JOB COMPLETION REPORT

Investigations Project

FILE

State of TEXAS

Project No. F2R5 Name: Fisheries Investigations and Surveys of the Waters of Region 6-B.

Job No. E-3 Title: Underwater Observations of the Fish Populations of Lake - Travis including the Effects of Various Sound Frequencies on the Fish Populations.

Period Covered: February 1, 1957 through January 31, 1958

ABSTRACT:

Equipment for transmitting controlled frequency sound as well as a system for recording and transmitting selected surface and sub-surface sounds has been developed. Inclement weather, floods, and turbid water limited both underwater observations by the diving team and field experimentation with the sound equipment. The limited work done with underwater sound indicated that small black bass and bluegill sunfish were apparently attracted by frequencies in the 600 cps to 14 kc range.

One large school of white bass including individuals ranging in size from 10 to 19 inches was observed at a depth of 60 feet during a sustained dive made during the segment period.

Recommendations include the need for continued work on the effects of underwater sound of fish and the expansion of the work locality to include all clear water lakes in Central Texas.

OBJECTIVES:

During previous segment periods it was found that several fish species are apparently attracted by underwater sounds. Short, sharp noises were particularly effective in attracting fish and at least one sound seems to repel some of the Centrarchid fishes.

A variable frequency sound will be produced and projected through a water proof speaker to ascertain the effect of different frequencies and volumes on a fish population.

The work will be carried out below ten feet where surface noises have little effect.

Visual observations will be used to determine the effect of the various frequencies.

If any frequency or frequencies are found to be effective in attracting fish, these sounds will be tested further.

In addition general observations will be conducted on fish activities, habitat requirements, and behavior patterns.

PROCEDURE:

A two man diving team was used to observe fish in Lake Travis, using the same techniques as in the previous segments. Slow exploration of shoreline areas from the surface to a depth of 70 feet provided the most information on fish activity.

Because of limited field work and testing of methods involving sound equipment, observations on technique and procedure are included in the Equipment and Discussion portions of this report.

EQUIPMENT:

Diving equipment used during the segment period is essentially the same as that acquired under Job E-1, Project F-2-R-3 and Job E-2, Project F-2-R-4. Three cold water garments of the "wet suit" type were obtained in November, 1957 and appear to be superior to the dry suits previously used for winter diving. Photos 1. and 2. show essential diving gear for summer and winter diving.

The necessary equipment for experimental work on underwater sound was commercially unavailable and had to be constructed by project personnel. Equipment to transmit sound underwater over a frequency range of 15 kc was designed and built.

The unit consists of a U. S. Navy hydrophone bought on the war surplur market, used sound projector, with a transistorized oscillator and amplifier for frequency control and amplification. The entire unit is powered by one twelve volt, 60 ampere-hour battery giving over fifteen hours of continous operation from a fully charged battery.

Although the oscillator was calibrated and dial settings used for frequency selecti in the preliminary work, it was later found that the oscillator would not hold calibration and would vary as much as 200 cycles with changes in temperature or position. An audio frequency meter, designed to show frequency output, was incorporated into the unit for greater accuracy.

The hydrophone, for sound projection, is a piezoelectric device composed of 20 barium titanate cylinders encased in a waterproof rubber sleeve. The hydrophone is cylindrical, measuring 42 inches in length with a diameter of 1 3/4 inches. Frequency response is nearly uniform from 200 to 15,000 cycles.

The oscillator will generate frequencies from 60 to 15,000 cycles although the range is not complete and some intermediate frequencies are not produced. The amplifier is capable of amplification over the entire 60 to 15,000 cps range with an approximate eight watt output. Sounds produced by the unit are audible for several hundred feet in an air media and over 2,000 yards underwater.

Although any form of oscillator-amplifier system could be utilized transistorized systems were used for portability and compactness. Excluding the battery, the entire unit weighs less than 25 pounds. Diagram 1, illustrates the basic circuit and Photo 3. shows the complete transmitting unit.

In addition to the unit for producing controlled frequency sound, other equipment has been obtained. A Wollensak tape recorder was purchased to be used for recording underwater sounds and for transmitting various surface and subsurface sounds to determine their effect on fish behavior.

The specifications of the recorder include a frequency response of 40 to 15,000 cps, ± 3 db at a tape speed of 7½ inches per second.

The tape recorder operates on 110 volts a-c but by using an inverter the machine will operate from the 12 volt battery, making it portable for field use.

Since the recorder had a similar frequency response to that of the hydrophone, it was only a matter of matching the impedences of the two units to obtain maximum power transfer. In this system the hydrophone functions as an underwater speaker and will transmit recorded sounds with considerable intensity and fidelity.

The unit for recording underwater sounds, using the hydrophone as an underwater microphone is slightly more complicated and not yet complete. A pre-amplifier to convert the high current-low voltage output of the hydorphone to the high voltage-low current input of the tape recorder is being constructed.

Diagrams 2 and 3 illustrate basic circuits for the underwater recording systems and the underwater transmitting unit. Photo 4. shows the equipment necessary for recording and transmitting underwater sounds.

DISCUSSION:

Inclement weather, floods, and turbid waters in Lake Travis curtailed diving activity and field testing of the sound producing device. In addition, trial and error methods of equipment construction consumed a great deal of time. No plans for the equipment were found and the various components of the sound unit were constructed, tested, and often rebuilt several times to attain the range and fidelity desired.

During the segment period six trips were made to Lake Travis for experimental work with the sound unit. Of the six field tests three were primarily equipment checks to test underwater audio intensity and to find defects in the unit.

The first test was conducted on July 7, 1957. The hydrophone was suspended approximately five feet below the surface and sounds of varying frequencies were projected at maximum volume. Two skindivers descended below the surface at varying distances from the sound source. The maximum distance travelled from the hydrophone was approximately 2,000 yards where the higher frequencies were distinctly audible. At the 2,000 yards range frequencies below four kc were heard only indistinctly and intermittantly. One dive was made at a point where a small peninsula extended between the divers and the sound source at a range of approximately 1,500 yards. The transmitted frequencies were still audible, undoubtedly the result of reflection from the lake banks, bottom, and solid underwater objects.

Immediately below the surface, where surface noises could still be heard, the transmitted sounds were more indistinct, whereas from five to ten feet below the surface where the ambient noise level is negligible, the sounds were quite sharp and clear.

It was found that a sound composed of rapidly changing frequencies was much easier to detect and appeared to have greater volume than one constant pure tone.

On July 12 the apparatus was again tested, with appreciably the same results. On July 13 the unit was put in operation and left on for a period of slightly over two hours. The output transformer in the amplifier was not heavy enough for this continuous operation and it short-circuited, burning out two power transistors and the output transformer. A new, heavier, transformer was wound and the amplifier was rebuilt to withstand the continuous use required.

In September the sound unit was put in operation from a floating dock in Lake Travis where a group of fish composed of small black bass, bluegill sunfish, and Rio Grande perch were visible from the surface.

The hydrophone was lowered to a depth of two feet below the surface and suspended horizontally. The small fish surrounding the dock were immediately attracted to the hydrophone although no sound was being produced. It appeared that the fish were curious as well as hungry and would respond to any object placed in the water. The attraction was only temporary and after a brief flurry around the hydrophone the fish population ignored it and returned to normal activity.

After several minutes of silence to allow the fish to become accustomed to the hydrophone, the unit was activated at a frequency of 600 cycles. The small black bass and sunfish were apparently attracted to the sound and approached to within inches of the hydrophone. The constant 600 cycle tone appeared to lose its attractive quality in a very short time since the fish disregarded the sound source within five minutes. However, when the frequency was raised to approximately 5 kc the fish once again were attracted. The frequency control was rotated rapidly back and forth through a 600 cps to 12 kc range, producing a vacillating sound which apparently had the greatest sustained attraction for these species, since many fish were observed in the immediate vicinity of the hydrophone during the entire period of rapid frequency fluctuation.

It was also observed that these fish were sensitive to frequency changes of less than 200 cps in certain frequency ranges. Fish were attracted with a 600 cps sound, and the unit transmitted this frequency until the fish disregarded the hydrophone and resumed normal activity. The oscillator was then tuned to slightly under 800 cps and the fish immediately returned to the sound source. The minimum frequency variation which could be distinguished by the Centrarchid bass and bluegill sunfish was not determined although it is probably somewhat under 200 cps.

Two interesting reactions of black bass and bluegill sunfish to the sound source were observed. It was noted in all tests with the unit that the majority of fish visible in the vicinity reacted to the sound by orienting themselves head foremost toward the source, seldom changing position. This alignment to sound has been noted by others working with underwater sound, but the reason for this behavior is apparently unknown.

While transmitting an undetermined frequency above 6 kc, a nine inch black bass approached the hydrophone and swam the length of the instrument with one side pressed against the vibrating surface. Although the sound was continued at the same level this behavior was not repeated.

No frequency transmitted during these preliminary tests appeared to have any visible effect on the Rio Grande perch in the area since no departure from normal activity was n. .d.

Two additional field tests were made in the same location and roughly the same procedure was followed. Appreciably the same reactions were noted on all tests.

No actual experiments have been conducted with the underwater recording system. Various tests have been run to find limitations of equipment and recording quality. Several recordings of known underwater sounds have been made and the recorded material appears to have good fidelity although one limitation of the system is the inability to accurately check the fidelity of the recordings.

Procedures to derive maximum information from experiments with the sound equipment have not been fully worked out and much more field work will be necessary to find the best methods of gaining useable data. However, at the present time, it is felt that preliminary work will have to include visual observations of fish reaction by SCUBA equipped divers.

The project plans included continued underwater observations by SCUBA equipped divers. High turbidity in Lake Travis curtailed diving activity and only one extended exploration was made. During a brief period of water clarity in September, one dive was made to a maximum depth of 70 feet along a rocky bluff at the mouth of Hurst Creek. Approximately 200 yards of shoreline were covered and unusually large numbers of fish were seen. Visibility on a horizontal plane never exceeded six feet at any depth but remained nearly constant at all depths. All observed fish were below 25 feet with the exception of four bluegill sunfish seen at 10 feet.

At sixty feet below the surface the divers encountered a school of white bass. The fish were moving quite rapidly and paid little attention to the divers. The school was composed of thousands of individuals of various size groups, ranging from small fish under 10 inches in length to larger specimens of at least three pounds. Four black bass were observed moving with the whites. The whites could be seen to the limits of visibility on both sides of the divers and covered a vertical distance of approximately five feet. The individuals in the group were swimming so close together that collisions between fish were common. Although moving rapidly the school took almost four minutes to pass the diving team. No attempt was made to count or estimate accurately the numbers in the group since the total width of the school could not be determined because of limited visibility.

In addition to the school of whites, many black bass were seen, usually in groups of three to ten. The majority of the black bass seen were below 40 feet. These fish ranged in size from approximately eight to 17 inches in total length with the majority in the eight to eleven inch size range.

Of the two divers who regularly accompanied the assistant project leader on underwater work, one resigned on September 30, and one has been on a part time basis since September 15, and unavailable for diving activity. Consequently the few dives which were made after September 30, 1957 were made primarily to train new personnel. Excessive turbidity has limited visibility to such an extent that even on practice dives visibility average less than two feet and no fish were encountered.

RECOMMENDATIONS:

Work during the segment was too limited to draw valid conclusions on the effectiveness of underwater sound for attracting fish. It is felt that the results, of the limited tests

made were interesting enough to warrant further experiments with the sound equipment and it is recommended that the study be continued.

It is also felt that much time was lost because the underwater work was confined to Lake Travis, which stayed extremely turbid throughout most of the year. To prevent a recurrence of this situation it is further recommended that the location for underwater work be expanded to cover any clear water lake in Central Texas.

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Approved by: Marion Toole
Chief Aquatic Biologist

Date: April 24, 1958

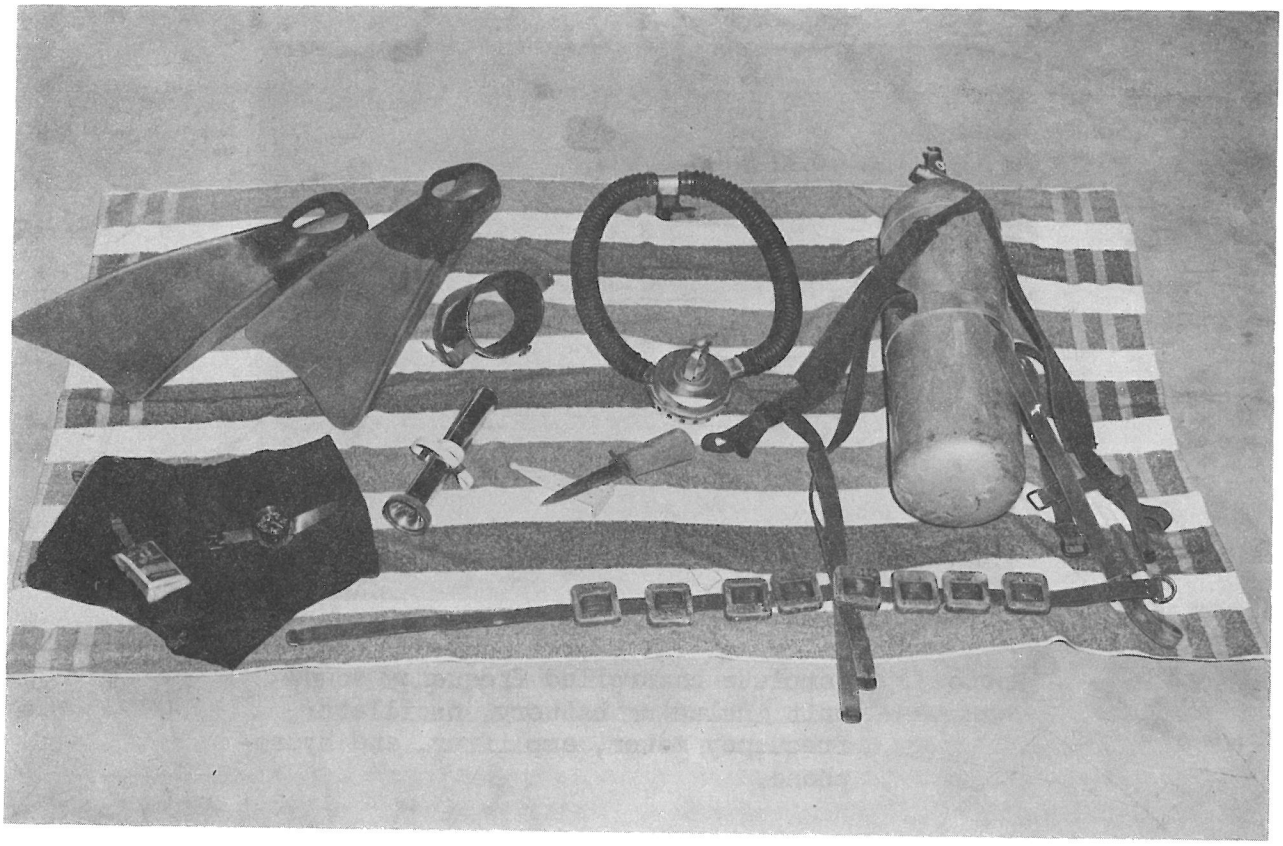


Photo 1. Equipment necessary for summer diving.

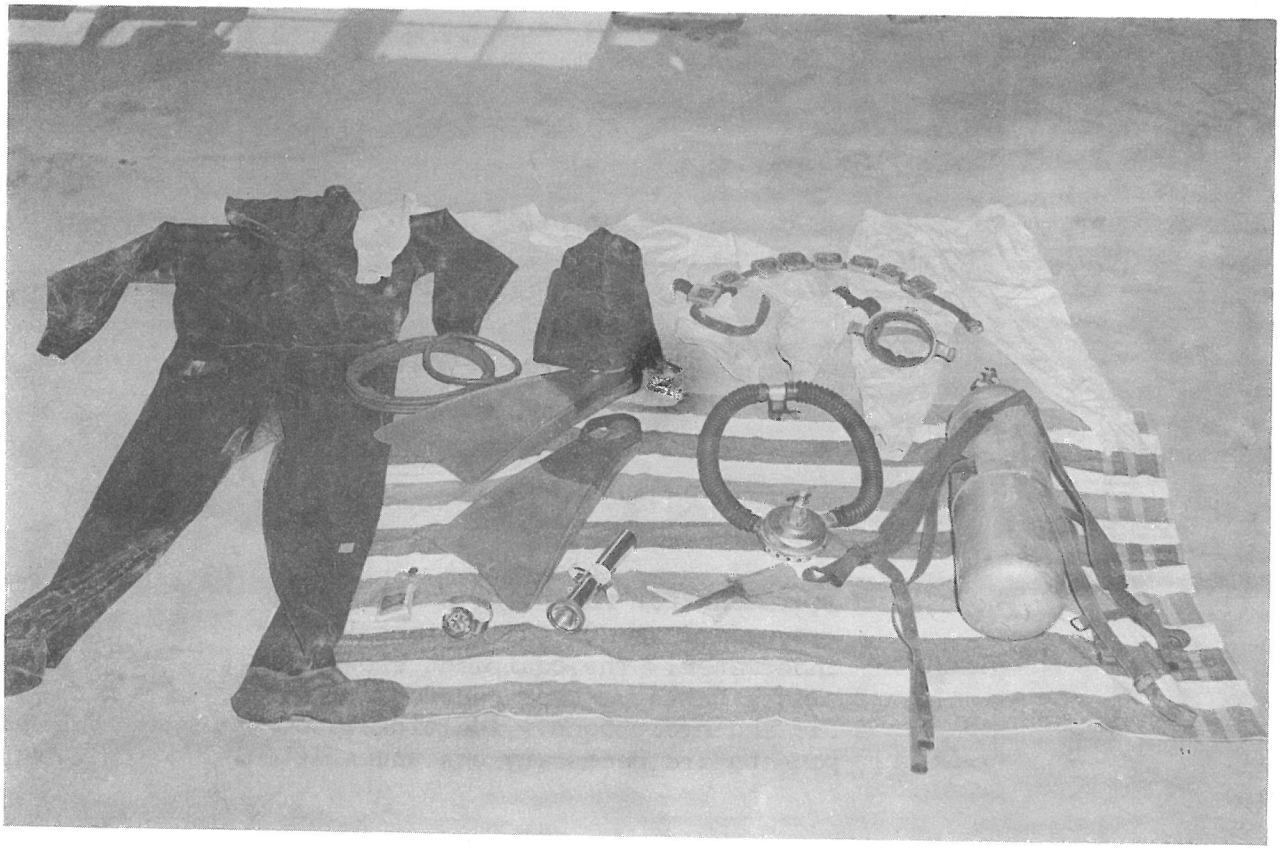


Photo 2. Equipment necessary for winter diving.

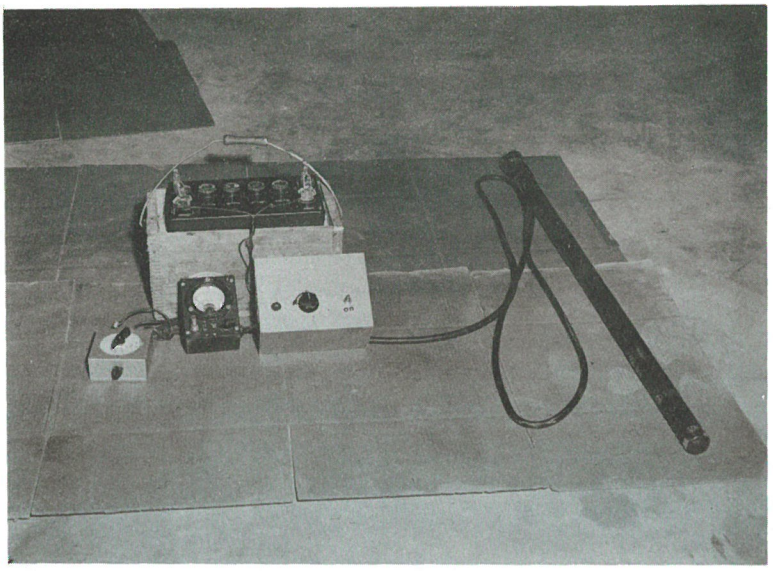


Photo 3. Complete controlled frequency sound unit including battery, oscillator, frequency meter, amplifier, and hydrophone.

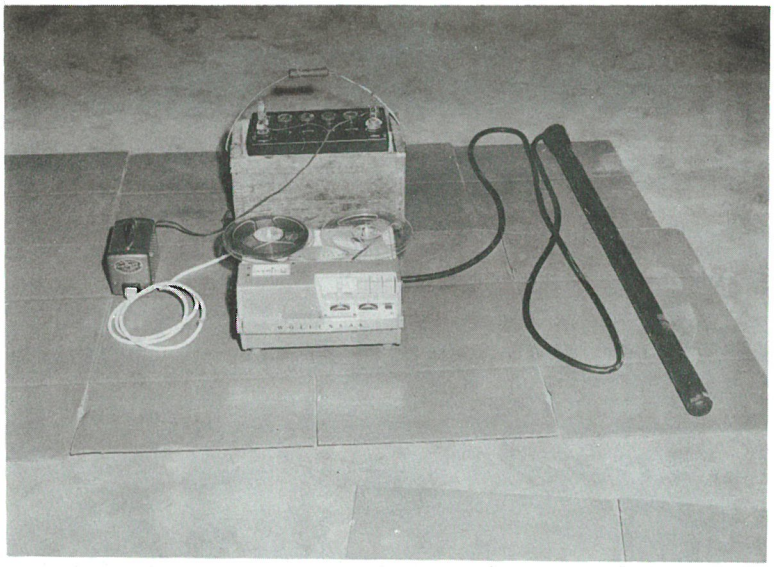


Photo 4. Equipment for recording surface and subsurface sounds and retransmitting underwater. The equipment shown includes battery, tape recorder, inverter and hydrophone. Additional components are necessary but uncompleted.

DIAGRAM 1. CONTROLLED FREQUENCY TRANSMITTING UNIT

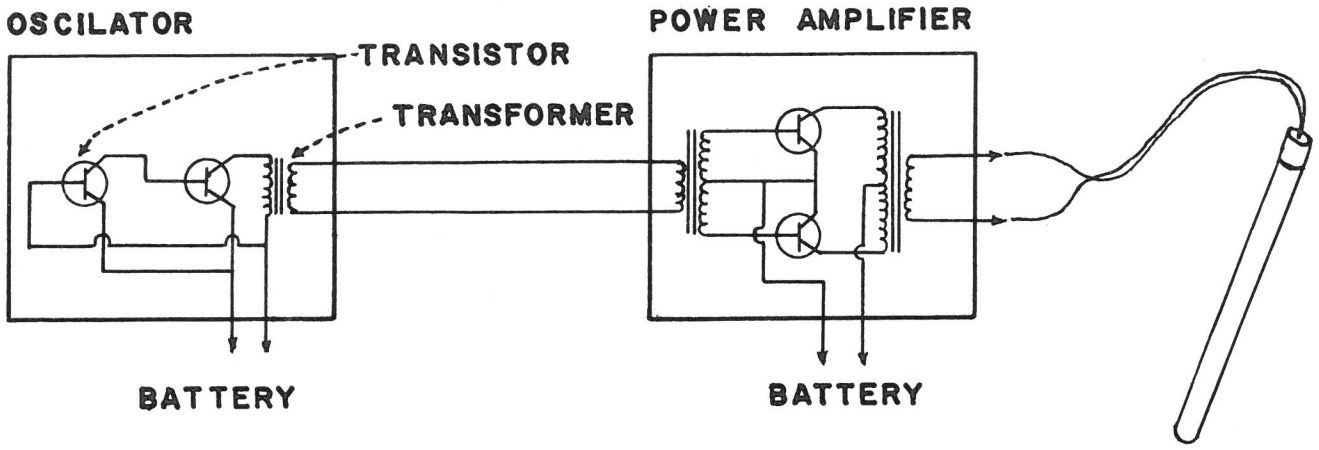
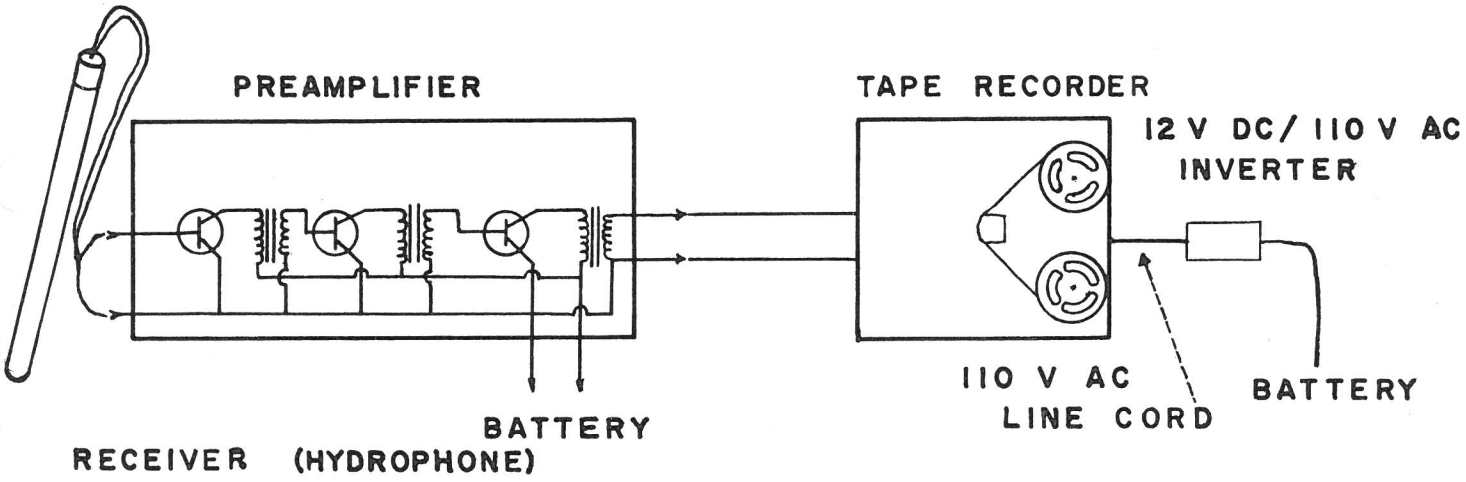


DIAGRAM 2. TAPE RECORDER WITH UNDERWATER RECORDING DEVICES



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