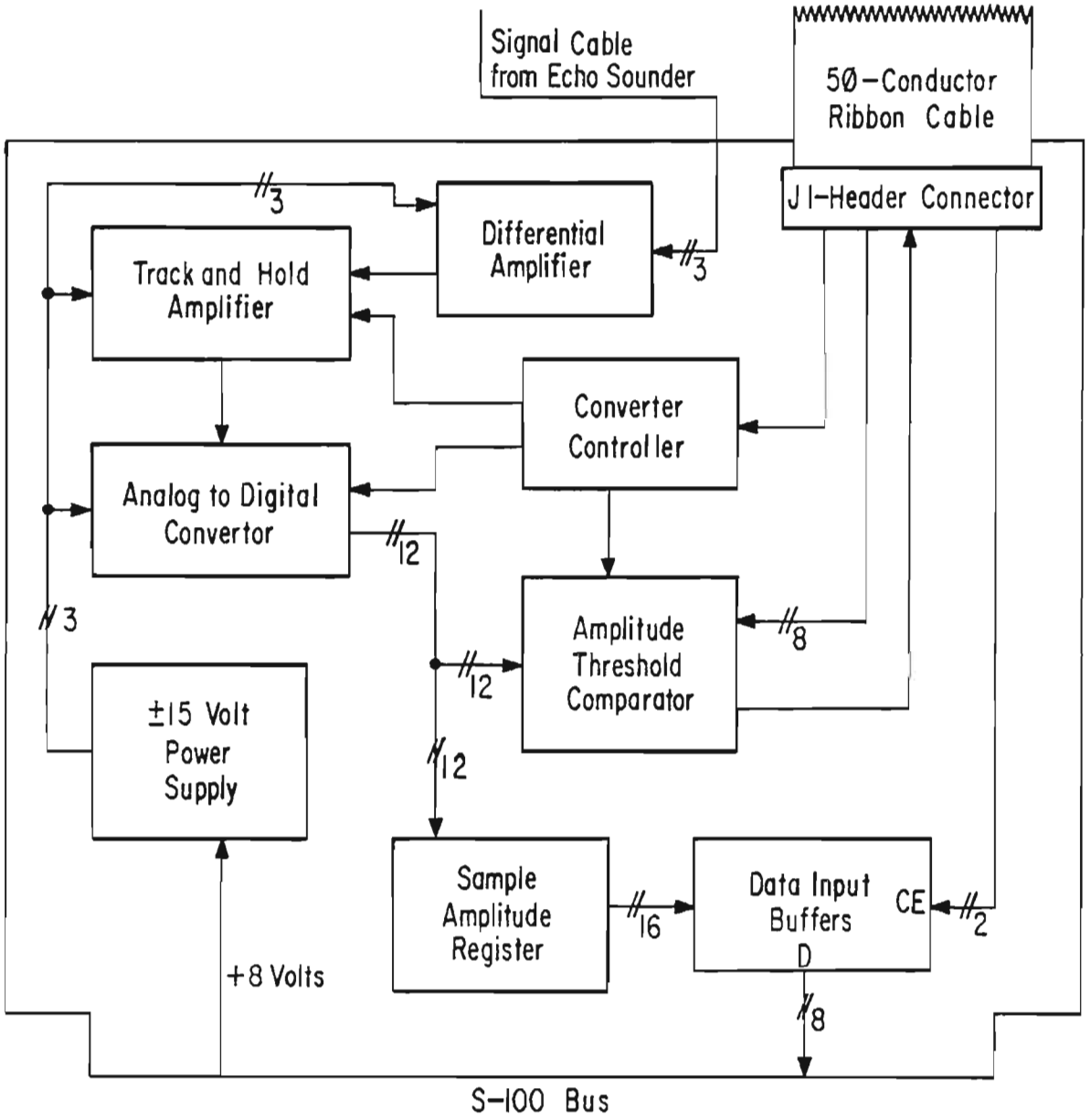
SYMBOL DEFINITIONS: A = Address Lines. C = Control Lines. CE = Chip Enable Lines. D = Data Lines. S = Status Lines. // = Multiple Lines. Ø = Clock.

Figure 8. Block Diagram of the Sample Controller Card: SCC 401.



SYMBOL DEFINITIONS: A = Address Lines. C = Control Lines. CE = Chip Enable Lines. D = Data Lines. // = Multiple Lines.

Figure 9. Block Diagram of the Sample Controller Card: SCC 402.



SYMBOL DEFINITIONS: CE Chip Enable Lines. D = Data Lines. // = Multiple Lines.

Figure 10. Block Diagram of the Sample Controller Card: SCC 403.

The remaining instrumentation in the Digital Subsystem is described below:

Video Terminal - Tektronix Model 4025: The video terminal provides the communication link between the operator and the computer. The operator enters commands and data via the terminal keyboard. The computer displays messages on the terminal screen.

Information is carried between the computer and the video terminal via an RS-232 cable.

9-Track Tape Transport and Formatter - Pertec Model FT8640A-98DF-45: The 9-track tape transport and formatter functions as the data storage unit for the system. All the information acquired by the computer is transferred to the transport for storage on digital magnetic tapes.

The information is carried from the computer to the transport by two cables. Each cable contains fifty twisted pairs of conductors.

The transport is configured to record in NRZI format at 800 characters per inch using a tape speed of 45 inches per second.

2.3.3 Digital Subsystem - Software

The software for the HYDAS computer is composed of three programs called HYDAS-400, CNAV and SCC-400. The executable code for these programs is stored in EPROM chips which are mounted on the circuit cards installed in the computer.

The HYDAS-400 program is executed by the MPU. It is the main program and controls the other two programs. The HYDAS-400 program is stored in four EPROM chips located on the EPROM and Serial Interface card.

The CNAV program is executed by the CPU on the Clock and Navigation Interface card. The program allows the card to perform the functions described in Section 2.3.1. The program is stored in one EPROM chip located on the Clock and Navigation Interface card.

The SCC-400 program is executed by the CPU located on the SCC-401 card of the Sample Controller Interface. The program allows the interface to perform the functions described in Section 2.3.1. The program is stored in one EPROM chip located on the SCC-401 card.

The three programs were developed the the Hydroacoustic Section of SB. The programs were written in Z80 assembler language using a Tektronix Microprocessor Development System, Model 8550. The development system also was used to transfer the executable code for the programs into the EPROM chips.

Copies of the assembler language listings for the three programs are available from the Hydroacoustic Section of SB.

3. HYDAS OPERATION

3.1 GENERAL INFORMATION

Surveys and studies which utilize hydroacoustic data acquisition systems, such as HYDAS, should be carefully planned. The behavior pattern of the fish species to be observed should be examined to determine when (i.e. the time of day, month, year, or period in life cycle) the fish are the most visible to the hydroacoustic system. In addition, ocean floor topography, commercial fishing activity, weather and ice conditions should be examined because they may restrict access to the proposed survey area.

The performance of the hydroacoustic system must be carefully monitored at all times during the execution of a survey or study. The echo sounder display devices (i.e. the color display, paper recorders, and oscilloscope) should be continuously observed. A logbook, containing numbered entries, should be completed at fixed intervals. The logbook entries should describe the operating environment (i.e. the echo sounder range and the recorder gain, the towed body depth, echogram observations, the vessel's course, speed and position, the data collection sequence (RUN) number and transect number, etc.). Each completed roll of echo sounder paper and reel of magnetic tape should be carefully labelled with its sequential number, the trip number and the dates it was used. The same information should be recorded in the logbook. The data recorded on the magnetic tapes should be examined with an analysis program (executed on a general purpose computer) as soon as possible to ensure the acquisition system is performing properly.

Before each transect is traversed, the bathymetric chart for the area should be carefully examined for sharp peaks and rises in the ocean floor which could cause the destruction or loss of the towed body and transducer. Operators must continuously watch out for other conditions which could be hazardous to the towed body and transducer, such as ice and fishing gear.

It is very important that the vessel's bridge officers be made aware of the performance of the towed body during vessel turns. In addition, the officers should be informed of the towed body towing depth and the amount of towing cable deployed. They should avoid hazardous conditions and should report possible hazards to the HYDAS operators.

3.2 TOWED BODY DEPLOYMENT AND RETRIEVAL

The deployment and retrieval system used with HYDAS is composed of an articulating crane fitted with two snatch block pulleys and a winch for storage of the towing cable. During the deployment cycle, the towed body must be raised from its deck storage location, swung out over the side of the vessel and then lowered into the water. To retrieve the towed body, the cycle is reversed.

In addition to the operator, one or two people are needed to steady the towed body when it is raised from or lowered into its storage location. During the period of time the towed body is out of its storage location and out of the water, it is free to swing with the motion of the vessel and the crane arm. Therefore, the operator of the deployment and retrieval system must be thoroughly

familiar with the crane and winch controls. In addition, the operator must proceed slowly and carefully while watching out for the safety of the assisting personnel.

The vessel speed should be maintained at three to four knots while the towed body is being deployed or retrieved. When the weather conditions are poor, it is difficult to deploy the towed body. The best procedure is to lift the towed body from its storage locations, swing it out over the side of the vessel and lower the crane arm until the towed body is close to the surface of the water, but not in danger of being hit by the crest of a wave. Next, have the vessel execute a slow, 360° turn. Wait for a time when the vessel is relatively steady and the wave amplitudes are small. Then submerge the body.

After the towed body has been put in the water, the vessel speed can be increased until the survey speed is reached and the vessel can be put on the survey course. When the vessel velocity is correct, the towed body depth can be adjusted by deploying or retrieving towing cable until the desired survey depth is obtained.

3.3 ECHO SOUNDER OPERATION

The Simrad EK400 echo sounder should be operated in accordance with the information provided in the Simrad EK400 Instruction Manual. In addition, never operate the echo sounder transmitter with the towed body transducer selected, unless the towed body is in the water (see Section 2.2.2, the TTSU, for a description of how the towed body transducer is selected). The transducer elements could be damaged if the transducer is operated while it is out of the water.

The switch on the front panel of each Logic Driver card in the Transceiver Unit should be set to the 'Inhibit' position before power is applied to the echo sounder. The transmitter will not produce transmit pulses while the switches are in the 'Inhibit' position. After power is applied, the echo sounder parameters (i.e. the recorder gain, pulse length, bandwidth, etc.) should be set to meet the operating requirements. Once the parameters have been selected and entered, and the towed body has been deployed, the towed body transducer can be selected and the Logic Driver card switches set to the 'Oper.' position.

The echo sounder parameters should be recorded in the logbook. Also, changes made to these parameters during the course of the trip should be recorded in the logbook at the time the changes are made. The digital display of the echo sounder Control Unit should be observed periodically to be sure that none of the parameters have been accidentally changed.

The shape and amplitude of the ocean floor echo (bottom echo) produced by the echo sounder should be continuously monitored. The bottom echo should appear on the echo gram recording as an abrupt light to dark transition. On the Color Display screen, the bottom echo should appear as an abrupt blue to red color change. On the oscilloscope screen, the bottom echo should produce a sharp vertical deflection of the beam and the amplitude of the bottom echo generally should be greater than eight volts. If the bottom echo does not appear as described above, then it is quite likely that the towed body is not performing

properly. This may be caused by an obstruction such as sea grass, kelp or garbage on the towing cable, an incorrectly balanced tow termination or towed body, or by torque forces in the towing cable. Also, poor bottom echoes can be produced when the system is operated in very deep water or when the ocean floor is rough.

Remember to turn off the echo sounder or set the Logic Driver card switches to 'Inhibit' before removing the towed body from the water.

4. COMPUTER OPERATION

4.1 COMPUTER OPERATING CONVENTIONS

The following conventions are used to explain the operation of the HYDAS computer:

(1) **Boldface characters** - all characters which appear in boldface are messages or prompts sent by the computer to be displayed on the video terminal screen.

(2) Underlined characters - all underlined characters are commands, parameter names, numbers, or text that must be entered by the operator via the terminal keyboard.

(3) <RETURN> - the names of terminal keyboard keys such as RUB OUT, BK SPACE, TTY LOCK, SHIFT, LINE FEED and RETURN are enclosed with less than and greater than (< >) symbols.

4.2 VIDEO TERMINAL KEYBOARD CONFIGURATION

All of the command and parameter names used by the HYDAS-400 program MUST BE ENTERED IN CAPITAL (upper case) LETTERS. Therefore, it is best to operate the terminal keyboard in the TTY (teletype) mode. If the red light in the <TTY LOCK> key of the 4025 terminal is illuminated, then the terminal keyboard is in the TTY mode. If the light is not illuminated, press the <TTY LOCK> key.

4.3 CORRECTING TYPING MISTAKES

The <BK SPACE> or the <RUB OUT> key of the terminal keyboard can be used to correct typing errors that occur on the current line (i.e. the line the cursor is presently on). Each time the <BK SPACE> or <RUB OUT> key is pressed, the cursor will be moved one character space to the left. The operator must use one of these keys to position the cursor under the incorrectly typed character. Then the operator must enter the correct character and all the other characters to the right of the mistake until the end of the line is reached.

When the <RETURN> key is pressed, the characters on the present line are processed by the computer program. The cursor moves to a new line and the characters on the previous line cannot be changed by the use of the <BK SPACE> or the <RUB OUT> keys.

It is possible to recover from many typing mistakes even though the <RETURN> key has been pressed because, in many instances, the program will only accept certain characters, character strings, or range of values. If the characters on the input line do not satisfy these conditions, the computer will recognize that a typing mistake has been made and it will repeat its request for information. For example, when the computer displays the **(Y/N) ?** prompt, it will only accept Y or N. If any other character is entered, the prompt will be repeated.

4.4. THE ECHO ACQUISITION TASK

The HYDAS microcomputer can be directed to perform the task of acquiring hydroacoustic data from the echo sounder (called Echo Acquisition) or the task of acquiring the data needed to determine the amplification characteristics of the TVG amplifiers of the echo sounder receiver (called TVG Acquisition). When the computer is powered up or reset, the Echo Acquisition task is automatically selected. The operation of the TVG Acquisition task is described in Section 4.5.

4.4.1 Echo Acquisition Commands

When the Echo Acquisition task is selected, there are eleven commands that can be used to control program operation. The commands are divided into two groups called the Idle mode commands and the Acquisition mode commands. The commands for both modes can only be entered in response to a prompt by the program. The Idle mode prompt is the colon symbol (:) and the Acquisition mode prompt is the greater than symbol (>). When the program is in the Idle mode, it is waiting for the operator to enter the information needed to configure the program to conduct data acquisition. When the program is in the Acquisition mode, it is acquiring hydroacoustic data from the echo sounder. There are ten commands that can be entered in response to the : prompt and four commands that can be entered in response to the > prompt. Three of the commands (COMM, LIST and LNAV) can be executed in both modes. Table 3 lists the command names and gives a brief description of each command.

The following is an alphabetical listing of the eleven commands with an explanation of each command.

COMM - allow operator to enter a Comment Record: The comment command can be used when the program is in the Idle mode or the Acquisition mode. The command allows the operator to enter lines of text via the terminal keyboard and have the text copied to the 9-track magnetic tape as a Comment Record (see Section 4.4.6 for a description of the Comment Record). The operator can use the COMM command when it is necessary or desirable to enter descriptions of events or changes in operating conditions which occur during a survey or study. The command provides a means of logging information that may be useful during data analysis.

Each line of text for a comment can be up to 76 characters in length and a comment can contain a maximum of ten lines. The text for a comment can be entered in upper or lower case characters. When the program is in the Idle mode, only one comment can be entered. If a second comment is entered, it will overwrite the first. This occurs because the Comment Record is not transferred to magnetic tape until the program is switched to the Acquisition mode. When the program is in the Acquisition mode, the COMM command can be used as often as required because each Comment Record is transferred to tape as it is entered.

To enter a comment, the operator types COMM <RETURN> in response to the : prompt or $COMM <RETURN> in response to the > prompt. The computer will display the comment prompt symbol (C*) and wait for the operator to enter text. Typing mistakes can be corrected in the manner described in Section 4.3. Each line of text is terminated by pressing the <RETURN> key. The operator notifies the program that the last line of text has been entered by entering a $ character and

Table 3. The Echo Acquisition Task Commands

Command name	Description
COMM	- allows the operator to enter text for a comment which is written as a Comment record on the magnetic tape
LIST	- displays the contents of the Parameter Table on the terminal screen
LNAV	- displays the contents of the Navigation record on the terminal screen
MARK	- writes a File Mark record on the magnetic tape and rewinds the tape to the load point
MENU	- displays a menu of procedures that can be used to initialize the Echo Acquisition task
REW	- rewinds the magnetic tape; caution - no File Mark record is written to tape
RMOUNT	- allows the operator to mount a previously used magnetic tape on the transport and search the tape for the first occurrence of a File Mark record
START	- allows the operator to start a data collection sequence (i.e. a RUN)
STEP	- allows the operator to sequentially view and update each parameter value in the Parameter Table
STOP	- allows the operator to end a data collection sequence (i.e. a RUN)
TVG	- allows the operator to select the TVG Acquisition task

Note that when the program is in the Acquisition mode (i.e. the > prompt is displayed) the commands COMM, LIST, LNAV and STOP must be preceded by the $ character.

pressing the <RETURN> key at the start of a new line (i.e. in response to the C* prompt).

LIST - display the Parameter Table: The LIST command can be used when the program is in the Idle mode or the Acquisition mode. The command allows the operator to display the contents of the Parameter Table on the terminal screen (see Section 4.4.2 for a description of the Parameter Table). When the command is entered, the program lists each parameter name with its current value on the screen. Then it displays the prompt character and waits for further instructions.

To enter the command, the operator types LIST <RETURN> in response to the : prompt or $LIST <RETURN> in response to the > prompt. The command can be entered at any time and as often as necessary.

LNAV - display the navigation data: The list navigation data command can be used when the program is in the Idle mode or the Acquisition mode. The command allows the operator to display the contents of the Navigation Record (see Section 4.4.6 for a description of the Navigation Record). Then it displays the prompt character and waits for further instructions.

To enter the command, the operator types LNAV <RETURN> in response to the : prompt or $LNAV <RETURN> in response to the > prompt. The command can be entered at any time and as often as necessary.

Note that the navigation computer (Magnovox 1107) must be configured to send navigation data to the HYDAS computer. The navigation computer sends the data via its printer port. The printer port must be initialized after the navigation computer is powered up or reset. To initialize the port, enter code 71 via the keyboard of the navigation computer and set the print interval to 0.5 minutes.

MARK - write a File Mark record and rewind the tape: The MARK command can be used only when the program is in the Idle mode. The command allows the operator to write a File Mark record on the magnetic tape. Once the File Mark record has been written, the program issues the rewind command (REW) which causes the transport to rewind the tape to the Load Point. Then the operator can dismount the tape for storage, analysis, testing, etc. The MARK command should be used to rewind tapes under normal operating conditions.

To enter the command, the operator types MARK <RETURN> in response to the : prompt. The program will display the message:

****** Confirm the MARK command (Y/N) ?**

and wait for the operator to reply. If the operator enters N <RETURN>, the command will not be executed and the program will display the : prompt or the Echo Acquisition task menu. If the operator enters Y <RETURN>, the program will execute the command and then it will display the : prompt or the Echo Acquisition task menu.

MENU - display menu and wait for operator selection: The MENU command can be used only when the program is in the Idle mode. The command allows the

operator to display a menu of procedures that can be used to initialize the Echo Acquisition task or to select the TVG Acquisition task (see Section 4.4.3 for a description of menu operation).

To enter the command, the operator types MENU <RETURN> in response to the : prompt. The program will display the complete menu and then the menu prompt symbol (*). Then it will wait for the operator to make a selection.

REW - rewind a tape: The rewind the magnetic tape command can be used only when the program is in the Idle mode. The command allows the operator to rewind a magnetic tape to the Load Point without writing a File Mark record on the tape. The command should be used only under unusual conditions or during system maintenance.

To enter the command, the operator types REW <RETURN> in response to the : prompt.

RMOUNT - remount a tape: The remount command can be used only when the program is in the Idle mode. The command allows the operator to remount a magnetic tape on the transport that had been used previously. When the command is entered, the program searches the tape for the first occurrence of a File Mark record. When a File Mark record is found, the program stops the tape so that new data can be written from that point forward. Note that the File Mark record will be overwritten by the new data.

To enter the command, the operator types RMOUNT <RETURN> in response to the : prompt. The program will display the message:

Do you want to remount a tape on the tape transport (Y/N) ?

and wait for the operator to respond. If the operator enters N <RETURN>, the program will not execute the RMOUNT command. It will display the : prompt and wait for the operator to respond. If the operator enters Y <RETURN>, the program will display the message:

Mount the tape and press the <RETURN> key when you are done.

and wait for the operator to respond. When the operator presses the <RETURN> key, the program will display the tape number parameter (TAPE) with its current value and wait for the operator to respond (see Section 4.4.2 for a description of the TAPE parameter). If the current value is correct, the operator should press the <RETURN> key and the program will display the message:

The value of the TAPE parameter has not been changed but the Tape Record Counter has been reset.

The program will check the status of the tape transport and report any errors that are detected on the terminal screen (see Section 4.6.1 for a description of tape transport errors and Section 4.4.2, the Tape parameter, for a description of the Tape Record Counter). If no errors are reported, the program will display the message:

Data can be written to this tape; it is not write protected.
The tape transport is ready.
The program is searching for a File Mark record - please wait.

and it will start a forward search of the tape looking for the first occurrence of a File Mark record.

If the current value of the TAPE parameter is incorrect, the operator should enter the correct value and then press the <RETURN> key. The program will check the status of the tape transport and report any errors that are detected to the terminal screen. If no errors are reported, the program will display the message:

Data can be written to this tape; it is not write protected.
The tape transport is ready.
The Tape Record Counter has been reset.
The program is searching for a File Mark record - please wait.

and it will start a forward search of the tape looking for the first occurrence of a File Mark record.

The program will continue the search for a File Mark record until one is found or the end-of-tape tab is encountered (if a tab is installed). If no File Mark record or end-of-tape tab is found the transport will wind all the tape off of the supply reel. To correct this problem, the operator must:

(1) depress and release the RESET button on the tape transport,

(2) rethread the tape through the guides, tension arms, and tape head,

(3) wind several turns of tape onto the supply reel,

(4) turn the supply reel until the slack tape has been taken up,

(5) depress and release the LOAD button,

(6) depress and release the REWIND button,

(7) depress and release the RESET button on the front panel of the computer,

(8) mount a new tape and initialize the Parameter Table.

If an end of tape tab is found, the program will display the message:

****** End of tape - no File Mark record was found. ******
Do you want to rewind the tape (Y/N)?

and wait for the operator to reply.

If the program finds a File Mark record, it will position the tape so that the File Mark record is overwritten by the first new record transferred to tape.

When the tape has been properly positioned, the program will display the message:

The tape has been properly positioned.
Do you want to change the value of the RUN parameter (Y/N) ?

and wait for the operator to respond (see Section 4.4.2 for a description of the RUN parameter).

START - begin a data collection sequence: The START command can be used only when the program is in the Idle mode. The command allows the operator to switch program operation from the Idle mode to the Acquisition mode and to begin a data collection sequence (i.e. a RUN). The RUN parameter is used to number the data collection sequences (see Section 4.4.2 for a description of the RUN parameter). Before the START command is entered, the operator should make certain the Parameter Table contains the correct values, the system is functioning correctly (i.e. the towed body, echo sounder, tape transport, etc. have been properly initialized), and the vessel is on the correct course and is moving at the proper speed.

To enter the command, the operator types START <RETURN> in response to the : prompt. The program will check the status of the echo sounder and report any errors that are detected on the terminal screen (see Section 4.6 for a description of computer detectable errors). If no errors are reported, the program will display the water depth value currently being used by the bottom tracking function of the computer and then wait for the operator to check if the value is correct. For example, if the current value was 165 meters the program would display the message:

DEPTH = 165 (Y/N) ?

and wait for the operator to respond.

The operator must compare this depth with the present water depth reported by the echo sounder. If the two values do not agree, the operator should enter N <RETURN>. The program will acquire a new depth value from the bottom tracking function, display the depth, and wait for the operator to reply. The program will repeat this sequence up to ten times before it will display an error message, return to the Idle mode, and display the : prompt.

When there is agreement between the two depth values, the operator should enter Y <RETURN>. The program will display the current time and wait until the beginning of the next full minute to start the data collection sequence. For example, if the present time was 10 46 14.105, the program would display the message:

The present time is 10 46 14.105
The RUN will not start until the beginning of the next full minute.

When the time advances to 10 47, the program will display the message:

```
**********************************
START OF RUN # 1
TIME = 10 47 0
DEPTH = 164
**********************************
```

followed by the navigation data and the > prompt. The program will start to digitize the signal from the output of the Detector Unit of the echo sounder and transfer records to the magnetic tape.

The program is now in the Acquisition mode; therefore, the operator must enter the $ character before a command or parameter name.

STEP - examine all values in the Parameter Table: The STEP command can be used only when the program is in the Idle mode. The command allows the operator to sequentially view and update each parameter value in the Parameter Table (see Section 4.4.2 for a description of the Parameter Table).

To enter the command, the operator types STEP <RETURN> in response to the : prompt. The program will display the first parameter name with its current value and wait for the operator to respond. If the current value for the parameter is correct, the operator should press the <RETURN> key and the program will display the second parameter name with its current value and wait for the operator to respond.

If the current value for the first parameter is incorrect, the operator should enter the correct value and then press the <RETURN> key. The program will display the second parameter name with its current value and wait for the operator to respond. This operating sequence is repeated until the last parameter in the table (i.e. TIME) has been examined by the operator. Then the program will list the updated Parameter Table on the screen, displays the message:

Are the values in the Parameter Table correct (Y/N) ?

and wait for the operator to reply.

The operator must review the updated Parameter Table and decide if the values are correct. If the values are correct, the operator should enter Y <RETURN> and the program will display the : prompt. If one or more of the values are incorrect, the operator should enter N <RETURN> and the program will display the message:

Enter the name of the parameter to be changed.

followed by the : prompt. The operator should enter the name of the parameter that has an incorrect value and then press <RETURN>. The program will display the parameter name with its current value and wait for the operator to respond. The operator should enter the correct value and press the <RETURN> key and the program will display the : prompt.

STOP - end a data collection sequence: The STOP command can be used only when the program is in the Acquisition mode. The command allows the operator to end a

data collection sequence (i.e. a RUN) and switch program operation from the Acquisition mode to the Idle mode.

To enter the command, the operator types $STOP <RETURN> in response to the > prompt. The program will list a final Interval Summary Data Table on the terminal screen (see Section 4.4.4 for a description of the Interval Summary Data Table). Then it will display the message:

Do you want to enter a comment to be recorded on the tape (Y/N) ?

and wait for the operator to reply. The operator can use this opportunity to enter text which will be written as a Comment Record on the magnetic tape (see the description of the COMM command in this section). To enter a comment, the operator must enter Y <RETURN>. Then the program will display the comment prompt symbol (C*). When the operator has finished entering the comment, or if the operator enters N <RETURN> in response to the previous question, the program will display the message:

Do you want to write a File Mark record and rewind the tape (Y/N) ?

and wait for the operator to reply. The operator can enter Y <RETURN> and the program will execute the MARK command (see the description of the MARK command in this section). When the program has executed the MARK command, or if the operator entered N <RETURN> in response to the previous question, the program will display the Echo Acquisition task menu and wait for the operator to make a selection (see the description of the MENU command in this section).

TVG - allows the operator to select the TVG Acquisition task: The command can be used only when the program is in the Idle mode. The command allows the operator to select the TVG Acquisition task (see Section 4.5 for a description of the operation of the TVG Acquisition task).

To enter the command, the operator types TVG <RETURN> in response to the : prompt.

4.4.2 The Parameter Table

The Parameter Table is maintained by the HYDAS-400 program when the Echo Acquisition task is selected. The table provides the operator with an organized format for the logging of pertinent parameter values during the course of a hydroacoustic survey or study. Copies of the Parameter Table are written on the magnetic tape as records, called Parameter records (see Section 4.4.6 for a description of the Parameter record). The table is copied to tape each time a data collection sequence (i.e. a RUN) is started and each time the depth offset (DOFF) parameter value or the amplitude threshold (THRS) parameter value is updated during the course of a RUN (i.e. while the program is in the Acquisition mode). When the tapes are analyzed, the information in the Parameter records can be used to configure the analysis program parameters.

The Parameter Table contains fifteen entries. Each entry is composed of a parameter name and its value. When the program is in the Idle mode, the operator can sequentially view and update each parameter value by entering the STEP

command in response to the : prompt (see Section 4.4.1 for a description of the STEP command). The operator can view and update a specific parameter value by entering the parameter name and then <RETURN>, in response to the : prompt. Two of the parameter values (DOFF and THRS) can be reviewed and updated while the program is in the Acquisition mode. In response to the > prompt, the operator must enter a $ followed by one of the two parameter names, and then <RETURN>.

When a parameter name is entered, the program will respond in the same manner regardless of whether it is in the Idle mode or the Acquisition mode. The program will display the parameter name with its current value and wait for the operator to respond. If the value needs to be changed, the operator should enter the new value and press <RETURN>. If the value is correct, the operator should press <RETURN>. In both cases the program will display the prompt for the current mode of operation and wait for the operator to respond. The previous description does not apply to the TAPE parameter (see the description of the TAPE parameter in this section).

Table 4 lists the parameter names and gives a brief description of each parameter. Table 5 lists the parameter names with their default values.

The following is a list of the fifteen parameters with a description of each. The parameters are arranged in the same order as they appear in the Parameter Table.

Ship - vessel name: The value entered for the SHIP parameter is the name of the vessel used to conduct the survey or study. A maximum of 24 characters can be entered.

Trip - vessel trip number: The value entered for the TRIP parameter is the vessel trip number. A maximum of 6 characters can be entered.

INTV - period of time between listings of the Interval Summary Data Table: The value entered for the INTV parameter is the period of time the program will allow between listings of the Interval Summary Data Table (see Section 4.4.4 for a description of the Interval Summary Data Table). The time period is measured in whole minutes and can be any integer from 1 to 15. If a larger or smaller value is entered, the program will repeat the parameter name with its previous value and wait for the operator to respond.

RSDB - hydroacoustic system receive sensitivity: The value entered for the RSDB parameter is the measured receive sensitivity of the hydroacoustic system. The receive sensitivity is measured in decibels referenced to one volt per one microbar (dB ref 1 volt/1 μbar). A maximum of 6 characters can be entered, including a minus sign and a decimal point. For an example, see Table 5.

SLDB - hydroacoustic system source level: The value entered for the SLDB parameter is the measured source level of the hydroacoustic system. The source level is measured in decibels referenced to one microbar per one volt at one meter (dB ref 1 μbar/1 volt @ 1 meter). A maximum of 6 characters can be entered, including a plus sign and a decimal point. For an example, see Table 5.

Table 4. The Parameter Names.

Parameter name	Brief description
SHIP	- vessel name
TRIP	- vessel trip number
INTV	- period of time between listings of the Interval Summary Data Table
RSDB	- hydroacoustic system receive sensitivity
SLDB	- hydroacoustic system source level
EMDB	- additional gain or attentuation added to or subtracted from the normal echo sounder receiver gain
PLDB	- ten times the common log of the transmit pulse length
DOFF	- depth offset
DTFS	- depth to first sample
THRS	- amplitude threshold
TAPE	- number of the magnetic tape
RUN	- number of the data collection sequence
TRAN	- transducer name, model, serial number
DATE	- day, month, year
TIME	- hour, minute, second, millisecond

Note that when the program is in the Acquisition mode (i.e. the > prompt is displayed) the parameters DOFF and THRS must be preceded by the $ character.

Table 5. The Parameter Names and Their Default Values.

Parameter name	Default value	Units
SHIP	-	GADUS ATLANTICA
TRIP	-	124
INTV	minutes	10
RSDB	dB	-86.0
SLDB	dB	123.5
EMDB	dB	0
PLDB	dB	-35.2
DOFF	meters	5
DTFS	meters	5
THRS	millivolts	50
TAPE	-	0
RUN	-	1
TRAN	-	Ametek/Straza SP-187-LT-11
DATE	-	0 0 1900
TIME	-	0 0 0.000

Note that when the program is in the Acquisition mode (i.e. the > prompt is displayed) the parameters DOFF and THRS must be preceded by the $ character.

EMDB - additional gain or attenuation added to or subtracted from the normal echo sounder receiver gain: The value entered for the EMDB parameter is the gain provided by an additional amplifier (i.e. the optional amplifier shown in Fig. 2) or the attenuation provided by the internal attenuator settings of the EK400 (see menu item 22 in Section 3.3 of the EK400 Instruction Manual). The gain or attenuation is measured in decibels referenced to one volt RMS (dB ref 1 volt RMS). A maximum of 6 characters can be entered, including a minus or a plus sign and a decimal point.

PLDB - ten times the common log of the transmit pulse length: The value entered for the PLDB parameter is the decibel equivalent of the transmit pulse length of the echo sounder (i.e. 10 log of the pulse length measured in seconds). The operator can select one of three pulse lengths via the EK400 control unit (see menu item 23 in Section 3.2 of the EK400 Instruction Manual). A maximum of 6 characters can be entered, including a minus sign and a decimal point.

DOFF - depth offset: The value entered for the DOFF parameter is used by the bottom tracking function of the computer to determine a maximum sampling depth (MSD) for each echo sounder transmit/receive cycle (ping). Under normal operation, the echo sounder generates a bottom pulse signal for each echo sounder ping by detecting the echo from the ocean floor. When the computer receives the bottom pulse signal, it stops digitizing the signal from the output of the Detector Unit of the echo sounder. Sometimes, when the ocean floor is very rough, or HYDAS is operated in an area where the water is too deep, or the Analog Subsystem is not functioning properly, the echo sounder will fail to generate a bottom pulse signal. When this occurs, the computer will use the MSD to determine the depth at which to stop digitizing the signal from the output of the Detector Unit.

The bottom tracking function uses either the maximum water depth value for the present ping or the MSD for the present ping to compute a new MSD for the next ping. If a bottom pulse signal was received for the present ping, the function will add the maximum water depth value for the present ping and the DOFF value to obtain a new MSD for the next ping. If a bottom pulse signal was not received, the function will add the MSD for the present ping and the DOFF value to obtain a new MSD for the next ping.

Under conditions where the echo sounder is unable to detect the ocean floor and generate a bottom pulse signal for many contiguous pings, the bottom tracking function of the computer will stop adding the DOFF value to the MSD. The function assumes that the true water depth is less than the MSD and uses the same MSD for three additional pings. If the echo sounder does not recognize the ocean floor and generated a bottom pulse signal during one of these three pings, the program will stop sampling, end the data collection sequence, and notify the operator of the error (see Section 4.6.3 for a description of the Lost Lock Error).

The units for the DOFF value are meters and the value can be any integer from 1 to 20. If a larger or smaller value is entered, the program will repeat the parameter name with its previous value and wait for the operator to respond.

DTFS - depth to first sample: The value entered for the DTFS parameter is the depth below the transducer at which the computer starts to digitized the signal from the output of the echo sounder Detector Unit. The computer does not start the sampling period for each echo sounder ping until the time equivalent of the DTFS value has elapsed (where time is equal to the DTFS value divided by 750 meters per second).

The units for the DTFS value are meters and the value can be any integer from 5 to 200. If a larger or smaller value is entered, the program will repeat the parameter name with its previous value and wait for the operator to respond.

THRS - amplitude threshold: The value entered for the THRS parameter determines the amplitude the signal from the output of the Detector Unit of the echo sounder must obtain before it is saved and recorded on the magnetic tape. The magnitude of each sample amplitude word produced by the analog to digital converter is compared to the value of the THRS parameter. If the magnitude of a sample amplitude word is equal to or greater than the THRS value, the word is saved and written to the tape as part of a Sample Data record (see Section 4.4.6 for a description of the Sample Data record).

Each sample amplitude word that is saved is counted and the total count obtained for each group of ten echo sounder pings is displayed as an entry in the Interval Summary Data Table (see Section 4.4.4 for a description of the Interval Summary Data Table).

The units for the value of the THRS parameter are millivolts referenced to one volt RMS. The value entered can be any one of the following integers: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 75, 80, 90, 100, 125, 150, 175, 200, 250. If an alternate value is entered, the program will repeat the parameter name with its previous value and wait for the operator to respond.

TAPE - the number of the magnetic tape: The value entered for the TAPE parameter is the sequential number of the magnetic tape mounted on the transport. A maximum of 6 characters can be entered.

When the name of the tape parameter is entered, the program will display the message:

Has a new tape been mounted on the tape transport (Y/N) ?

If a new tape has not been mounted, the operator should enter N <RETURN>. The program will display the message:

Since a new tape has not been mounted on the tape transport the value of the TAPE parameter should not be changed.

and then display the : prompt. If a new tape has been mounted, the operator should enter Y <RETURN>. The program will display the parameter name with its value and wait for the operator to respond.

The program sequentially numbers the records it writes on the magnetic tape. If the operator enters a value when the tape parameter name and value are

displayed, the program will reset the counter used to number the records (i.e the Tape Record Counter). Therefore, a value should be entered only when a new tape has been mounted on the transport. If no value is entered, the program will display the message:

> **Since the value for the TAPE parameter has not been changed, the program assumes that a new tape has not been mounted on the tape transport. Therefore, the Tape Record Counter has not been reset.**

and then display the : prompt. If a value is entered, the program will check the status of the tape transport and formatter and report any errors that are detected. A description of errors is given in Section 4.6.1, Tape Transport Errors. If no errors are detected, the program will display the message:

> **Data can be written to this tape; it is not write protected.**
> **The tape transport is ready.**
> **The Tape Record Counter has been reset.**

and then display the : prompt.

RUN - the number of the data collection sequence: The value entered for the RUN parameter is the sequential number of the data collection sequence. A maximum of 6 characters can be entered.

TRAN - transducer name, model, serial number: The value entered for the TRAN parameter is the name, model, or serial number of the transducer mounted in the towed body. A maximum of 30 characters can be entered.

DATE - day, month, year: The value entered for the DATE parameter is the current date in day, month, year format. Enter a <SPACE> to separate the day from the month and the month from the year. Enter only the last two digits of the year value.

TIME - hour, minute, second, millisecond: The value entered for the TIME parameter is the current time in hour, minute, second, millisecond format. The hour value must be a number from 0 to 23. Enter a <SPACE> to separate the hour from the minute, the minute from the second, etc. The operator should enter a complete time specification (i.e. hour, minute, second and millisecond). Note that the second and millisecond values may be entered as zeros (i.e. hh mm 0 0).

Note that the DATE and TIME parameter are not included in the Parameter record because they are part of the Parameter record header (see Section 4.4.6 for a description of the Parameter record and the Parameter record header).

4.4.3 Menu Operation

To improve the operation of the HYDAS-400 program, frequently used operating procedures have been assigned numbers and these numbered procedures are displayed on the terminal screen as a menu. Then the operator can have a specific procedure executed by entering the procedure number.

The menu is displayed at the following times:

(1) When the computer is powered up,

(2) After the RESET button on the front panel of the computer has been depressed and released,

(3) When the MENU command is entered in response to the : prompt (see Section 4.4.1 for a description of the MENU command),

(4) After the program has executed the STOP command (see Section 4.4.1 for a description of the STOP command), and

(5) When the program has completed the TVG Acquisition task (see Section 4.5 for a description of the TVG Acquisition task).

When one of these five events occurs, the program will display the message:

****** Echo Acquisition Task Menu ******
1 - Change the value of the RUN parameter.
2 - Start a new tape.
3 - Examine all the values in the Parameter Table.
4 - Remount a tape.
5 - Display the Idle mode prompt (:).
6 - Select the TVG Acquisition task.

and then display the menu prompt symbol (*). The operator can select a procedure by entering the procedure number and then pressing the <RETURN> key.

The following is a description of the procedures included in the menu:

Item Number 1 (Change the value of the RUN parameter)

Item number 1 should be selected when it is necessary to update only the value of the RUN parameter before starting a new data collection sequence. When item number 1 is selected, the program displays the RUN parameter with its current value and waits for the operator to respond (see Section 4.4.2 for a description of the RUN parameter). After the operator has pressed <RETURN> the program displays the : prompt and waits for the operator to respond.

Item Number 2 (Start a new tape)

Item number 2 should be selected when a new tape is mounted on the tape transport. When item number 2 is selected, the program allows the operator to examine and update the value of the TAPE parameter and then the RUN parameter (see Section 4.4.2 for a description of the TAPE and RUN parameters).

Item Number 3 (Examine all the values in the Parameter Table)

Item number 3 should be selected when it is necessary to update most or all of the values in the Parameter Table. When item number 3 is selected, the program

executes the STEP command (see Section 4.4.1 for a description of the STEP command).

Item Number 4 (Remount a tape)

Item number 4 should be selected when a tape is remounted on the tape transport. When item number 4 is selected, the program executes the RMOUNT command (see Section 4.4.1 for a description of the RMOUNT command).

Item Number 5 (Display the Idle mode prompt)

Item number 5 should be selected when the operator wishes to enter commands or update parameters. When item number 5 is selected, the program displays the Idle mode prompt (:) and waits for the operator to respond.

Item Number 6 (Select the TVG Acquisition task)

Item number 6 should be selected when the operator wants to execute the TVG Acquisition task (see Section 4.5 for a description of the TVG Acquisition task).

4.4.4 Interval Summary Data Table

Once a data collection sequence has been started, the program periodically displays a message on the terminal screen called the Interval Summary Data Table. This table provides the operator with information about the performance of the system.

The main information provided by the table is a breakdown of the number of sample amplitude words that were saved and written to the magnetic tape since the previous table was displayed (see Section 4.4.2, the THRS parameter, for a description of a sample amplitude word). The entries in the main body of the table are the number of sample amplitude words that were saved for each group of ten contiguous echo sounder pings. Table 6 is an example of a typical Interval Summary Data Table. For this table, 31 sample amplitude words were saved during the first group of ten pings, 364 sample amplitude words were saved during the second group of ten pings, 152 sample amplitude words were saved during the nineteenth group of ten pings, 1536 samples were saved during the forty-fourth group of ten pings, etc.

When an Interval Summary Data Table is displayed, the operator should examine the magnitude of the table entries in relation to the size of the pelagic schools and/or groundfish concentrations displayed on the echo sounder Recorder Units and the Color Display. Large numbers should correspond to large schools or concentrations. Pelagic schools which are very narrow horizontally but extend over many tens of meters in depth will produce large numbers for only a few table entries. Under normal operation, table entries will be zeros only if the ocean floor is very hard and flat and/or the value of the THRS parameter is very large in relation to the water depth (see Section 4.4.5, Signal Noise and Amplitude Threshold).

Table 6. An Example of a Typical Interval Summary Data Table.

****
********** INTERVAL SUMMARY DATA TABLE **********
****

Each table entry is the sum of the samples collected for 10 echo sounder pings

Entry #	0	1	2	3	4	5	6	7	8	9
0 :	-	31	364	379	255	179	123	26	55	159
10 :	514	423	800	945	1150	981	671	390	230	152
20 :	150	57	14	19	67	124	130	111	73	451
30 :	455	564	233	49	52	57	167	435	767	940
40 :	1141	1282	1452	1645	1536	1003	795	656	559	312
50 :	39	11	10	51	99	302	397	327	218	164
60 :	387	333	253	247	285	223	549	162	56	35
70 :	35	68	186	778	731					

Trip # 109 RUN # 1 INTERVAL # 1

Summary Period (min.) = 10 DEPTH = 164

DATE = 6 1 1986 TIME = 13 28 0

The period of time between listings of the Interval Summary Data Table is controlled by the value of the INTV parameter (see Section 4.4.2 for a description of the INTV parameter). The value of the INTV parameter is displayed in the Interval Summary Data Table as the value for the Summary Period (see Table 6).

The depth value displayed in the Interval Summary Data table is the water depth measured for the last ping in the Summary Period. If the echo sounder fails to generate a bottom pulse signal for this ping, the depth value will be the MSD (see Section 4.4.2, the DOFF parameter, for a description of the MSD).

The date and time values displayed in the Interval Summary Data Table are the starting date and time (i.e. the transmit time) for the last ping in the Summary Period.

When the Interval Summary Data Table is displayed, the terminal bell and the computer alarm are sounded. This is done to signal the operator to make an event (or log) mark on the echo sound recorder paper and to write an entry in the logbook. To make an event mark on the recorder paper, the operator must depress and release the Event Mark button located on the front panel of the computer chassis.

4.4.5 Signal Noise and Amplitude Threshold Value

The receiver amplifiers of the EK400 echo sounder have 20 log R + 2αR (where R is range from the transducer) gain functions to compensate for spreading and absorption of the transmit pulse and the returning echoes. Signals from noise sources also will be amplified by the logarithmic gain functions of the receiver. Therefore, noise which produces output signals with relatively low amplitudes at small R values will produce output signals with much higher amplitudes at large R values. In an attempt to prevent noise signals from being recorded on tape as valid fish echoes, the computer compares the signal from the output of the Detector Unit to the value of the THRS parameter and only saves the signals (sample amplitude words) which equal or exceed the value of the THRS parameter (see Section 4.4.2 for a description of the THRS parameter). Since the value of the THRS parameter is a constant, it will be correct for only a small range of R values. For R values closer to the transducer, the amplitude threshold will be too high and will reject valid fish echoes. For R values further from the transducer, the amplitude threshold will be too low to remove noise signals. To minimize the loss of valid data, the operator should select a THRS value which allows some of the noise from long ranges to be recorded. The noise can be removed during analysis through the application of a range dependent amplitude threshold function.

The amplitude of the noise signals should be carefully observed and noted in the logbook and/or as comments recorded on the magnetic tape via the COMM command (see Section 4.4.1 for a description of the COMM command). Some of the variables which affect the amplitude of the noise signal are:

(1) water depth,

(2) depth of the towed body transducer,

(3) speed and course of the vessel,

(4) sea state,

(5) biological noise,

(6) propeller pitch and RPM of engines, and

(7) number of engines, generators, pumps, etc. operating.

The operator should use the oscilloscope to observe the amplitude of the noise signals (see Section 2.2.2 for a description of the oscilloscope). The trigger selection and horizontal time base controls of the oscilloscope should be adjusted to display the full ping length (i.e. from the transmit point to the bottom echo). The vertical amplitude and vertical position controls should be adjusted so that the noise peaks can be measured easily.

If the amplitude of the noise signals is equal to or greater than the THRS value for a large range of R values, the computer will be very busy digitizing the noise signals and recording them on the magnetic tape. In fact, if the THRS value is very small in relation to the amplitude of the noise signals, the computer may become so busy that it will not respond to operator commands entered via the keyboard. In addition, it may not display the Interval Summary Data Table at the proper time (see Section 4.4.4 for a description of the Interval Summary Data Table). When (and if) an Interval Summary Data Table is displayed, most of the table entries will be very large numbers (i.e. greater than 5000). Also, the operator may notice that records are being written continuously to the tape. Since the computer will not respond to keyboard commands, the only way to regain control is to depress and release the RESET button located on the front panel of the computer.

The problem described in the previous paragraph generally will occur only under the following conditions:

(1) The THRS value has been set for operation in shallow water. Then the vessel moves to a deep water area, but the operator neglects to increase the THRS value.

(2) The operator enters a THRS value that is too small in relation to the amplitude of the noise signals.

(3) A problem occurs with the Wet End of the Analog Subsystem (e.g. an object becomes caught on the towing cable or the towed body is damaged by ice or a collision with the bottom).

4.4.6 Echo Acquisition Task Record Types and Formats

The Echo Acquisition task uses nine record types to write information on the 9-track magnetic tape. All records are written in NRZI format at 800 characters per inch (cpi).

The first record type is the File Mark record which is written on the tape when the MARK command is executed (see Section 4.4.1 for a description of the MARK command). A description of the File Mark record is presented in Section 3.5.5 of the Microformatter Addendum of the Pertec Operating and Service Manual.

The remaining eight record types have a common record header format. The header is composed of seven unsigned binary words (i.e. 16-bits). The following is a description of the seven header words.

Word Ø - tape record sequence number: The tape record sequence number is the first word in a record. The program sequentially numbers the records it writes on the tape by incrementing an internal counter (the Tape Record Counter) by one each time a record needs to be written to tape and then copying the contents of the counter to tape as Word Ø.

Word 1 - record type: Eight unique numbers have been used to define the record types. A description of each record type with its respective number is given later in this section.

Word 2 - record length: The program uses this word to define the total length of the record in words.

Word 3 - time; hours and minutes: The program uses Words 3, 4, 5, and 6 to define the time and date at which the record was written to the tape. The high byte of Word 3 is the hours value and the low byte is the minutes value.

Word 4 - time; seconds and milliseconds (low): The high byte is the seconds value and the low byte is the least significant byte of the milliseconds value.

Word 5 - time and date; milliseconds (high) and days: The high byte is the most significant byte of the milliseconds value and the low byte is the days value.

Word 6 - date; months and years (minus 1900): The high byte is the months value and the low byte is the years value. Note that 1900 has been subtracted from the years value.

The following is a description of the eight record types:

Start of RUN Record - type number 0100H (400 octal): The Start of RUN record is written to the tape to signify the commencement of an Echo Acquisition task data collection sequence (i.e. a RUN). The record contains the HYDAS program name and version number and the current value of the RUN parameter. The body of the record (i.e. the part following the seven word header) is composed of ASCII

characters. The total record length is 38 words. The Start of RUN record is the first record written on the tape when a data collection sequence is started.

Parameter Record - type number 0200H (1000 octal): The Parameter record is a copy of the Parameter Table minus the DATE and TIME parameters (see Section 4.4.2 for a description of the Parameter Table). The body of the record is composed of ASCII characters. The total record length is 145 words. The Parameter record is the second record written to the tape when a data collection sequence is started. In addition, it is written on the tape each time the value of the DOFF or THRS parameter is changed during the course of a data collection sequence (see Section 4.4.2 for a description of the DOFF and THRS parameters).

Comment Record - type number 0300H (1400 octal): The comment record contains text entered by the operator via the terminal keyboard in response to the execution of the COMM command (see Section 4.4.1 for a description of the COMM command). The body of the record is composed of ASCII characters. The total record length can be up to 415 words. If the operator uses the COMM command to enter text before the START command is entered, the Comment record containing that text will be the fourth record written to the tape when a data collection sequence is started (see Section 4.4.1 for a description of the START command). While a data collection sequence is in progress, a Comment record will be written to the tape each time the COMM command is used to enter text.

End of RUN Record - type number 0400H (2000 octal): The End of RUN record is written to the tape to signify the completion of an Echo Acquisition task data collection sequence. The record contains the HYDAS program name and version number and the current value of the RUN parameter. The body of the record is composed of ASCII characters. The total record length is 37 words.

Lost Lock Record - type number 0500H (2400 octal): The Lost Lock record is written to the tape to signify that the computer has stopped digitizing the signal from the output of the Detector Unit because the bottom tracking function of the computer is not receiving bottom pulse signals from the echo sounder and can no longer compute a MSD (see Section 4.4.2, the DOFF parameter for a description of the MSD and the operation of the bottom tracking function). The body of the record is an error message composed of ASCII characters. The total length of the record is 49 words. When a Lost Lock record is written to the tape, the operator is notified of the error (see Section 4.6.3 for a description of the Lost Lock Error). The program will stop the data collection sequence when a Lost Lock record is written to the tape; therefore, an End of RUN record will always follow a Lost Lock record.

Switch Wrong Record - type number 0600H (3000 octal): The Switch Wrong record is written to the tape to signify that the computer has stopped digitizing the signal from the output of the Detector Unit because the computer has detected that the Tape/Normal and/or the Meter/Fathom switches of the echo sounder are incorrectly set (see section 3.2 of the EK400 Instruction Manual for a description of the switch functions). The body of the record is an error message composed of ASCII characters. The total length of the record is 67 words. When a Switch Wrong record is written to the tape, the operator is notified of the error (see Section 4.6.4 for a description of the Switch Wrong Error). The program will stop the data collection sequence when a Switch Wrong record is written to

the tape; therefore, an End of RUN record will always follow a Switch Wrong record.

Navigation Record - type number 0700H (3400 octal): The Navigation record contains the positional information acquired from the vessel's navigation system. The least significant bit of word 7 in the record is used to indicate the availability of navigational data. If the bit is a zero, data are available. If the bit is a one, no data are being received from the navigation system. The remaining 131 words in the record are the ASCII characters received from the navigation computer (see the Magnavox Model 1107L Installation Manual for a description of the navigation message). The total record length is 139 words. The Navigation record is the third record written to the tape when a data collection sequence is started. In addition, the record is written to the tape at the end of each two minute interval during a data collection sequence.

Sample Data Record - type number 1000H (10,000 octal): Each Sample Data record contains one or more sub records called Ping records. A Ping record contains the information acquired during one echo sounder ping. It is composed of a ping record header, sample amplitude and sample depth words, (i.e. the samples), the maximum water depth measured for the ping, and a ping status word. The format of the Ping record is described in more detail later in this section.

At the end of each echo sounder ping, the program computes the amount of memory area (i.e RAM) used to store the Ping record. The amount of RAM used will depend on the number of samples acquired during the ping. In addition, the program computes the total amount of RAM used to store the Ping records acquired since the last Sample Data record was written to the tape. If more than 2048 memory locations (2K bytes) have been used, the contents of the RAM (i.e. the Sample Data record header and the Ping records) are written to the tape as a Sample Data record.

During a data collection sequence, Sample Data records are written to the tape as the need arises (i.e. whenever more than 2K of RAM has been used). All of the information in a Sample Data record is recorded as unsigned binary words. The maximum size a Sample Data record could attain is approximately 19,000 words. Note that a Sample Data record may contain only a Sample Data record header and one Ping record and that one Ping record may contain over 9,000 samples.

The Ping record header is composed of six words which are assigned as follows:

Word A - Ping record sequence number: The program sequentially numbers the Ping records by incrementing an internal counter by one for each echo sounder ping and then copying the contents of this counter to tape as Word A. Note that the Ping Record Counter is reset at the start of a RUN.

Word B - time; hours and minutes: The program uses Words B, C, D, and E to define the time and date at which the transmit pulse for the ping was emitted. The high byte of Word B is the hours value and the low byte is the minutes value.

Word C - time; seconds, and milliseconds (low): The high byte is the seconds value and the low byte is the lease significant byte of the milliseconds value.

Word D - time and date; milliseconds (high) and days: The high byte is the most significant byte of the milliseconds value and the low byte is the days value.

Word E - date; months and years (minus 1900): The high byte is the months value and the low byte is the years value. Note that 1900 has been subtracted from the years value.

Word F - number of samples in the Ping record: The program uses Word F to report the number of samples contained in the Ping record.

A Ping record may or may not contain samples. If it does contain samples, they will be placed after Word F. Each sample is composed of two words. The first word is the depth at which the sample was acquired (i.e. the sample depth word). The second word is the sample amplitude word.

To convert a sample depth word to meters, the speed of sound in water must be known or assumed. The depth in meters is given by:

$$D = 0.5\ V(SDW)P \qquad (1)$$

where: D is the depth in meters,
V is the velocity of sound in water,
SDW is the value of the sample depth word, and
P is the sample period (i.e. reciprocal of the 15KHz sample rate).

If the speed of sound in water is assumed to be 1500 meters per second, then equation 1 reduces to:

$$D = 0.05\ (SDW) \qquad (2)$$

The amplitude of a sample in volts RMS is given by:

$$V = 0.0025\ (SAW) \qquad (3)$$

where: V is volts RMS, and
SAW is the value of the sample amplitude word.

The resolution of the analog to digital converter is 0.0025 volts and maximum output of the converter is 10.2375 volts.

The second last word in a Ping record will always be the maximum water depth for the ping or the MSD for the ping if a bottom pulse signal was not received from the echo sounder.

The last word in a Ping record is called the ping status word. The word is used to report whether the value of the second last word is the maximum water depth for the ping or the MSD for the ping. The ping status word will have the value 0000H if the maximum water depth was reported or the value 0001H if the MSD was reported.

The total number of words in a Ping record is given by:

$$W = 2\,(\text{Word F}) + 8 \qquad (4)$$

where: W is the total number of words, and
Word F is the number of samples in the Ping record.

A typical Sample Data record is shown in Table 7. The record in the table contains a Sample Data record header and three Ping records. Each Ping record contains a Ping record header, sample depth and sample amplitude words, a maximum depth or MSD word, and a ping status word.

4.5 THE TVG ACQUISITION TASK

The HYDAS microcomputer can be directed to perform the task of acquiring the data needed to determine the amplification characteristics of the TVG amplifiers of the echo sounder receiver. The data is stored on 9-track tape and can be processed on a general purpose computer to provide correction factors which can be used during data reduction to compensate for errors in the TVG amplifiers.

4.5.1 Selection of the TVG Acquisition Task

The operator can select the TVG Acquisition task when the Echo Acquisition task menu is displayed on the terminal screen by entering 6 <RETURN> in response to the * prompt. For a description of the Echo Acquisition task menu and a list of the times when it is displayed, see Section 4.4.3. Alternatively, the operator can enter the TVG command in response to the : prompt (see Section 4.4.1 for a description of the TVG command). Regardless of which selection technique is used, the program will display the message:

```
************************************
* T.V.G. Acq. Ver. 1.6   27 Mar 86 *
************************************
Do you want to select the TVG Acquisition task (Y/N) ?
```

If the TVG Acquisition task was selected by mistake, the operator can enter N <RETURN> and the program will display the Echo Acquisition task menu and wait for the operator to respond. The operator should enter Y <RETURN> to select the TVG Acquisition task. The program will display the message:

```
Configure the Dry End of the Analog Subsystem to perform
the TVG Acquisition task.
```

4.5.2 Configuration

Before the TVG Acquisition task can collect data, the operator must properly configure the echo sounder and the test and measurement instrumentation. The operator should carry out the following steps while referring to Fig. 2, Fig. 3, and the appropriate reference manuals:

Table 7. A Typical Sample Data Record.

Word number	Description
Word 0 through Word 6	- sample data record header
Word 7 through Word 12	- first ping record header
Word 13	- first sample depth word
Word 14	- first sample amplitude word
Word 15	- second sample depth word
Word 16	- second sample amplitude word
.	.
.	.
.	.
Word K-3	- last sample depth word
Word K-2	- last sample amplitude word
Word K-1	- maximum water depth or MSD
Word K	- ping status word
Word K+1 through K+6	- second ping record header
Word K+7	- first sample depth word
Word K+8	- second sample amplitude word
.	.
.	.
.	.
Word L-3	- last sample depth word
Word L-2	- last sample amplitude word
Word L-1	- maximum water depth or MSD
Word L	- ping status word
Word L+1 through L+6	- third ping record header
Word L+7	- first sample depth word
.	.
.	.
.	.
Word N-2	- last sample amplitude word
Word N-1	- maximum water depth or MSD
Word N	- ping status word

(1) Set the switches on the Logic Driver cards of the Transceiver Unit to the 'Inhibit' position.

(2) Enter code 11 (recorder gain) via the key pad of the MV101 Control Unit and select 0 (zero gain).

(3) Enter code 30 (main range) via the key pad of the Control Unit and select 8 (0 to 600 meters).

(4) Examine the display of the Control Unit to see if the sound velocity, bandwidth, and attenuator values are set as they were, or will be, for the survey. Adjust the values as necessary.

(5) Use the Digital Multimeter and the Function Generator to inject a 49 KHz, continuous sine wave, with an amplitude of approximately -22 dB, into the Test Input of the EK400 Test Panel.

(6) Set switches S1 and S2 on the front panel of the Transducer Test and Selector Unit (TTSU) to allow the signal from the Tx Output of the Test Panel to be injected into the Transceiver Unit.

(7) If a fixed gain amplifier or attenuator was used or will be used to adjust the level of the signal before it is detected by the Detector Unit, set the gain or attenuation to the same value that was used or will be used for the survey.

(8) Choose the receiver channel to be measured (i.e. the 40 log R or the 20 log R) and connect the cables from the analog-to-digital converter of the computer and the vertical amplifier of the oscilloscope to the appropriate BNC output connector (i.e. 20 log R or 40 log R) on the front panel of the Detector Unit.

(9) Set the trigger selection and the horizontal time base controls of the oscilloscope to display the signal from the output of the Detector Unit. The controls should be adjusted to allow the signal to be observed over the range of 0 to 500 meters. The vertical gain and vertical position controls should be adjusted to allow the maximum amplitude of the signal to be observed.

(10) Using the gain control of the Function Generator, adjust the amplitude of the injected signal to utilize the dynamic range of the receiver amplifier, the detector, and the analog-to-digital converter. Check that the signal is not being clipped in any part of the depth range to be measured.

The TVG Acquisition task will allow the operator to acquire many data sets at the same or different injected signal levels (see the next section).

4.5.3 Operation of the TVG Acquisition Task

Once the Dry End of the Analog Subsystem has been properly configured, the operator must check the DATE and TIME parameters. The program will display the DATE parameter with its current value and wait for the operator to respond (see section 4.4.2 for a description of the DATE parameter). Next, the TIME parameter with its current value will be displayed and the program will wait for the operator to respond (see Section 4.4.2 for a description of the TIME parameter). When the operator has finished updating the TIME parameter, the program will display the message:

Mount a tape on the transport and then press the <RETURN> key.

and wait for the operator to respond.

After the operator has mounted a tape and pressed the <RETURN> key, the program will check the status of the tape transport and formatter and report any errors that are detected. A description of the errors is given in Section 4.6.1, Tape Transport Errors. If no errors are detected, the program will display the message:

Data can be written to this tape; it is not write protected.
The tape transport is ready.
The Tape Record Counter has been reset.

Next the RUN parameter with its current value will be displayed and the program will wait for the operator to respond (see Section 4.4.2 for a description of the RUN parameter).

After the value of the RUN parameter has been updated, the program will write the TVG Start of RUN record to the tape (see Section 4.5.4 for a description of the TVG Acquisition task record types and formats). Next the program will display the message:

Enter the amplitude of the input signal level (in dB reference 1 volt RMS). For example enter: -20.3 DB.

The operator should enter the amplitude of the signal which is injected into the Test Input of the EK400 Test Panel. The amplitude should be expressed in dB referenced to 1 volt RMS. As an example, say the operator entered -26.2 DB. and then pressed the <RETURN> key. The program will write a Comment record to the tape containing the following text:

The input signal level for this RUN is -26.2 DB.

(See Section 4.4.6 for a description of the Comment record.) Then the program will display the message:

Do you want to enter a comment to be recorded on the tape (Y/N) ?

and wait for the operator to respond. If the operator enters Y <RETURN>, the program will execute the COMM command (see Section 4.4.1 for a description of the COMM command) and the operator can enter text to be written to the tape as a Comment record. The operator should use this opportunity to log the echo sounder parameters such as bandwidth, attenuation, etc. Once the comment has been entered, or if the operator replied with N <RETURN> to the previous question, the program will display the message:

When you are ready to start sampling press the <RETURN> key.

and wait for the operator to respond. When the operator is sure that all is ready, the <RETURN> key should be pressed. The program will display the message:

***** Sampling has started. *****

Then it will display the TIME parameter with its current value and begin the data collection sequence.

The program will digitize the signal from the output of the Detector Unit at 0.1 meter increments (i.e. the sample rate is 7.5 KHz) from 3 meters to 500.0 meters for 30 pings. The amplitude threshold value will be set at 0.0025 volts RMS and all 4971 sample amplitude words from each ping will be written to the tape (see Section 4.5.4 for a description of TVG Data records).

When the program has finished acquiring samples from the 30 pings, it will display the message:

***** The RUN is finished. *****
Do you want to enter a comment to be recorded on the tape (Y/N) ?

If the operator enters Y <RETURN>, the COMM command will be executed allowing the operator to enter text which will be written to the tape as a Comment record. Once the comment has been entered, or if the operator enters N <RETURN>, the program will write the TVG End of RUN record to the tape (see Section 4.5.4 for a description of the TVG End of RUN record).

Next the program will display the message:

Was that the last RUN (Y/N) ?

If it is necessary to acquire additional data sets, the operator should enter N <RETURN>. The program will return to the beginning of the TVG Acquisition task, display the RUN parameter with with its value, and wait for the operator to respond.

If the operator enters Y <RETURN>, the program will execute the MARK command (see Section 4.4.1 for a description of the MARK command). Once a File Mark record has been written to the tape and the tape has been rewound, the program will:

(1) set the value of the TAPE parameter to 0,

(2) restore the values of the THRS, DOFF, and DTFS parameters to what they were before the TVG Acquisition task was selected,

(3) display the following message:

****** Please carefully examine the Parameter Table before starting a RUN. ******

(4) display the Echo Acquisition task menu and wait for the operator to respond.

4.5.4 TVG Acquisition Task Record Types and Formats

The TVG Acquisition task uses nine record types to write information on the 9-track magnetic tape. All records are written in NRZI format at 800 cpi.

The first record type is the File Mark record which is written on the tape when the MARK command is executed (see Section 4.4.1 for a description of the MARK command). A description of the File Mark record is presented in Section 3.5.5 of the Microformatter Addendum of the Pertec Operating and Service Manual.

The remaining eight record types have a common record header format. A description of the record header format is given in Section 4.4.6. The following is a description of the eight record types.

Start of RUN record - type number 0100H (400 octal): The Start of RUN record is written to the tape to signify the commencement of a TVG Acquisition task data collection sequence. The record contains the TVG Acquisition task name and version number and the current value of the RUN parameter. The body of the record is composed of ASCII characters. The total record length is 38 words. The Start of RUN record is the first record written to the tape when a data collection sequence is started..

Comment Record - type number 0300H (1400 octal): The Comment records for the TVG Acquisition task have the same construction as the Comment records for the Echo Acquisition task; therefore, see Section 4.4.6 for a description of the Comment record. Note that a Comment record will always be the second record written to the tape when a data collection sequence is started (see the previous section).

End of RUN Record - type number 0400H (2000 octal): The End of RUN record is written to the tape to signify the completion of a TVG Acquisition task data collection sequence. The record contains the TVG Acquisition task name and version number and the current value of the RUN parameter. The body of the record is composed of ASCII characters. The total record length is 37 words.

First TVG Data Record - type number 1010H (10020 octal): The TVG Acquisition task writes five TVG Data records to the tape for each echo sounder ping. The

First TVG Data record contains the samples acquired from 3.0 meters to 100.0 meters (at 0.1 meter increments). Each sample is composed of two words. The first word is the sample depth word and the second word is the sample amplitude word.

All the information in the record is recorded in unsigned binary words. To convert the sample depth words to meters and the sample amplitude words to volts RMS, see equations 1, 2, and 3 in the description of Sample Data records in Section 4.4.6.

The record length is 1949 words.

Second TVG Data Record - type number 1020H (10040 octal): The Second TVG Data record contains the samples acquired from 100.1 meters to 200.0 meters (at 0.1 meter increments). The record has the same format as the First TVG Data record. The total record length is 2007 words.

Third TVG Data Record - type number 1030H (10060 octal): The Third TVG Data record contains the samples acquired from 200.1 meters to 300.0 meters (at 0.1 metre increments). The record has the same format as the First TVG Data record. The total record length is 2007 words.

Fourth TVG Data Record - type number 1040H (10100 octal): The Fourth TVG Data record contains the samples acquired from 300.1 meters to 400.0 meters (at 0.1 meter increments). The record has the same format as the First TVG Data record. The total record length is 2007 words.

Fifth TVG Data Record - type number 1050H (10120 octal): The Fifth TVG Data record contains the samples acquired from 400.1 meters to 500.0 meters (at 0.1 meter increments). The record has the same format as the First TVG Data record. The total record length is 2007 words.

Each time the TVG Acquisition task executes a data collection sequence, a minimum of 153 records are written to the tape; 155 records if the operator enters comments at the start and end of the RUN.

4.5.5 Utilization of TVG Acquisition Task Data

The data collected by the TVG Acquisition task (i.e. the TVG Data records) can be used to determine:

(1) the fixed gain of the echo sounder receiver amplifier,

(2) correction factors to compensate for errors in the TVG function of an echo sounder receiver amplifier,

(3) correction factors to compensate for the difference between the absorption coefficient (α) of the echo sounder receiver amplifier and the α chosen for data analysis,

(4) changes in the TVG function of the echo sounder receiver amplifier over periods of time, and

(5) the behavior of the TVG function of the echo sounder receiver amplifier at different injected signal levels.

Data analysis is carried out by comparing an acquired data set to a data set generated under ideal conditions (i.e. via an equation). Miller and Stevens (MS 1984) used the following procedure to determine the fixed gain of the receiver amplifier and to determine the correction factors to compensate for errors in the TVG function of the 20 log R receiver amplifier.

Let: V_{cal} be the signal (voltage) injected into the echo sounder receiver amplifier expressed in dB ref 1 volt RMS,

R be the range from the transducer (i.e. the sample depth word in the TVG Data record) in meters,

V_R be the digital value (voltage) of the converted signal from the output of the Detector Unit at range R (i.e. the sample amplitude word that corresponds to the sample depth word for range R) expressed in dB ref 1 volt RMS,

R_{ref} be the reference depth (in meters) chosen as a normalizing point, and

V_{ref} be the reference voltage from the output of the Detector Unit at range R_{ref} (i.e. at R_{ref}, $V_{ref} = V_R$) expressed in dB ref 1 volt RMS.

An ideal data set (i.e. output voltages for a given range of R values) can be generated for an ideal 20 log R + 2αR amplifier using the following equation:

$$V_{IDEAL_R} = V_{ref} + (20 \log R + 2\alpha R) - (20 \log R_{ref} + 2\alpha R_{ref}) \quad (5)$$

where: V_{IDEAL_R} is the ideal output voltage at range R expressed in dB ref 1 volt RMS and
α is the absorption coefficient expressed in dB per meter.

The correction factor to compensate for an error in the TVG amplifier at range R is given by:

$$B_R = V_{IDEAL_R} - V_R \quad (6)$$

where: B_R is the correction factor for range R expressed in dB ref 1 volt RMS.

The fixed gain of the echo sounder receiver amplifier is given by:

$$G_A = V_{ref} - V_{CAL} - (20 \log R_{ref} + 2\alpha R_{ref}) \quad (7)$$

where: G_A is the fixed gain expressed in dB ref 1 volt RMS.

To determine the correction factors and the fixed gain for a 40 log R receiver amplifier, the 20 log terms in equations 5 and 7 must be changed to 40 log.

4.6 COMPUTER DETECTABLE ERRORS

4.6.1 Tape Transport Errors

The HYDAS-400 program checks for tape transport errors at the following times:

(1) when a tape is mounted,

(2) before a record is written to the tape, and

(3) after a record has been written to the tape.

A description of the nature of the checks performed at each of these times is given below:

Errors Detected When a Tape is Mounted

The operator should see Section 3.3 of the Pertec Operating and Service Manual for assistance with the tape mounting procedure.

The operator informs the program that a tape has been mounted on the transport by entering a value for the TAPE parameter (see Section 4.4.2 for a description of the TAPE parameter). Once this has happened, the program examines the status of the transport and formatter.

First, the program checks that the transport has been powered up and that tension has been applied to the tape. If an error is detected, the program will display the message:

****** Tape Transport Error ******
Check that the transport has been powered up. The POWER switch should be in the ON position and the indicator light should be illuminated.
Check that tension has been applied to the tape. If not, depress and release the LOAD button.
When you are ready to continue press the <RETURN> key.

If the program continues to display this message after these checks have been carried out, or if:

(1) the indicator light in the POWER switch is not illuminated,

(2) tension cannot be applied to the tape, or

(3) any other transport malfunction is detected,

the operator should ask for technical assistance.

Second, the program checks that the reflective (silver) tab on the tape has been positioned at the Load Point (i.e. the Beginning Of Tape (BOT) position). If an error is detected, the program will display the message:

****** Tape Transport Error ******
The tape has not been positioned at the Load Point.
Depress and release the LOAD button.

Under normal operating conditions, the LOAD button is depressed and released to cause tension to be applied to the tape and then it is depressed and released a second time to cause the tape to advance to the BOT position. It is possible to:

(1) mount a tape which has no BOT tab,

(2) mount the tape so that the BOT tab has passed the Load Point before tension is applied, or

(3) have the sensor fail to detect the BOT tab.

If one of these events occurs, the tape will start to move forward at the operating velocity the second time the LOAD button is depressed and released. The tape will continue to move forward until the operator intervenes. To correct this problem, the operator should depress and release the RESET button (on the transport) and then the REWIND button. The tape should rewind and stop at the Load Point, the indicator light in the LOAD button should be illuminated. If the tape rewinds completely, see if the tape has a BOT tab. If not, mount a tape with a BOT tab. If the tape still cannot be positioned at the Load Point, or if the program continues to display this error message, the operator should ask for technical assistance.

Third, the program checks that the transport has been placed in the On-line mode. If not, the program will display the message:

****** Tape Transport Error ******
The transport is not in the On-line mode.
Depress and release the ON LINE button.

In order for the program to control the operation of the transport, the transport must be placed in the On-line mode. The transport is in the On-line mode when the indicator light in the ON LINE button is illuminated. Depressing and releasing the ON LINE button changes the state of the transport from Off-line to On-line or from On-line to Off-line. If the indicator light will not illuminate when the ON LINE button is depressed and released or if the program continues to display this error message, the operator should ask for technical assistance.

Fourth, the program checks that a write enable ring is installed on the tape mounted on the transport. If not, the program will display the message:

****** Tape Transport Error ******
Data cannot be written to this tape.
Dismount the tape and install a write enable ring
on the back of the tape reel.

When you are ready to continue press the <RETURN> key.

In order for the program to write records on the tape, a write enable ring (i.e. a removable plastic ring) must be inserted in the circular groove on the back of the tape reel. When a write enable ring is installed, either the WRT EN indicator light of the transport will be illuminated or the FPT indicator light of the transport will not be illuminated. The transports in service have either a WRT EN indicator or a FPT indicator. If the indicator light does not go to the proper state when a write enable ring is installed or the program continues to display this error message, the operator should ask for technical assistance.

If the program does not detect any of the errors described above, it will display the message:

The tape transport is ready.
The Tape Record Counter has been reset.

and allow the operator to continue.

Errors Detected Before a Record is Written to the Tape

The program will check that the transport is in the On-line mode before it writes a record to the tape. If the program is in the Acquisition mode when it determines that the transport has been placed in the Off-line mode, it will carry out the following steps:

(1) It will stop sampling the signal from the output of the Detector Unit of the echo sounder and end the current data collection sequence.

(2) It will display the message:

****** Tape Transport Error ******
The transport has been placed in the Off-line mode.
Data cannot be written to the tape.
The data collection sequence has been stopped.

Note that it is not possible for the program to write an error message or an End of RUN record to the tape. Therefore, the operator must write a description of the problem in the logbook.

(3) It will display the current value of the TIME parameter.

Note that the time value should be used when completing the logbook.

(4) It will sound the alarm to notify the operator that an error has been detected and it will display the message:

Press the <RETURN> key to shut off the alarm.

When the operator presses the <RETURN> key to shut off the alarm, the program will return to the Idle mode and display the : prompt.

If the program is in the Idle mode when it detects this error, the program will display the message:

****** Tape Transport Error ******
The tape transport has been placed in the Off-line mode.
Data cannot be written to the tape.
Depress and release the ON LINE button.
When you are ready to continue press the <RETURN> key.

The error may have been caused by an electronic fault or by the ON LINE button being depressed and released. If the indicator light in the ON LINE button is illuminated, it is quite likely that the error was caused by an electronic fault. Therefore, the operator should ask for technical assistance. If the indicator is not illuminated, the operator should depress and release the ON LINE button. If the indicator does not illuminate, the operator should ask for technical assistance because the error probably was caused by an electronic fault. If the indicator does illuminate, then the error probably was caused by the ON LINE button being depressed and released.

Errors Detected After a Record has been Written to the Tape

After a record has been written to the tape, the program will examine the status of the transport and formatter to determine if the end-of-tape (EOT) tab was detected while the record was being written. If the EOT tab was recognized, the program will carry out the following steps:

(1) It will stop sampling the signal from the output of the Detector Unit of the echo sounder and end the current data collection sequence.

(2) It will try to write a File Mark record on the tape and then rewind the tape.

Note that it will not be possible for the program to write a File Mark record and rewind the tape if there is no tape remaining on the supply reel.

(3) It will display the message:

****** Tape Transport Error ******
The end-of-tape tab has been detected.
No more data can be written to the tape.

Note that it is not possible for the program to write an error message or an End of RUN record to the tape. Therefore, the operator must write a description of the problem in the logbook.

(4) It will display the current value of the TIME parameter.

Note that the time value should be used when completing the logbook.

(5) It will sound the alarm to notify the operator that an error has been detected and it will display the message:

Press the <RETURN> key to shut off the alarm.

When the operator presses the <RETURN> key to shut off the alarm, the program will return to the Idle mode and display the : prompt.

If the supply reel contained enough tape to allow the program to carry out the rewind function, the tape will stop at the Load Point.

If the supply reel did not contain enough tape to allow the program to carry out the rewind function, the operator must:

(1) depress and release the RESET button on the tape transport,

(2) rethread the tape through the guides, tension arms, and tape head,

(3) wind several turns of tape onto the supply reel,

(4) turn the supply reel until the slack tape has been taken up,

(5) depress and release the LOAD button, and

(6) depress and release the REWIND button.

The transport will rewind the tape and stop it at the Load Point.

4.6.2 Bottom Tracking Error

When the START command is entered, the program will display the water depth value currently being used by the bottom tracking function of the computer (see Section 4.4.1 for a description of the Start command). The operator must compare this value to the water depth value reported by the echo sounder. If the two values do not agree, the operator should instruct the program to acquire and display a new water depth value. Again, the operator must compare the new value to the value reported by the echo sounder and inform the program as to the result of the comparison. If there is still no agreement between the two values after ten attempts have been made, the program will assume an error has occurred and it will carry out the following steps:

(1) It will display the message:

****** Bottom Tracking Error ******
The bottom tracking function of the computer cannot find the correct depth. Please examine the system for problems.

(2) It will return to the Idle mode, display the : prompt, and wait for the operator to respond.

Note that the data collection sequence was not started and that no records were written to the tape. Therefore, it is not necessary to write a description of the problem in the logbook.

The operator should try to determine what caused the error before reentering the START command. Some possible causes are:

(1) The towed body is not towing properly because objects are caught on the towing cable or the tow terminator, or because the towed body has been damaged through a collision with ice or the bottom.

(2) The echo sounder is being operated in an area where the water is too deep for the sounder to detect the echo from the ocean floor.

(3) The Analog Subsystem is not performing properly due to an electrical break in the towing cable, a poor cable connection, low transmitter power, low receiver gain, etc.

(4) The ocean floor is extremely rough; therefore, the value of the DOFF parameter should be increased (see Section 4.4.2 for a description of the DOFF parameter).

If the program detects this error the second time the START command is entered, the operator should ask for technical assistance.

4.6.3 Lost Lock Error

The Lost Lock error occurs when the bottom tracking function of the computer does not receive bottom pulse signals from the echo sounder for many contiguous pings (see Section 4.4.2, the DOFF parameter for a description of the operation of the bottom tracking function). When the program recognized this error condition, it will carry out the following steps:

(1) It will stop sampling the signal from the output of the Detector Unit of the echo sounder and end the current data collection sequence.

(2) It will write a Lost Lock record and an End of RUN record to the tape (see Section 4.4.6 for a description of the Lost Lock and End of RUN records).

(3) It will display the message:

****** Lost Lock Error ******
The echo sounder is not generating bottom pulse signals.
The data collection sequence has been stopped.

Note that the operator should write a description of the problem in the logbook.

(4) It will display the current value of the TIME parameter. Note that the time value should be used when completing the logbook.

(5) It will sound the alarm to notify the operator that an error has been detected and it will display the message:

Press the <RETURN> key to shut off the alarm.

When the operator presses the <RETURN> key to shut off the alarm, the program will return to the Idle mode and display the : prompt.

The operator should try to determine what caused the error condition before starting a new data collection sequence. Some possible causes are:

(1) The towed body is not towing properly because objects are caught on the towing cable or the tow terminator, or because the body has been damaged through a collision with ice or the bottom.

(2) The towed body has been lifted from the water by a pan of ice.

(3) The echo sounder is being operated in an area where the water is too deep for the sounder to detect the echo from the ocean floor.

(4) The Analog Subsystem is not performing properly due to an electrical break in the towing cable, a poor cable connection, low transmitter power, low receiver gain, etc.

(5) The ocean floor is extremely rough; therefore, the value of the DOFF parameter should be increased (see Section 4.4.2 for a description of the DOFF parameter).

If the program detects this error several times in a relatively short period of time, the operator should ask for technical assistance.

4.6.4 Switch Wrong Error

The Switch Wrong error occurs when the computer detects that the Tape/Normal switch or the Meter/Fathom switch on the front panel of the Control Unit of the echo sounder are incorrectly set. For proper operation, the Tape/Normal switch must be set to the 'Normal' position and the Meter/Fathom switch must be set to the 'Meter' position.

When the program is in the Acquisition mode and it recognizes that one of the switches is incorrectly set, it will carry out the following steps:

(1) It will stop sampling the signal from the output of the Detector Unit of the echo sounder and end the current data collection sequence.

(2) It will write a Switch Wrong record and an End of RUN record to the tape (see Section 4.4.6 for a description of the Switch Wrong and the End of RUN records).

(3) It will display the message:

****** Switch Wrong Error ******
The Tape/Normal switch or the Meter/Fathom switch on the Control Unit of the echo sounder is incorrectly set.

The data collection sequence has been stopped.

Note that the operator should write a description of the problem in the logbook.

(4) It will display the current value of the TIME parameter.

Note that the time value should be used when completing the logbook.

(5) It will sound the alarm to notify the operator an error has been detected and it will display the message:

Press the <RETURN> key to shut off the alarm.

When the operator presses the <RETURN> key to shut off the alarm, the program will return to the Idle mode and display the : prompt.

If the program is in the Idle mode when the error is detected, it will display the message:

****** Switch Wrong Error ******
The Tape/Normal switch or the Meter/Fathom switch on the Control Unit of the echo sounder is incorrectly set.
Please check the switches.

and then display the : prompt.

The operator should set the switches to the proper position before starting a new data collection sequence.

4.6.5 Sample Controller Card Error

The HYDAS-400 program executed by the Master CPU checks the time required for the CPU on the Sample Controller Card to acknowledge the receipt of commands issued by the Master CPU. If an acknowledgment is not received within a specified period of time, the HYDAS-400 program assumes that an error has occurred. If the program is in the Acquisition mode when it detects this error, it will carry out the following steps:

(1) It will stop sampling the signal from the output of the Detector Unit and end the current data collection sequence.

(2) It will display the message:

****** Sample Controller Card Error ******
The Master CPU cannot communicate with the Sample Controller cards.
The data collection sequence has been stopped.

Note that it is not possible for the program to write an error message or an End of RUN record on the tape. Therefore, the operator must write a description of the problem in the logbook.

(3) It will display the current value of the TIME parameter.

Note that the time value should be used when completing the logbook.

(4) It will sound the alarm to notify the operator that an error has been detected and it will display the message:

Press the <RETURN> key to shut off the alarm.

When the operator presses the <RETURN> key to shut off the alarm, the program will return to the Idle mode and display the : prompt.

If the program is in the Idle mode when it detects this error, the program will display the message:

****** Sample Controller Error ******
The Master CPU cannot communicate with the Sample Controller cards.
There probably is a hardware fault on one of the Sample Controller cards.

and then display the : prompt.

The error probably was caused by an electronic fault on one of the Sample Controller cards. The operator should:

(1) enter the MARK command to write a File Mark record on the tape and rewind the tape (see Section 4.4.1 for a description of the MARK command),

Note that it may not be possible for the computer to carry out this step due to the electronic fault.

(2) dismount the current tape and mount a new tape,

(3) press the RESET button on the front panel of the computer chassis, and

(4) update the values in the Parameter Table and try to start a new data collection sequence.

If the Sample Controller Card Error message is displayed again, the operator should ask for technical assistance. If not, the system should be watched very carefully because the computer probably has developed an intermittent electronic fault.

5. CALIBRATION

5.1 SOURCE LEVEL AND RECEIVE SENSITIVITY MEASUREMENTS

The source level and the receive sensitivity of the Analog Subsystem are measured at the start of each survey or study. The measurements are repeated during or after the cruise if any critical instrumentation in the system is exchanged or repaired.

The measurements are performed by attaching the towed body to the top of a rigid frame and then positioning a hydrophone at the bottom end of the frame on the acoustic axis of the transducer. The distance from the face of the transducer to the hydrophone is approximately 3 meters. The hydrophone is a Bruel and Kjaer model 8100.

5.2 ECHO SOUNDER PARAMETER MEASUREMENTS

The transmit pulse lengths, receiver gain, receiver bandwiths, and receiver attenuation settings of the echo sounder are measured at the start of each survey or study. The measurements are repeated during or after the cruise if any critical components of the echo sounder are exchanged or repaired. The measurements are performed using the test and measurement instrumentation described in Section 2.2.2.

5.3 ECHO SOUNDER TVG MEASUREMENTS

The data needed to determine the amplification characteristics of the TVG amplifiers of the echo sounder receiver is acquired by the HYDAS microcomputer when it is directed to perform the TVG Acquisition task (see Section 4.5 for a description of the TVG Acquisition task). The amplification characteristics of the TVG amplifiers are measured at the start of each survey or study. The measurement is repeated during or after the cruise if any critical components of the echo sounder are exchanged or repaired.

6. DISCUSSIONS

6.1 RATIONALE FOR THE USE OF TOWED BODIES

Research vessels operating in the Newfoundland Region often are required to carry out their duties in poor weather conditions. In order to increase the quality of the data acquired by HYDAS when it is operated under such conditions, the SB uses a transducer mounted in a towed body, instead of a transducer mounted on the hull of the research vessel. The towed body can be positioned below the turbulent, aerated surface water; therefore, its transducer is not subjected to the high degree of pitch, roll, and cavitation experienced by a hull mounted transducer. Consequently, the towed body transducer moves steadily through air-free water, which results in improved system performance.

A transducer mounted in a towed body can be accessed easily for calibration and service work, where as a hull mounted transducer is difficult to access. In addition, a transducer mounted in a towed body can be positioned closer to the fish under study (e.g. demersal species) than can a hull mounted transducer. Therefore, a system which uses a transducer mounted in a towed body can provide a better signal to noise ratio. The larger signal to noise ratio will give the system a wider dynamic range in which to detect fish targets. The improved performance is realized because the electrical attenuation of the signal by the towing cable is far less than the combined spreading and absorption losses the signal would experience while travelling through an equivalent path in water.

The main disadvantage of using a transducer mounted in a towed body is that a portion of the water column cannot be observed. The transducer for HYDAS is configured for downward looking operation. Therefore, the portion of the water column from approximately 3 meters below the transducer (i.e. the beginning of the far field) to the surface cannot be observed. This could result in a significant loss of information when surveying pelagic species.

Another problem encountered when using a transducer mounted in a towed body is the possibility of collisions with the ocean floor, fixed fishing gear, and ice. Such mishaps usually result in heavily damaged or lost equipment.

6.2 TOWING CABLES AND TOWED BODY DEPTH

Unfaired towing cables of lengths from 400 to 800 meters have been used with HYDAS for cod (Gadus morhua) and redfish (Sebastes spp.) surveys. When an 800 meter towing cable is used, and the research vessel speed is maintained at 6 knots, it is possible to deploy the towed body to approximately 150 meters below the surface.

Towing cables fitted with soft fairing have been used by the SB in attempts to increase the towed body depth for a given length of towing cable. No significant improvement in towing depth was realized and cable handling problems were experienced. Only part of the cables were faired and the level wind mechanism of the winch could not be adjusted to compensate for the difference in the diameter of the faired and unfaired parts of the cables. Therefore, the cables could not be spooled properly on the winch. In addition,

the fairing caught in the pulleys and level wind rollers and was torn from the cables. No attempts have been made to utilize cables fitted with hard fairing due to the high cost of this type of fairing and the winch required to store a cable fitted with hard fairing.

Unfaired towing cables of lengths from 100 to 200 meters have been used for capelin surveys. For this work an unfaired towing cable is desirable so that the towed body (i.e. the transducer) can be positioned as far behind the research vessel and as close to the surface as possible. This procedure allows the maximum amount of water column to be searched by the downward looking transducer with the minimum amount of interference from the noise generated by the vessel.

Generally, capelin surveys are conducted at vessel speeds from 8 to 10 knots and the towed body is positioned from 5 to 20 meters below the surface. The depth of the towed body depends on the maximum water depth in the survey area and the weather conditions. The depth of the towed body must be increased when the system is used in deep water (i.e. greater than 200 meters) and during periods of rough weather (i.e. Beaufort Wind Scale, force 5 and greater). The towed body must be positioned at deeper depths to reduce the acoustic noise level.

6.3 USE OF HYDAS BY THE SB

The first version of HYDAS was successfully field tested by the SB in June of 1981 (Miller et al. MS 1982). Since then, the SB has used the system to conduct more than twenty surveys and studies of capelin, redfish, and cod. In fact, since 1981 the biomass estimates derived from the data collected by HYDAS have played an important role in formulating advice for the management of the capelin stocks in the Newfoundland Region.

Since 1981, many modifications have been made to HYDAS which have improved and expanded its capabilities. It is anticipated that additional modifications will be made to the system during the coming year and that the SB will continue to use the system for at least another 2 years before replacing it with an advanced technique of hydroacoustic data acquisition.

ACKNOWLEDGMENTS

The original design goals for HYDAS were written in 1979 with the assistance of Dan Miller and Jim Carscadden of the SB. Part of the software for the first version of the HYDAS program was written and debugged by Harold Snow while on two work term projects (1980 and 1981) with Memorial University's Co-op Engineering Program. Part of his software is used in the present version of the program (i.e. HYDAS-400). He also devised the HYDAS acronym. The software required to move all the source files for the first version of the HYDAS program from their original home on a Cromemco computer to the Tektronix Microprocessor Development Lab, Model 8550, was written and debugged by Chris Lang while on a work term project (1981) with Memorial University's Co-op Engineering Program. Gary Mason of the Hydroacoustic Section of the SB designed and debugged the first (1983) and second (1985) versions of the EPROM and Serial Interface card. He also designed and debugged part of the hardware and software for the Clock and Navigation

Interface card (1985). Gordon Pike of the Hydroacoustic Section wire wrapped all the versions of each computer card developed from 1980 to 1986. He also constructed the first (1985) and the second (1986) versions of the Transducer Test and Selector Unit.

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Dan Miller developed all of the programs required to test and analyze the data written on the 9-track magnetic tapes by HYDAS.

The idea for the technique used to determine the TVG correction factors was presented by Dr. John Ehrenberg at a course given at the University of Washington in 1978.

The original draft of the report and the revisions were typed by K. Lynch and final revisions were completed by J. Lannon, of SB. The figures were prepared by Herb Mullett of SB.

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