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A PORTABLE LISTENING AND RECORDING
SYSTEM FOR UNDERWATER SOUND

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Woods Hole, Massachusetts

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A PORTABLE LISTENING AND RECORDING
SYSTEM FOR UNDERWATER SOUND

(Under National Science Foundation Grant 6171)

William A. Watkins

APPROVED FOR DISTRIBUTION

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ABSTRACT

This report describes the Rowboat System, a compact, self contained portable listening and recording system designed and built at the Woods Hole Oceanographic Institution for listening to and recording underwater sounds in the frequency range of 30 to 30,000 cps. It is designed for animal sounds primarily. The system is all-transistor and includes a hydrophone-matching preamplifier, a 65-db amplifier, a record amplifier and bias oscillator, a meter and speech amplifier, and a 1000-cps speed reference oscillator. These are built around a commercial spring-wound tape deck and are battery powered. All are comfortable in a one-half cubic foot box.

INTRODUCTION

A complete underwater listening and recording system that is readily usable in a rowboat has many advantages in biological recording in the ocean. It can be used in places where large ships cannot go as well as making it possible to isolate oneself from the noise that such ships generate. Alternatively, since it requires no external source of power, it can be used from large ships where all machinery including generators and converters have been shut down. In recording and listening to porpoises and whales we have used the rowboat system from large ships, from remote docks, from a seaplane, and from small rowboats. This report describes the engineering and construction of the rowboat system.

ACKNOWLEDGEMENTS

The encouragement of William E. Schevill and the suggestions of Neil L. Brown are much appreciated. Mr. Schevill has given the stimulus for making the system usable in a small boat and has loaned the experience of many years of biological recording. Mr. Brown has made several valuable technical suggestions; his are the low frequency feed-back loops in the amplifier and the instruction on the utility of the small pot-core coils.

The work has been supported by a National Science Foundation Grant (6171, Environmental Cetology).

Construction of the record amplifier is on printed-circuit board (Figures 11 and 12) with plug-in connections for supply voltage, inputs and outputs. All coils are ferrite pot-cores (Ferroxcube No. K. 300047).

Channel II bias is only turned on when the "Mic" switch is on. Both bias oscillators are then locked in synchronization by tying the two emitters together.

METER AND SPEECH AMPLIFIER

The meter and speech amplifier is a separate amplifier used to raise the signal present at the output jack to a high enough level for convenient display on the "VU" meter (See Figure 3). It is designed to give a "flat" portrayal on the "VU" meter throughout the spectrum capable of being recorded on the tape. The meter is shunted to eliminate bias reading. Signal level indication is set by a resistance in series with the meter. Zero "VU" indicates a signal level of 0.05 volts rms, and is better than 12 db below distortion in the record amplifier (better than 18 db below tape saturation at 1000 cps). When switched to battery, the "VU" meter reads battery level. Zero "VU" indicates full 12 volts, minus one "VU" indicates 11 volts, minus two "VU" indicates 10 volts, etc.

The "Mic" switch connects the microphone input to this same amplifier and it then becomes the speech amplifier for recording on Channel II.

SPEED REFERENCE OSCILLATOR

The speed reference oscillator is a low power, stable,

1000 cps oscillator, used intermittently during recording to indicate relative tape speed during play-back (Figure 3). The frequency stability in this circuit depends largely on the physical characteristics of the pot-core (Ferroxcube No. K300102). Varying voltages or changes within components have little effect on frequency. (A drop of the supply voltage from 12 to 6 volts changes the frequency by two cycles). It draws 200 microamps at 12 volts.

The output of the speed reference oscillator is fed to the input of the mid-amplifier step attenuator, by-passing the first gain section of the main amplifier but retaining the possibility of controlling the level of the 1000-cps signal. This also permits the speed reference signal to be mixed with the signal being recorded. This oscillator is isolated (in a 2 in. x 2 in. x 2 in. box) for isolation purposes. It is built on Alden board and has one adjustment, a small trimmer for final frequency tuning.

TAPE TRANSPORT

The tape transport is driven by a spring motor (acquired from Amplifier Corporation of America) (Figures 1 and 2). It is crank-wound and runs 2-3 minutes (between windings) with good speed control at 15 ips. Speed is maintained by a centrifugal governor and a heavy flywheel (also by Amplifier Corporation of America). Practice is to keep the springs nearly fully wound by winding a turn every few seconds, in this way the flutter index can be maintained at less than 0.2%. The springs must, however, be kept unwound when not in use. Five inch reels are used, allowing a maximum of 7 1/2 minutes of

recording on tape 1 1/2 mil. thick.

POWER SUPPLY

The power supply is a common one for all functions and is composed of two parallel sets of two rechargeable alkaline cells (Eveready No. 560) giving 15 volts and 50 hours of operation.

A voltage regulator (zener diode controlled) keeps the power to the recorder at 12 volts. The total drain on the battery stack during two channel recording is 250 milliamperes, but only 20 milliamperes for the amplifier alone.

PLAY-BACK

The play-back circuit is only a test play-back. The signal from the head is fed to the amplifier side of the input attenuator. This allows attenuation of any noise due to an open circuit input to the preamplifier. The play-back signal is then amplified without equalization and fed to the output jack.

SWITCHING

The several functions of the system are selected by these controls:

On-Off = Main power supply switch, by-passed
only by "Amp. Only" switch.

Play-Record = Record position, connects all the
units for recording. Play position,
removes power from all units but the
amplifier and connects head to the
amplifier input.

Mic = Channel II control, supplies power to channel II bias oscillator and shifts the input of the meter amplifier from the main amplifier output to the microphone jack. (Meter amplifier now becomes the speech amplifier).

Amp. Only = Allows the main amplifier to be operated with all else turned off.

1 KC = Supplies power to the speed reference oscillator (operates only during "record"), and connects it to the input of the mid-amplifier attenuator.

"Vu" - "Batt." = Meter switch, for either signal monitoring or battery level indication.

Stop-Start = Controls the spring motor mechanically --- no electrical connections.

PARTS LIST

The Rowboat System is built of standard, generally available parts. The components listed here are those used in this system and it is not suggested that they are ideal -- only that they were available and appear to be satisfactory. The total cost of parts for the rowboat system is approximately \$300.

Pre-amplifier:

1	10K 0.1w resistor	
2	47K 0.1w resistor	
1	100K 0.1w resistor	
1	560K 0.1w resistor	
1	1 M Ω 0.1w resistor	
1	0.1 mf 150v capacitor	(Cornell Dubilier)
2	100 mf 15v capacitor	(Cornell Dubilier)
2	2N1309 transistor	(Texas Instrument)
1	Phone jack, 3 conductor	(Switchcraft No. 12B) (IN)
1	Connector, 12 contact	(Amphenol No. 143-010-01)

Amplifier:

1	1 ohm 0.1w resistor	
3	100 ohm 0.1w resistor	
1	100 ohm (wire wound) 0.25w resistor	
1	560 ohm 0.1w resistor	
1	1K (wire wound) 0.25w resistor	
1	2.2K 0.1w resistor	
1	2.7K 0.1w resistor	
2	3.3K 0.1w resistor	
1	4.7K 0.1w resistor	
2	8.2K 0.1w resistor	
2	10K 0.1w resistor	
1	10K (wire wound) 0.25w resistor	
1	12K 0.1w resistor	
1	15K 0.1w resistor	
1	39K 0.1w resistor	
1	82K 0.1w resistor	
1	10 mf 15v. capacitor	(Cornell Dubilier)
4	100 mf 15v. capacitor	(Cornell Dubilier)
1	225 mf 10v. capacitor	(Cornell Dubilier)
1	0.001 mf Mica capacitor	(Cornell Dubilier)

Amplifier Cont.

5 2N1309 transistors (Texas Instruments)
1 Phone jack 2 conductor (OUT)
1 Single pole, three position switch
1 10K, 2 db per step, 40 db attenuator
(last step infinity) (Daven CP-120M.)
1 Connector, 10 contact (Amphenol No. 143-010-01)

Channel I

Record Amplifier Bias Oscillator

1 19 ohm 2w resistor
1 47 ohm 0.5w resistor
1 47 ohm 0.1w resistor
2 1K 0.1w resistor
1 1.2K 0.1w resistor
1 1.5K 0.1w resistor
1 2.7K 0.1w resistor
1 12K 0.1w resistor
1 15K 0.1w resistor
1 39K 0.1w resistor
1 0.0005 mf Mica capacitor
3 0.001 mf Mica capacitor
1 0.005 mf Mica capacitor
1 0.02 mf Mica capacitor
1 0.2 mf 50v. capacitor
1 2.mf 50v. capacitor
1 100 mf 15v. capacitor
2 100 mf 25v. capacitor
1 225mf 10v. capacitor
1 2N1309 transistor (Texas Instruments)
1 2N301 transistor " "
3 Pot core coils (Ferroxcube No. K300047)
1 Connector, 10 contact (Amphenol No. 143-010-01)

1 Three pole, 2 position switch (Play-Record)
1 "Crown" two-track record head (B822)

Channel II

Record Amp. and Bias Osc. is identical but with these additions:

1 Diode (Sarkes Tarzian No. F4)
1 Double pole, single throw switch (Mic)
1 Phone jack 2 contact (Mic)

Meter and Speech Amplifier

- 1 100 ohm 0.1w resistor
- 1 2.2K 0.1w resistor
- 2 3.3K 0.1w resistor
- 3 10K 0.1w resistor
- 1 47K 0.1w resistor
- 1 56K 0.1w resistor
- 1 120K 0.1w resistor
- 1 0.01 mf 50v. capacitor (Meter shunt)
- 3 100 mf 15v. capacitor
- 2 2N109 Transistors
- 1 "VU" meter miniature with 6K shunt removed (Lafayette)
- 1 Single pole, single throw switch (Meter)

Speed Reference Osc.

- 1 15K 0.1w resistor
- 1 22K 0.1w resistor
- 1 27K 0.1w resistor
- 1 47K 0.1w resistor
- 1 0.002025 mf Mica capacitor
- 1 0.000045 mf variable capacitor
- 1 0.1 mf 50v. capacitor
- 1 100 mf 25v. capacitor
- 1 2N109 transistor
- 1 Double pole, single throw switch (1 Kc)
- 1 Pot core (Ferroxcube No. K300102)

Power Supply and Voltage Regulation

- 1 820 ohm 0.1w resistor
- 1 2N 1907 transistor (Texas Instruments)
- 1 Heat sink for transistor (Birtcher No. 3B-663)
- 1 IN 1524A Zener diode (International rectifier)
- 4 7.5v. Eveready No. 560
(Rechargeable alkaline cells)
- 1 Double-pole, double throw switch (ON-OFF)
- 1 Single-pole, single throw switch (Amp. Only)

Tape Transport

The mechanical parts of a spring driven tape deck by Amplifier Corp., of America (Model 610-E) including the following:

Spring-wound motor and governor assembly
Capstan and flywheel for 15 ips
Pressure roller
Tape guides
Reel platforms

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FIGURE 1. TOP VIEW OF ROWBOAT RECORDER

FIGURE 2. BOTTOM VIEW OF RECORDER CHASSIS

FIGURE 3. FREQUENCY RESPONSE CURVE OF ENTIRE ROWBOAT SYSTEM

FIGURE 4. CIRCUIT DIAGRAM OF CHANNEL I OF THE ROWBOAT SYSTEM

FIGURE 5. CIRCUIT DIAGRAM OF CHANNEL II OF THE ROWBOAT SYSTEM

FIGURE 6. PRINTED-CIRCUIT LAYOUT FOR PREAMPLIFIER

FIGURE 7. COMPONENT LAYOUT FOR PRINTED-CIRCUIT CONSTRUCTION OF PREAMPLIFIER

A = IN
 B = -12 v.
 C = HI
 D = LO
 E = IMP. OUT
 F = ATT. OUT
 H = ATT. IN
 J = ATT. COM.
 K = +12 v.
 L = OUT

CONTACT SPACING FOR AMPHENOL CONNECTOR # 143-010-01.
 IN THE ROWBOAT SYSTEM THE C IS NOT USED & D & E ARE
 SHORTED TOGETHER.
 CONTACTS C, D, & E PROVIDE A MEANS OF BY PASSING THE FINAL STAGE
 OR SWITCHING IT IN AS DESIRED (THIS GIVES A CHOICE OF OUTPUTS WITH
 HIGH IMPEDANCE & LOW BATTERY DRAIN OR LOW IMPEDANCE &
 CORRESPONDINGLY LARGER BATTERY DRAIN.)

FIGURE 8. PRINTED-CIRCUIT LAYOUT FOR AMPLIFIER

FIGURE 9. COMPONENT LAYOUT FOR PRINTED-CIRCUIT CONSTRUCTION OF AMPLIFIER

WOODS HOLE OCEANOGRAPHIC INSTITUTION

Reference No. 62-36

A Portable Listening and Recording System for

Underwater Sound

(The Rowboat System)

William A. Watkins

ERRATA

Figures 10, 11, and 12 are mixed and therefore appear with erroneous captions.

The last figure, Figure 12, should appear with the caption on Figure 10.

Figure 10 should appear with the caption on Figure 11.

Figure 11 should appear with the caption on Figure 12.

FIGURE 10. EQUALIZATION CURVE OF RECORD AMPLIFIER

FIGURE 11. PRINTED-CIRCUIT LAYOUT FOR RECORD AMPLIFIER AND BIAS OSCILLATOR

EQUALIZATION CURVE OF RECORD AMPLIFIER

FIGURE 12. COMPONENT LAYOUT FOR PRINTED-CIRCUIT
 CONSTRUCTION OF RECORD AMPLIFIER AND BIAS
 OSCILLATOR

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