BUILD THE MARINELIFE ACOUSTIC SENSOR

Eavesdrop on the sounds of the deep with this simple, handheld device!

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In truth, the silent deep is far from silent—the raucous deep would be a better name. Most of us are aware that marine mammals make sounds or noise for communication, searching for food, self-defense, or other reasons. Shrimp, for example, make a clicking or popping sound that might be caused by the movement of the parts of their shells, legs, or jaws. A certain breed of fish, called a Drum, makes a sound very much like, well, a drum.

Man-made devices, such as boat motors and ship engines add to the noise of the marine environment. In fact, the oceans are so filled with sounds and noises, it can be difficult (or impossible) to determine what the various noises are. A safe assumption is that any marine life that is much larger than a microscopic organism will make noise.

A swimmer or diver in the ocean will not hear much in the way of sound, except perhaps during a close encounter with a medium or large marine mammal such as a whale or dolphin. The sound is there, but we can't hear much of it because our ears are designed to work in air rather than water.

Most of us have heard of the marine-sonar and passive-listening devices that were developed before World War II. Their use was, and is, essential in both submarine and anti-submarine warfare. It is known that schools of fish and marine mammals would often foul up those sonar operations. We can use that fact to listen to, or eavesdrop, on the denizens of the deep.

The MarineLife Acoustic Sensor project described here is an electromechanical listening device that works on the same principle as the passive sonar devices in submarines. It has the same basic components: an acoustic transducer, a high-gain amplifier, and connections for headphones, speakers, or a tape recorder. It is small, lightweight, compact, and battery operated. Those features make it easy to use the MarineLife Acoustic Sensor in a large boat, a small boat, a rowboat, or even a canoe. You can even use it off a pier or a bridge.

About The System. The MarineLife Acoustic Sensor is built around an LM386 high-gain audio amplifier. That IC is able to drive a 4-, 8-, or 16-ohm speaker or headphones with at least 250 mW of power.

The tricky part of the system is the receiving transducer. It will be immersed in a hostile saltwater environment, so it must be waterproof. A regular microphone could be made waterproof, but that would interfere with the microphone's sensitivity. Any transducer for listening to underwater sounds must be quite sensitive, so a waterproofed microphone would be useless for our needs.

However, a device exists that is almost perfect for the job at hand. It is a piezo-electric transducer, which is usually used to make sound. It can also act as a sound receiver. It consists of a thin, round, brass disc, a little under 1½-inches in diameter. Bonded to the surface of

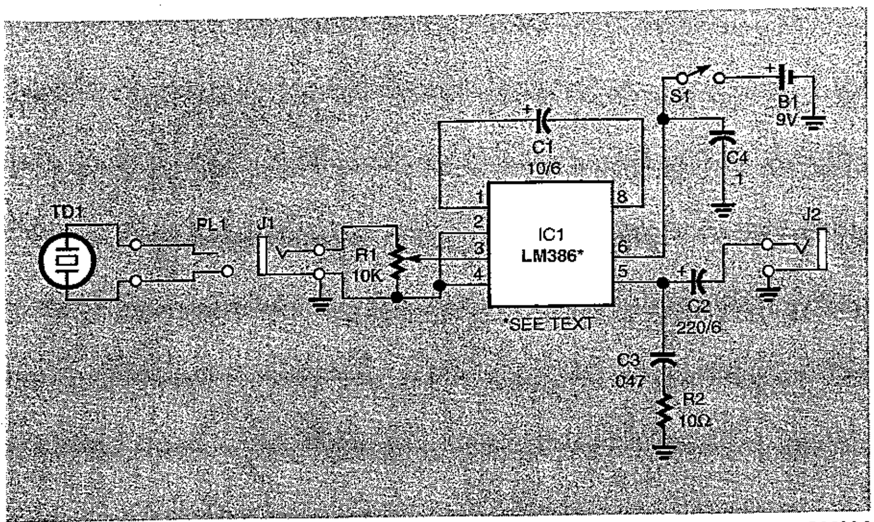


Fig. 1. The MarineLife Acoustic Sensor is a simple headphone amplifier built around an LM386 amplifier chip. A piezo-ceramic transducer picks up sound from the water. There are two different versions of the LM386, depending on what voltage battery you will be using.

PARTS LIST FOR THE MARINELIFE ACOUSTIC SENSOR

Capacitors

C1—10-µF, 6-WVDC, electrolytic
C2—220-µF, 6-WVDC, electrolytic
C3—0.047-µF, ceramic-disc
C4—0.1-µF, metal-film

Resistors

R1—10,000-ohm potentiometer (integral with S1—see text)
R2—10-ohm, ¼-watt, 5% carbon-film

Additional Parts and Materials

IC1—LM386N-1 or LM386N-3 audio amplifier, integrated circuit (see text)
B1—6- or 9-volt battery
J1, J2—Mini stereo or mono phone jack
S1—Single-pole, single-throw switch (integral with R1—see text)
TD1—Piezo-ceramic disc, see text
Battery clip, case (RadioShack 270-211 or similar), label, knob, PC board, potting compound, wire, solder, hardware, etc.

the brass disc is a thin ceramic wafer of barium titanate. The wafer is coated with a thin layer of silver that forms a second contact. Like a quartz crystal, the barium titanate will physically vibrate when an AC signal is applied to it. It will also generate a voltage when pressure is applied to it—just like a microphone. That piezo-electric effect is perfect for a waterproof acoustic sensor. With a cable attached to the two plates (the brass and the silver), we can amplify the generated voltage and hear the vibrations that are striking the sensor. Encapsulating the sensor with an insulating and waterproofing material will ressult in a marine acoustical transducer. It will be very sensitive, waterproof, and able to withstand the harsh saltwater environment of the ocean.

About The Circuit. The schematic diagram in Fig. 1 shows that the heart of the circuit is, as previously mentioned, IC1, an LM386 audio-amplifier IC. The inverting input is grounded and the input signal from J1 is fed to the non-inverting input through volume control R1. The overall gain of IC1 is set by C1. The output, pin 5, is AC-coupled to J2 by C2. The output of IC1 is bypassed to ground with C3 and R2. That will prevent radio-frequency interference from affecting the circuit. Additional protection from AC signals is provided by C4.

Construction. The circuit for the MarineLife Acoustic Sensor can be built on either a perfboard or a printed-circuit board. If you choose to use the PC board approach, a foil pattern has been provided. Should you choose to use the foil pattern, the parts-placement diagram in Fig. 2 should be followed for the correct component location and wiring.

The usual precautions for handling semiconductors should be followed during assembly. Be sure to observe the polarity of the electrolytic capacitors when inserting them into the PC board. If those components are installed backwards, the circuit will be destroyed and the capacitors might explode!

There are two versions of the LM386 that can be used in the MarineLife Acoustic Sensor. The LM386N-1 is rated for a 250-mW output with a 6-volt supply, while the LM386N-3 can put out 500 mW at 9 volts. The LM386N-1 will draw

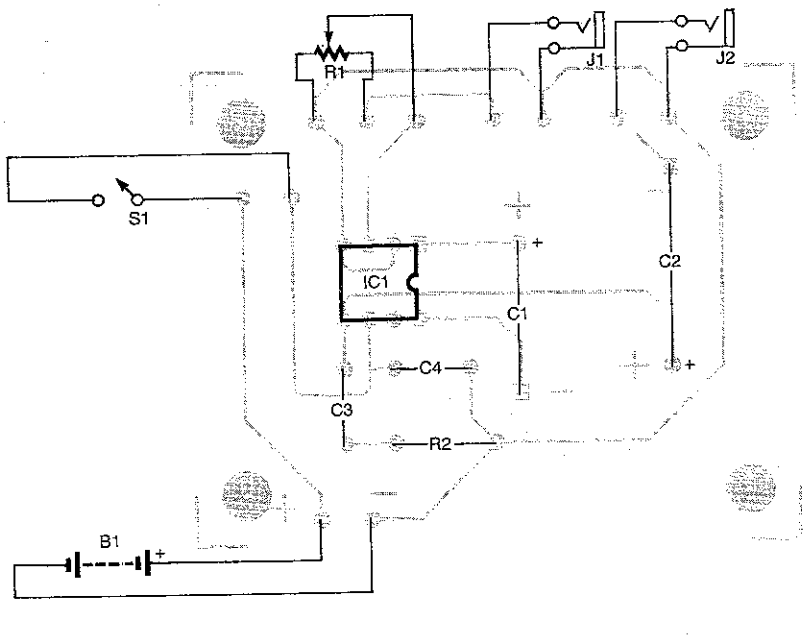


Fig. 2. Use this parts-placement diagram if you are going to use the foil pattern included here.

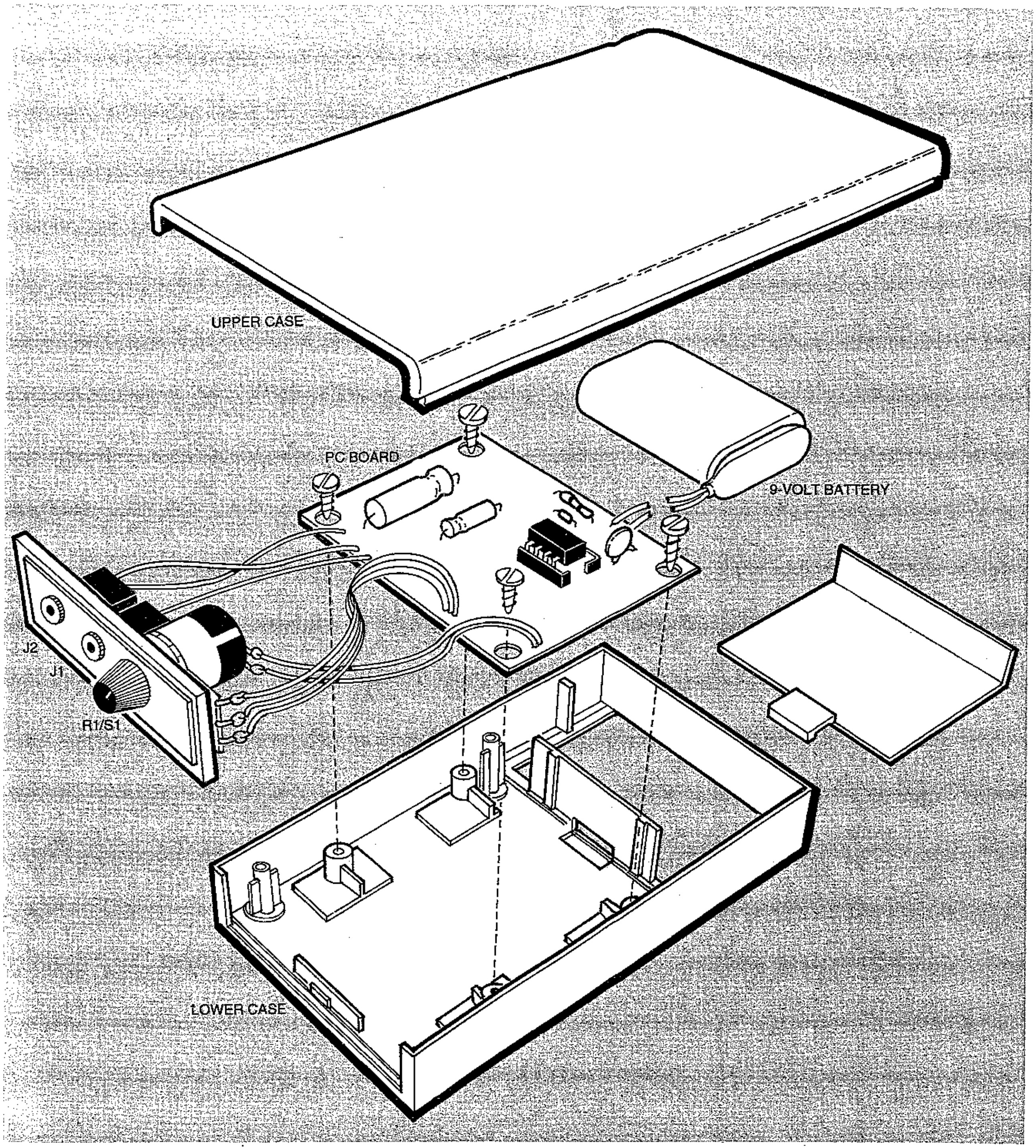


Fig 3. The MarineLife Acoustic Sensor fits easily into a hand-held case that includes a battery compartment. Using a potentiometer with an integrated on-off switch for R1 and S1 makes operating the Acoustic Sensor easy.

less power from a 9-volt battery. That part will give you longer battery life, but the sound will not be as loud. As with most designs, there is a trade-off between performance and economy. As either will work, the choice is yours.

Select a suitable case to hold the PC board, battery, and controls. One type of case is a split-type with an accessible battery compartment. Those types of cases sometimes come with a removable end panel. Having such a panel makes drilling the holes for the jacks and controls easy. A suggested arrangement using that type of case is shown in Fig 3.

If you use stereo jacks for J1 and J2, be sure to wire both channels together. That way, both mono and stereo plugs can be used—especially with stereo headphones. Switch S1 can be either a separate switch or integral to R1. The second arrangement is preferred and lets the MarineLife Acoustic Sensor be

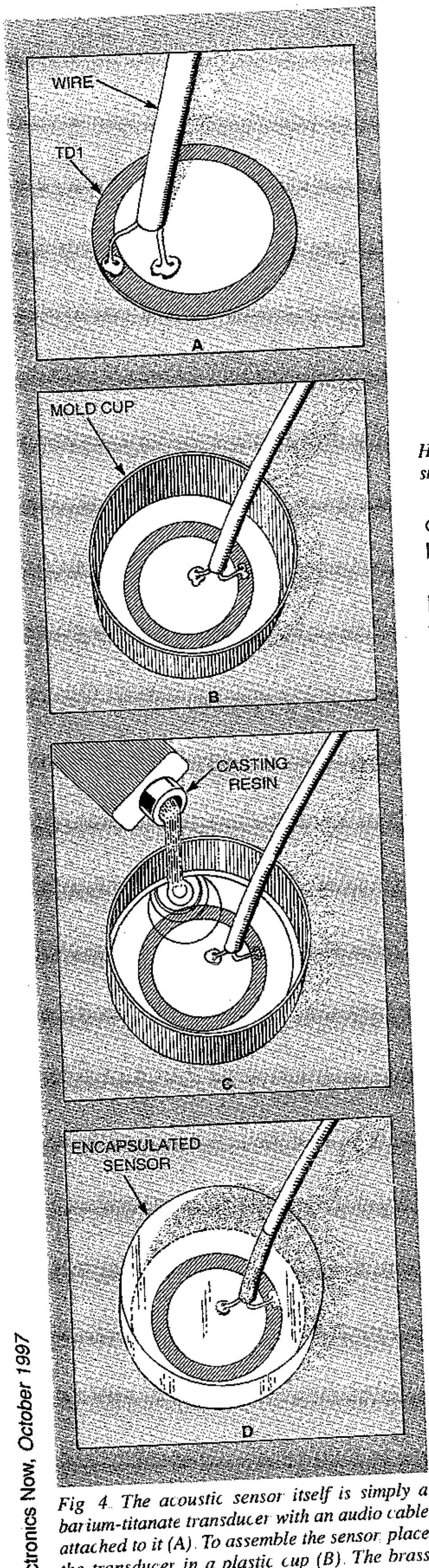
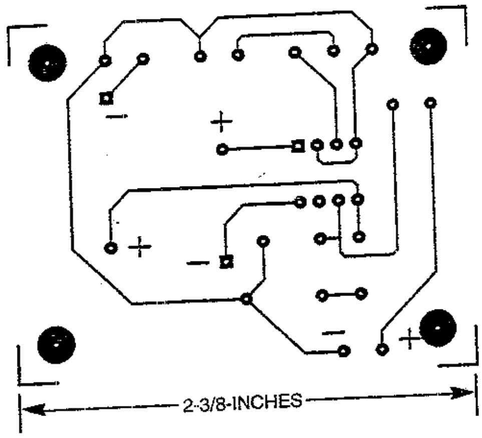


Fig 4. The acoustic sensor itself is simply a barium-titanate transducer with an audio cable attached to it (A). To assemble the sensor place the transducer in a plastic cup (B). The brass side should be facing down. Fill the cup with potting compound or acrylic casting plastic (C). After the compound cures, remove the mold (D). The sensor is then ready to go



Here's the foil pattern for the MarineLife Acoustic Sensor. The circuit is simple enough to fit on a small, single-sided PC board

operated like a radio—the volume knob turns the unit on and off.

Building the Sensor. The barium titanate disc used for TD1 can be salvaged from a piezo buzzer. They are also available from various mail-order sources. The transducer cable is a single-conductor vinyl-jacketed shielded microphone or audio cable. It should be long enough to reach to the water from wherever you plan to use the system. You should also consider the depth of the water in which you will be using it. A 100-foot cable is not excessive and will not attenuate the signal enough to notice. However, that's a lot of cable to deal with, especially when rolling and unrolling it.

Strip one end of the wire about 1 inch and separate the shield from the inner conductor. Strip the end of the exposed center conductor about 1/8 inch. Tin both the wires and the braid. Carefully tin a small area on the brass disc and on the silvered back of the wafer. Solder the shield braid to the brass and *very* carefully solder the center conductor to the silver. Do not overheat the silver, and do not stress or bend the cable at the disc. The silver coating is very delicate, and will peel off the disc with very little effort. Follow Fig. 4A for that procedure.

A small plastic or metal cup about 1-inch deep and large enough in diameter to hold the sensor will be used as a mold. Place the disc in the cup so that it is flat against the bottom (Fig 4B). The mold will then be filled with an electrical potting compound such as ScotchCast. Potting compounds might be difficult to find through mail-order companies, so a well-stocked local electronic supplier might be a better source. An alternative is to use a clear acrylic-casting resin that is available from most art and craft supply stores.

The compound is mixed according to the manufacturer's directions. Pour the compound into the cup as shown in Fig 4C. After the compound is cured, remove the sensor from the cup and solder a plug onto the other end of the cable. The completed sensor should look like the illustration in Fig 4D.

Testing. Testing the MarineLife Acoustic Sensor is very simple. With S1 off, connect a battery to the circuit and plug in the transducer into J1 and a set of headphones or a speaker into J2. Turn S1 on and rotate R1 to one-quarter volume. Tap the transducer with your fingertip. You should hear some sound. Gradually advance the volume control until the maximum comfortable volume is reached.

Using the Sensor. Of course, you will need a source of underwater sound to perform the final checkout of the system. Either the ocean of a saltwater aquarium will do. Simply dunk the sensor into the water and start listening. Although the author has not tested the MarineLife Acoustic Sensor in fresh water, it should also work there.