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JUN 82 D E KOELSCH, K R PEAL, G M PURDY N00014-82-C-0019
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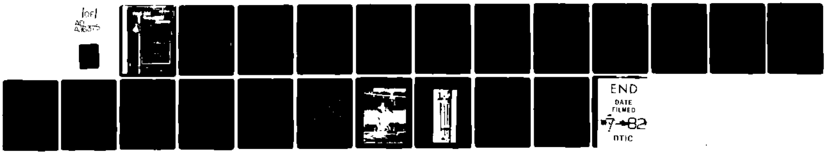

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ABSTRACT

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WHOI-82-30

THE WOODS HOLE OCEANOGRAPHIC INSTITUTION DIGITAL OCEAN BOTTOM HYDROPHONE INSTRUMENT

by

D.E. Koelsch, K.R. Peal,
and
G.M. Purdy

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

June 1982

TECHNICAL REPORT

Prepared for the Office of Naval Research under Contract N00014-82-C-0019; NR 083-004.

Approved for Distribution: John I. Ewing

John I. Ewing, Chairman
Department of Geology & Geophysics

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1. DESCRIPTION

A new data acquisition system has been designed to collect acoustic and seismic data while deployed on the ocean bottom. It can digitize signals from several input channels at sampling rates from 80Hz to 8500Hz and record them, with the necessary time and calibration data, on a self-contained tape recorder for playback after instrument recovery. The instrument currently uses a single hydrophone as the sensor and is called a digital ocean bottom hydrophone (DOBH). The principal design objectives were to produce an instrument that combined flexibility and reliability in operation with a capability for system expansion and modification that would ensure a long (10yr) useful life for the basic unit. This has been achieved by the use of microprocessor control of the maximum number of functions (eg. channel selection, digitization rate, gain, recording mode etc.); a dual port 64K byte memory so a second processor can be added to allow the use of complex event detection algorithms and/or the processing of data before recording; and modular construction that allows the sensor package and associated analog amplifiers to be changed with the minimum of modifications to the remainder of the system, and higher capacity cartridge tape recorders to be substituted as they become available on the commercial market. Reliability in recovery is ensured as far as possible by retaining the identical system and hardware configuration to that which has already provided us with in excess of 100 loss free deployments of the WHOI analog OBH instruments.

The instrument uses a commercially available tape recorder that has a capacity of 16.7 megabyte of formatted data. Read-after-write capability is used in conjunction with error checking to minimize data loss due to bad records and a large data buffer is used to avoid acoustical noise problems caused by operation of the tape recorder during data acquisition. A full calendar real time clock enables the instrument to start and stop various tasks according to a previously established schedule. Within each task, operations are either time-programmed or event driven with all data time tagged to a resolution of 20 microseconds.

During one deployment, the instrument can perform several different tasks. It is possible, for example, to start a deployment with event-driven data acquisition (e.g. during air gun operation) then to wait for a specified period before performing a different task such as preprogrammed operation (e.g. for ambient noise measurements).

The analog section consists of two subsections designated high and low frequency. The high-frequency subsection has a switchable filter/detector followed by an amplifier and a fast 8-bit A/D converter. The gain of the amplifier is processor controlled in four 6 dB steps. The low-frequency subsection has four channels each comprising a filter and a gain-ranging amplifier. These are multiplexed then digitized by a single 12-bit A/D converter. The dynamic range of each of these low frequency channels is 120 dB. Special care is taken to avoid noise problems in the analog data caused by crosstalk from the digital section. The sequence of scanning and digitizing the four low frequency channels is completely processor controlled. The four channels may be used for different tasks during one deployment allowing entirely different filtering and sampling schemes to be implemented without recovering the instrument. System self calibration is provided by twelve one-second long sine waves of frequencies from 1 Hz to 2000 Hz. The data from part or all of this sequence are recorded on tape with the acquired data.

2. MODES OF OPERATION

The instrument can perform many different data acquisition tasks. Examples of its applications are given in Table I. Filtering schemes, sample rates, event thresholds etc. are defined for each task prior to deployment by installing either hardware modules (i.e. plug-in filter cards) or software parameters. The latter are loaded into the instrument's memory from one of a selection of disc files stored on an external computer. During loading, verification is performed and a hardcopy record is printed.

The instrument's software currently has three modes of operation which can be invoked (numbered 0, 2 and 3) with a fourth (numbered 1) which can be implemented with software enhancements. These are described below. During a deployment, the instrument enters any of the four operating modes one or more times. Each such occurrence is called a task and is defined in the instrument by parameters in the form of a table. Each table completely specifies one mode of operation and consists of:

i) start and stop times
ii) active channels
iii) filtering scheme
iv) high frequency gain, rate, and threshold (if applicable)
v) low frequency rate and event threshold (if applicable)
vi) calibration interval and configuration
vii) dead time after each event
viii) data record and block size

A deployment is defined by a set of such tables that is created as a file on a computer external to the instrument. Prior to deployment this task file is loaded into the instrument's memory. At this time the instrument can perform up to five tasks during one deployment and at a later date will be expanded to more than twenty tasks with a simple software change.

In all cases, a calibration cycle is performed when first entering a given mode and after each occurrence of a specified number of events. Tape writes always occur between acquisition cycles. In each of the event driven modes, (1, 2, and 3) an event is declared only after determining that was not caused by an outgoing pulse from the instrument's own acoustic transponder. Also one sample near the event is tagged and the corresponding time is logged.

A description of the four modes follows.

i) Mode 0 - Programmed acquisition. A specified number of low frequency (LF) samples and a (possibly different) number of high frequency (HF) samples are collected repeatedly at a specified time interval. The interval can be any number from 1 second to 64K seconds (about 18 hours). In this mode, both channels can be active or either one can run alone. In each acquisition cycle, one HF and LF sample is tagged and the corresponding real time is logged.

ii) Mode 1 - Low frequency event driven acquisition with no high frequency data. Only the LF converter runs. It continuously fills a buffer (called the history buffer) in a circular fashion until a value above a specified threshold is received on the designated input channel. It then fills a separate buffer (called the data buffer) and stops for the given dead time before resuming acquisition into a new history buffer. This mode needs additional software to be operational.

iii) Mode 2 - High frequency event driven acquisition with no low frequency data. Only the HF converter runs. It continuously fills a history buffer in a circular fashion until a value above a given threshold is received. It then fills a separate data buffer and stops for the given dead time before resuming acquisition into a new history buffer.

iv) Mode 3 - High frequency event driven acquisition with simultaneous low frequency acquisition. Both converters run continuously filling two history buffers (possibly different in size) in a circular fashion until a high frequency value above the given threshold is received. Then two separate data buffers (possibly different in size) are filled and both converters are stopped for the given dead time before resuming acquisition into new history buffers. In this mode, both converters run and the LF data are always recorded, but the HF data may or may not be recorded. In either case, the HF data defines the occurrence of an event.

3. HARDWARE SPECIFICATIONS

i) Hydrophone sensitivity: -187 dB ±1 re 1 volt/micropascals: 0 to 5 KHz

ii) Preamplifier sensitivity: +20dB±0.5: 3Hz to 4kHz

iii) Low frequency channels: four channels with six available antialias filters:

a) Low pass 4 pole (24 dB/octave roll off) tuned to 80, 200, 400, and 600 Hz

b) Band pass tuned to 3500 & 600 Hz

Gain ranging amplifier has five 12dB gain steps.

Analog to digital converter is 12 bit, offset binary code device. The least significant bit represents 0.0022 micropascals with a total dynamic range of 120 dB (thus allowing pressure waves from 0.022 micropascal to 2200 pascal in amplitude to be recorded). Digitization rates are software selectable with 230 different rates from 80 to 1500 samples/second.

iv) High frequency channel: one channel, the preconditioning for which is software selectable either to prefilter with channel #3 filter or filter band pass from 300 to 500 Hz and envelope detect for waterwave detection. The gain is software selectable, 4 steps 60, 66, 72, 80 dB. The analog to digital converter is 8 bit offset binary with digitization rates software selectable from 300 to 8500 samples/sec. in 247 steps.

v) Recording and Control: the recorder is a commercially available cartridge type using DC 300 XL magnetic tape cartridges. Format is 6400 BPI MFM and the recording capacity is 16.7 megabytes of (formatted) data in one lowering. Data acquisition and recording is controlled by a low power 1802 microprocessor with 64K bytes of memory.

vi) Power and Timing: Multiple lithium sulphur dioxide battery stacks supply enough power in the existing pressure case for a 21 day deployment. Time accuracy is 1 part in 10^9 supplied by an oven controlled crystal oscillator. Resolution of the real time clock is 20 microseconds

vii) Support: a TRS-80 micro-computer is used to load the operating program and task parameters and an HP 2100 converts data on the cartridge to standard 9 track tape format and also runs 1802 cross-assembler and simulator for instrument software development.

viii) Hardware: buoyancy is provided by six 19" glass balls each giving 50 lbs. buoyancy. Maximum operational depth is 6000m. Location and recovery by standard unmodified AMF acoustic transponder release system.

4. SOFTWARE SPECIFICATIONS

The system is operated by an assembly language program running on an RCA 1802 COSMAC microprocessor. There are available 64K bytes of memory of which

8K is allocated for the operating program and 56K for buffer storage. The memory has dual ports and it is planned in the future to split the 56K into two buffers each accessible by one of two processors. This will enable complex event detection algorithms to be implemented in the second processor using its own 8K program space.

The present program (ORAM9) occupies less than 4400 locations of the 8K program space to implement three of the four operating modes as described above. Within the 8K are included necessary operating parameters and tables to describe the tasks to be performed leaving a full 56K buffer space. The program uses the buffer so that tape writes always occur between acquisition cycles. This prevents recorder noise from affecting acquisition and also achieves good tape usage due to the long records. Typically 32K byte records are used which provides over 15 megabytes of data storage on a 450 ft. cartridge.

All software controllable functions are run-time selectable from tables which are loaded into memory to describe the tasks to be performed. Table II summarizes these functions.

When the operating program (see flowchart) is initially loaded and run, it idles checking the task list for tasks to do and the SAIL port for commands to be processed. During initialization a null list is produced so there are no tasks to be done until commands are received from the external processor via the SAIL port.

The SAIL port is a computer compatible port similar to RS-232 which is used for communication with the instrument. Through this port an external computer loads parameters and tables into the instrument's memory to describe the tasks to be performed. After verification of the parameters through the same port, the computer then commands the instrument to begin operation.

In operation, the instrument works sequentially through the task list to perform each specified task. For each task a table specifies the start and stop time and the mode of operation. The microprocessor verifies that the times are reasonable, sets up the system in the manner specified then enters a low power sleep mode until the start time occurs. At that point, the appropriate acquisition program (PROG 0, 1, 2, or 3) controls operation including tape writing until the stop time occurs. The program then returns to check the list for the next task as before.

When all tasks are completed or when the tape is full the program returns to checking for commands from the SAIL port. This enables communication with the instrument when recovered for purposes of data retrieval, system test or assignment of new tasks.

	TASK #	SOURCE	MODE	DATE TIME START	DATE TIME END	LF CHANNEL	HF CHANNEL	DEAD TIME or REP RATE	TOTAL NOS OF EVENTS	TAPE RECORDS
Deployment Example 1	1	airgun	3	1/1/83 0400	1/1/83 1600	250Hz sampling 80Hz LP antialias 4 sec. recorded before event 1 sec. recorded after event	1000Hz sampling Envelope detected/rectified 1 sec. recorded before event 1 sec. recorded after event	20 sec.	1200	175
	2	explosive	3	1/1/83 1700	1/2/83 0500	250Hz sampling 80Hz LP antialias 15 sec. recorded before event 1 sec. recorded after event	1000Hz sampling Envelope dectected/rectified 5 sec. recorded before event 1 sec. recorded after event	60 sec.	120	64
	3	passive monitoring	0	1/2/83 0600	1/15/83 0000	1000Hz sampling 400Hz LP antialias 2 secs. of data every 15 mins.	none	15 mins.	1224	157
Deployment Example 2	1	3.5kHz pinger	0	1/16/83 0400	1/16/83 0630	none	7.8kHz sampling 3.5kHz band-pass filter 1 sec. of data every 5 secs.	5 sec.	1860	453
Deployment Example 3	1	640Hz pinger	0	1/17/83 1200	1/17/83 1400	none	1800Hz sampling 640Hz band pass filter 2 sec. of data every 12 secs.	12 secs.	600	70
	2	watergun	3	1/17/83 1800	1/17/83 2400	1220Hz sampling 400Hz LP antialias filter 3 sec. recorded before event 0.5s recorded after event	1500Hz sampling Envelope detected/rectified 0.5s recorded before event 0.5s recorded after event	10 sec.	1080	364

TABLE I The DOBH in its existing configuration is capable of the listed example deployments

Table II

SOFTWARE CONTROLLABLE FUNCTIONS

Mode of operation - preprogrammed or event driven

Tasks - 1 to 5 per deployment (expandable)

Task start and stop time - year, month, day, hour, minute, second, counter 1, 2 (resolution 20 microsec)

Tape record size - 2K to 53248 bytes

Tape block size - up to record size

Low frequency section

- A/D rates: 80 to 1500 samples/sec
- multiplexer start, stop channels: 0, 1, 2, 3 (stop must be equal to or greater than start)
- number of samples per event: number of samples (2 bytes each) in history and data buffers

High frequency section

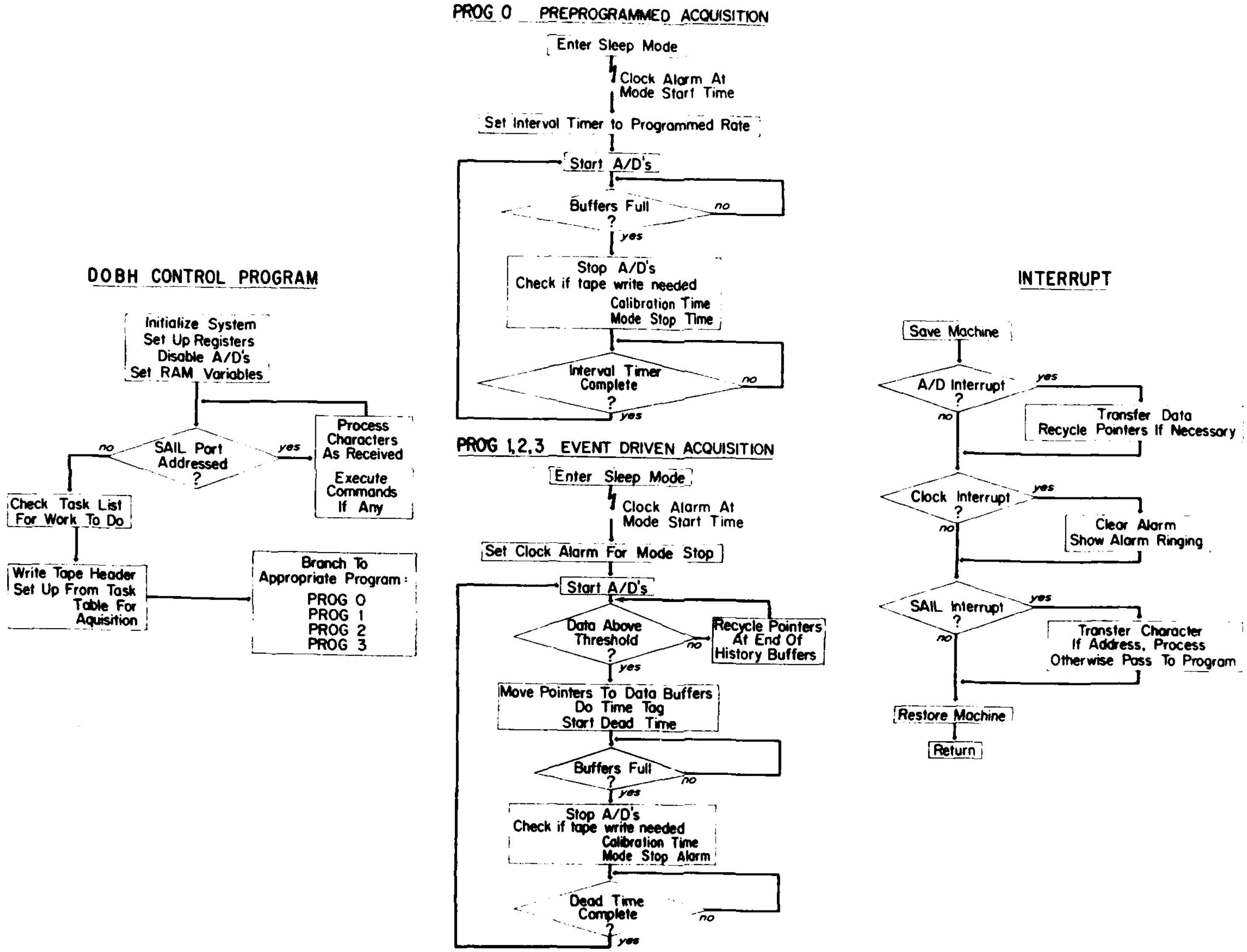
- A/D rates: 300 to 8500 samples/sec
- pre filter: in/out
- envelope detect: on/off
- gain: 20,26,32 or 40 dB
- event threshold: percent of full scale
- number of samples per event: number of bytes (1 byte/sample) in history and data buffers

Dead time - 1 to 64k seconds (about 18 hours) after each event

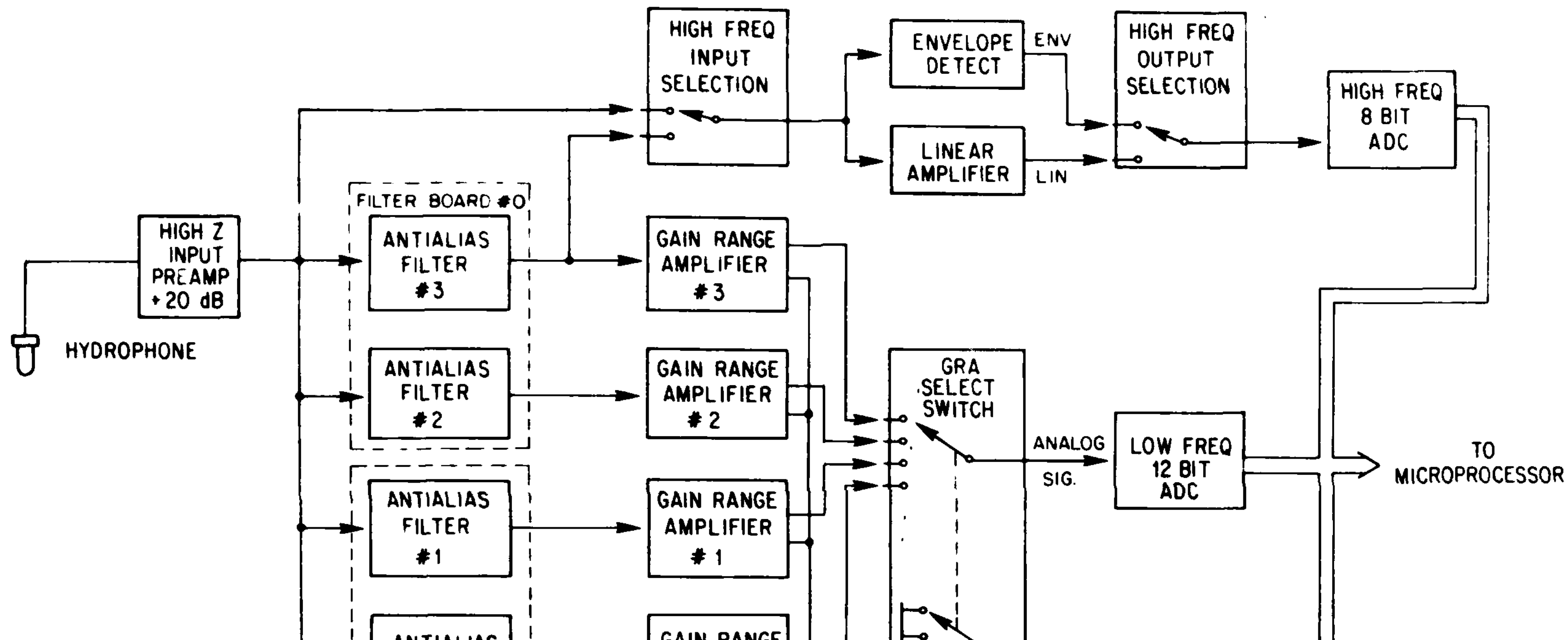
Calibration

- every "n" events
- number of HF samples for each of 12 seconds
- number of LF samples for each of 12 seconds

Timing - real time clock is set and checked with hardware/software combination which allows automatic computer controlled testing to 20 microsec resolution.



DOBH SOFTWARE FLOW DIAGRAM



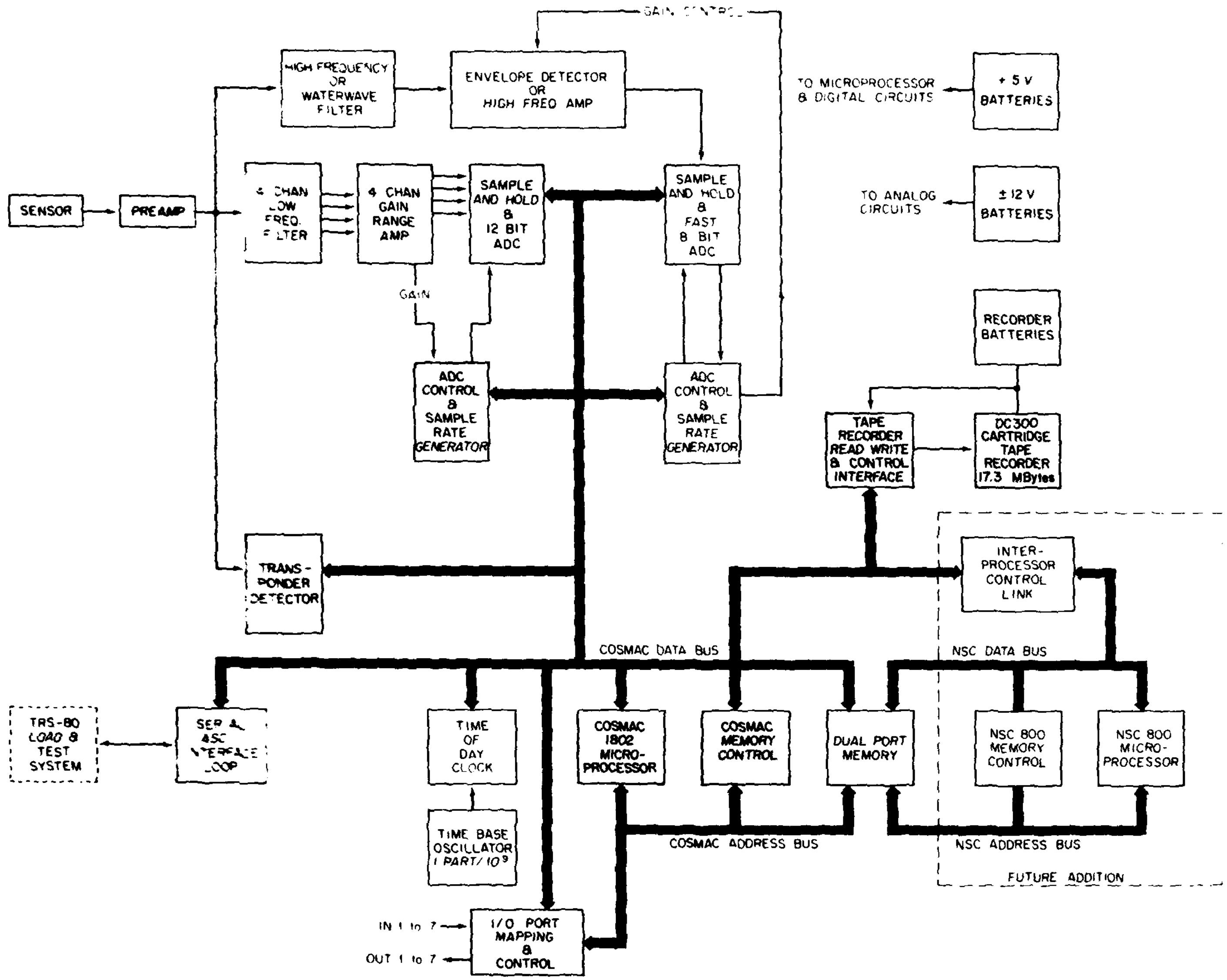
Antialias Filters can be constructed from 5Hz to 3.5KHz

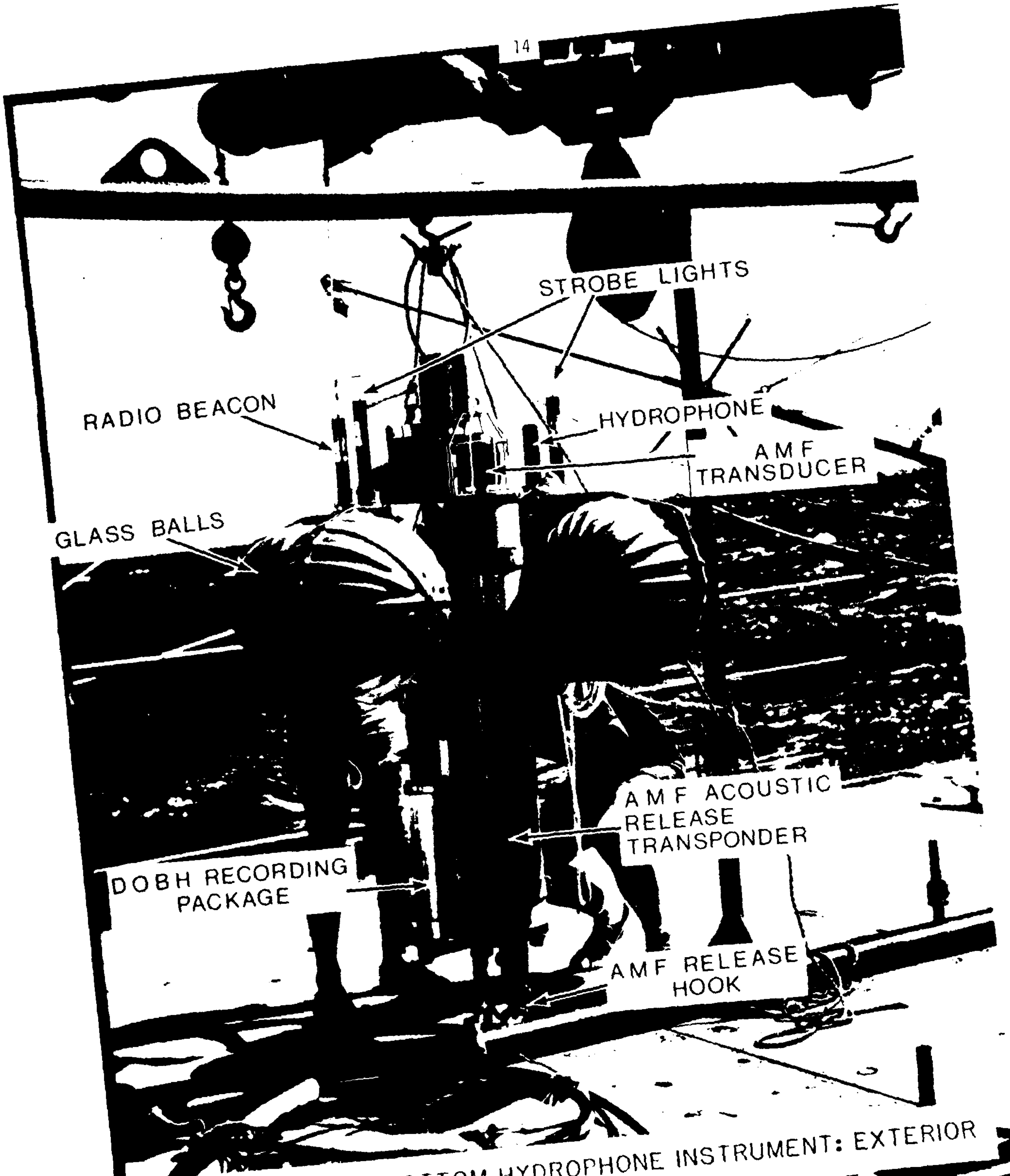
EXISTING FILTER BOARDS

S/N 1	FIL 0	80Hz	LOW PASS
	FIL 1	200Hz	LOW PASS
S/N 2	FIL 0	400Hz	LOW PASS
	FIL 1	600Hz	BAND PASS
S/N 3	FIL 0	600Hz	LOW PASS
	FIL 1	3.5KHz	BAND PASS

DIGITAL OCEAN BOTTOM HYDROPHONE
ANALOG ELECTRONICS BLOCK DIAGRAM

DIGITAL OCEAN BOTTOM HYDROPHONE ELECTRONICS





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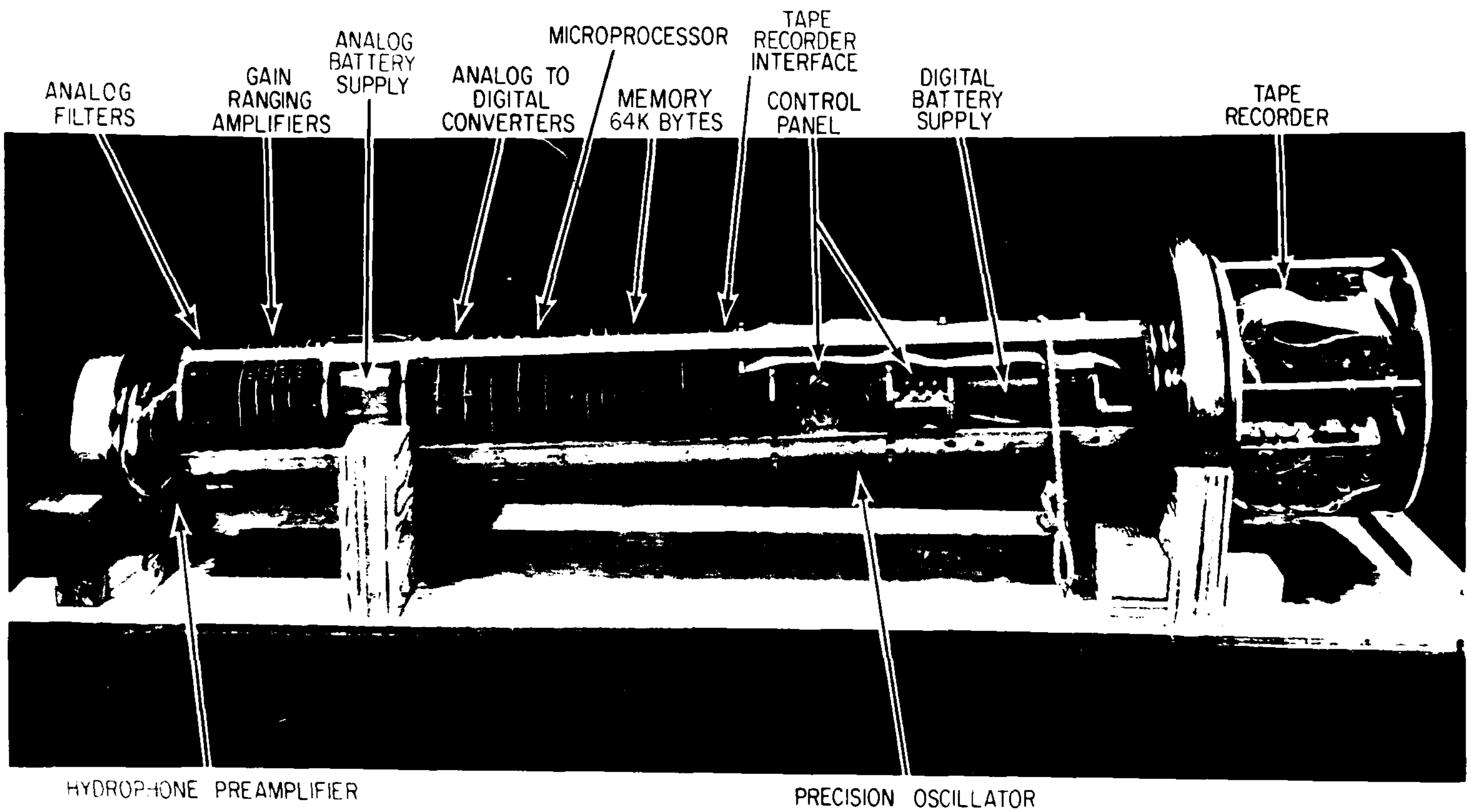

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THE WOODS HOLE OCEANOGRAPHIC INSTITUTION DIGITAL OCEAN BOTTOM HYDROPHONE INSTRUMENT by D.E. Koelsch, K.R. Peal, and G.M. Purdy. 15 pages. June 1982. Prepared for the Office of Naval Research under Contract N00014-82-C-0019, NR 083-004.

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