BUILD A HYDROPHONE

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PURPOSE: Sounds fill the sea. They come from waves breaking on the beach, passing boats, thunder in the atmosphere, earthquakes, and marine animals that use sound to navigate, find food, or locate a companion. Here's an inexpensive way to drop in and listen to all the chatter!

MATERIALS: Pretty much everything you need comes from Radio Shack or scrap parts from around the house.

A	B	C	D
	Parts List		
Quan	Description	Radio Shack P/N	Cost
1	Condenser Microphone Element	270-092c	$2.99
1	Audio Cable, 2 conductors (#24) plus shield	278-513	$7.99
1	two conductor, 1/8" phone plug	274-286A	$1.99
1	Mini Audio Amplifier with Speaker	277-1008C	$11.99
1 roll	black tape (Don't get PVC tape!)	64-2352	$2.99
1	Battery holder, fits 1 "C" cell	270-402	$0.89
1	Battery, "C" cell, Alkaline	23-871 (2/pack)	$2.79
3 ft	Wire, Insulated, #24. 1 ft of red, wht, blue	--	scrap
	(The same color wire will do if you are careful to identify which lead is which.)		
1	35mm plastic film cannister	--	scrap
1/4c	Vegetable or mineral oil	--	from Mom
1 tube	RTV, Silicone Seal, Bath Tub Chaulk	--	$3.00
		Total	$31.84

ASSEMBLY: See the attached schematic drawings.

DEPLOYMENT NOTES:

1. The first time or two in the water, a little oil from under the lid of the fim canister may seep out. This is residual oil left over from the assembly process. Place the hydrophone in a pail to allow this to clear before you put it someplace like the family fish tank.

2. The oil in the hydrophone wants to float, and there is a little air inside the audio cable that makes the cable less heavy in water. Lash, tape, or twisty seal a 4 oz lead fishing or tire weight to the cable a little above your hydrophone. This will be enough to pull your hydrophone under to a good depth.

THINK ABOUT: Can fish in an aquarium tank hear what's going on in the room where their tank is? Can you clap your hands underwater? How do animals make their sounds? What does a sonarman on a submarine hear? Can you tell what direction the sound comes from using this hydrophone? Is what you hear really that loud or are you just amplifying it?

TERMS:

acoustic coupling- How well connected the listening device is to the air or water around it. The better coupled, the better it picks up sound around it. Ear plugs decouple your ear from the surrounding sounds.

decibels- The measure of how loud a sound is. An important factor in this calculation is the compressibility of the medium the sound travels through. For example, air is much more compressible than water. So decibels in air are different than decibels in water! Like having two Mr. Smith's, this can lead to some confusion! Even scientists get this mixed up sometimes, and make mistakes that are wrong by 1,000,000 times the right answer! To keep it straight, some scientists now just talk about "watts" of power. Those are the same above and below the water's surface.

hydrophone- an underwater microphone

hydrostatic pressure- water pressure. Increases with depth.

Pressure balanced- Two volumes are separated by a wall. Changing air or water pressure on one side only places a strain on the wall. Equalizing the pressure on both sides of the wall takes the strain off. This is what happens when you "pop" your ears when you drive up a mountain or swim to the bottom of the pool. The balloon around our hydrophone is soft and flexible (compliant) and will yield to increasing pressure.

Pressure protected- Two volumes are separated by a wall. Changing air or water pressure on one side only places a strain on the wall. The wall is strong enough to resist the increased strain. Everything inside the wall is protected from the outside pressure. A sealed glass jar from the store will "pop" when you open it because there was lower pressure on the inside protected from the normal higher pressure outside. Look for words like "vacuum sealed" on the jar or lid. If the strain gets too great, the wall collapses inward. This is called "implosion".

waterblocked cable- water is prevented from traveling up the inside of a cable pushed by hydrostatic pressure because there is a rubber dam of some kind to block the water.

ADVANCED WORK:

--Build your own amplifier from simple parts. Check out Radio Shack's "Engineer's Mini-Notebook, Basic Semiconductor Circuits," by Forrest M. Mims III (p/n 276-5013" as one source. Radio Shack's Electronics Lab kits, such as the "Advanced Electronics Lab-300 Projects," (p/n 28-270) are well worth the money as a self-taught program in basic electronics.

--Build a band pass filter to narrow the frequency ranges you listen to.

--Build your own sound projector. See how far away you can be and still hear it. Does the frequency of sound you send make a difference? The depth of water?

--Record sounds for playback later to friends.

Areas of Further Study:

- --Properties of sound in the sea. SOFAR channel, surface duct, affects of temperature and pressure. Attenuation. Multipath.
- --Sonar systems. Active and passive.
- --Submarine and Antisubmarine warfare. Acoustic homing torpedoes.
- --Digital signal processing

Some Scientific Applications:

--Some scientists at the Scripps Institution of Oceanography use sound in the sea to measure global warming! The sound they send is so small that you can't even hear it with a hydrophone and an amplifier unless you are right over the source. They figured out a way to use what one Scripps scientist calls "the acoustic equivalent of a time lapse photograph" to know their sound signal actually arrived. Their signals can travel from near Antarctica all the way to the both coasts of America! Even at the speed of sound in water, which is three times faster than the speed of sound in air, the coded signal still takes over 3 hours and 40 minutes to travel from the sound source to the the sound receivers. Maybe it's not such a small world after all! Using the time lapse technique and the physics of the ocean, a sound source of only 250 watts, about a couple of lightbulbs worth of power, can send a signal in the sea from California to New Zealand!

Web References:

--Acoustic Thermometry of Ocean Climate, Scripps Institution of Oceanography/UCSD,
http://atocdb.ucsd.edu/

--Acoustics and Sonar Information Resources
lots of links to other cool places
http://www.aticourses.com/acoustics.htm

--Center for Arms Control, Energy and Environmental Studies, Moscow Institute of Physics and Technology
"What is Known About the Character of Noise Created by Submarines?"
http://www.armscontrol.ru/subs/snf/snf03221.htm

--Cabrillo High School Aquarium
http://site.yahoo.com/cabrillo/

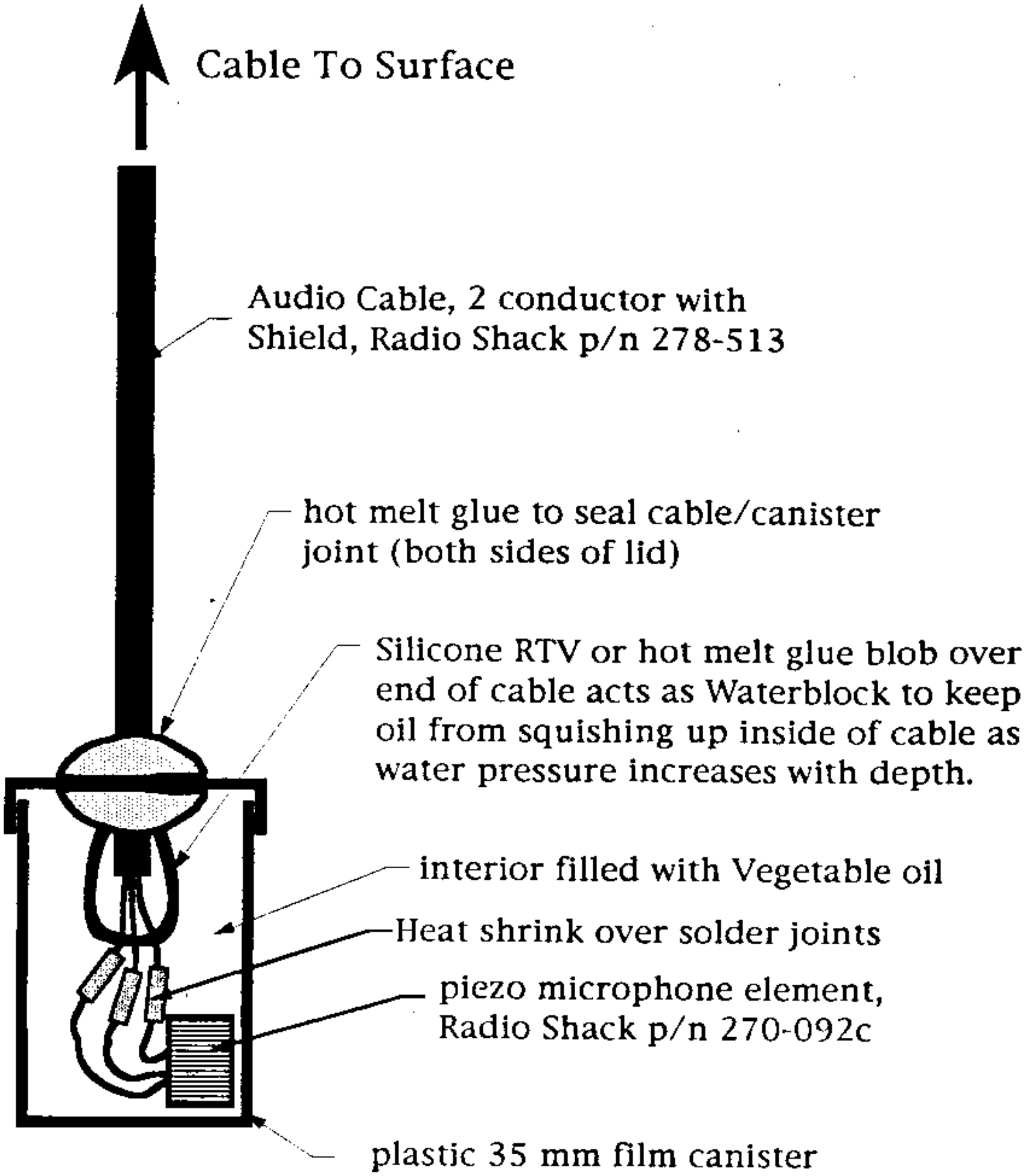
--SeaView: A window into the marine life of Southern California
Orange County Register. What might be making some of the chatter off the southern California coast.
http://www.ocregister.com/science/features/seaview/

REFERENCES:

--"How to Build & Use Low Cost Hydrophones", Frank Watlington, 1979, ISBN #0-8306-1079-0, TAB Books, Blue Ridge Summit, PA (Excellent resource, but currently out-of-print)

--"Fundamentals of Transducers," R.H. Warring & Stan Gibilisco, 1985, ISBN #0-8306-1693-4, TAB Books, Blue Ridge Summit, PA

--"Advanced Electronics Lab-300 Projects", Radio Shack, (p/n 28-270)



BUILD A HYDROPHONE

HYDROPHONE MECHANICAL SCHEMATIC

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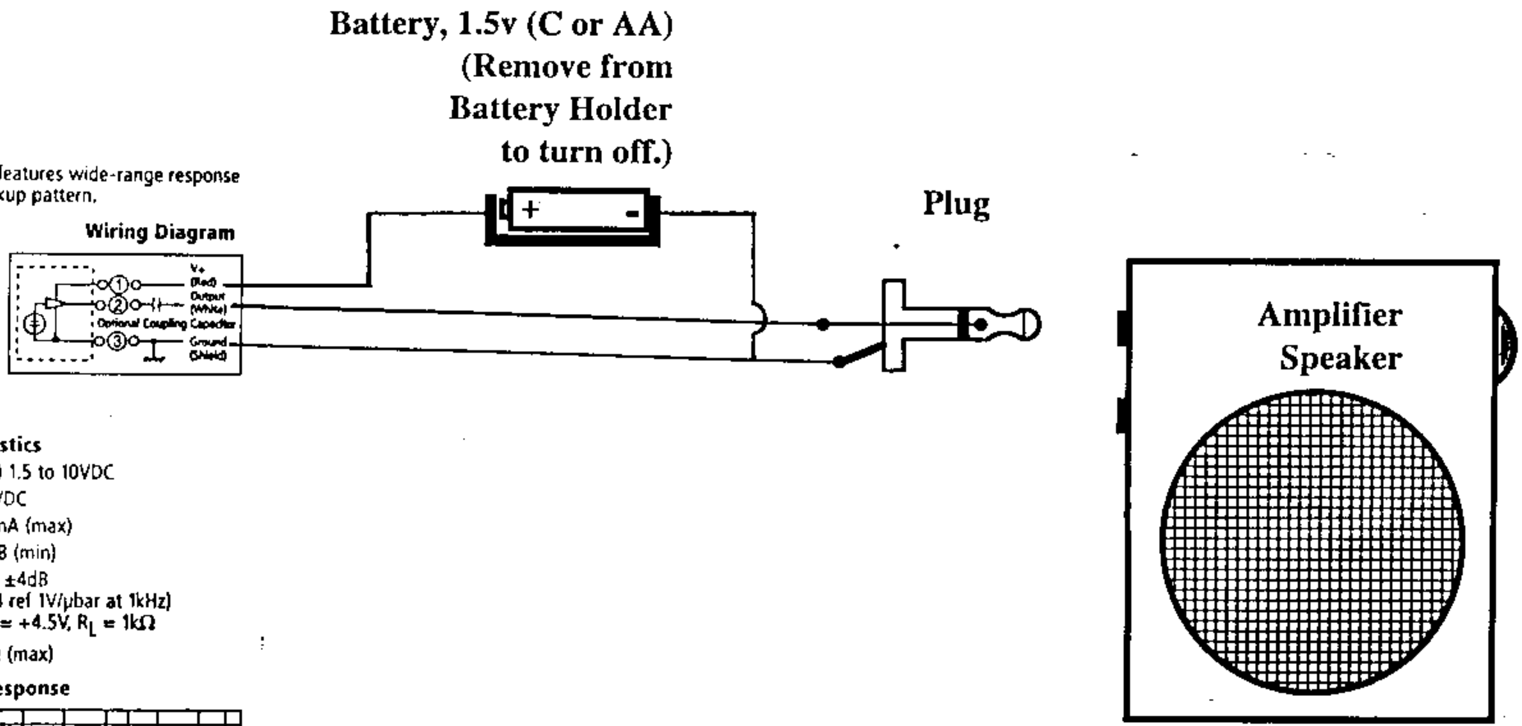
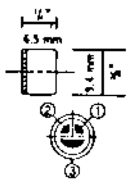


Condenser microphone features wide-range response and omnidirectional pickup pattern.

Outer Dimensions

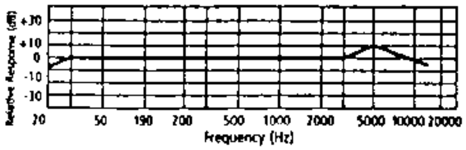


Electrical Characteristics

Supply voltage:	(V+) 1.5 to 10VDC
Nominal supply:	4.5VDC
Current drain:	0.5mA (max)
Signal/noise:	40dB (min)
Sensitivity:	−65 ±4dB (0dB ref 1V/μbar at 1kHz) V_{CC} = +4.5V, R_L = 1kΩ

Output impedance: 1kΩ (max)

Typical Frequency Response



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BUILD A HYDROPHONE

HYDROPHONE ELECTRICAL SCHEMATIC

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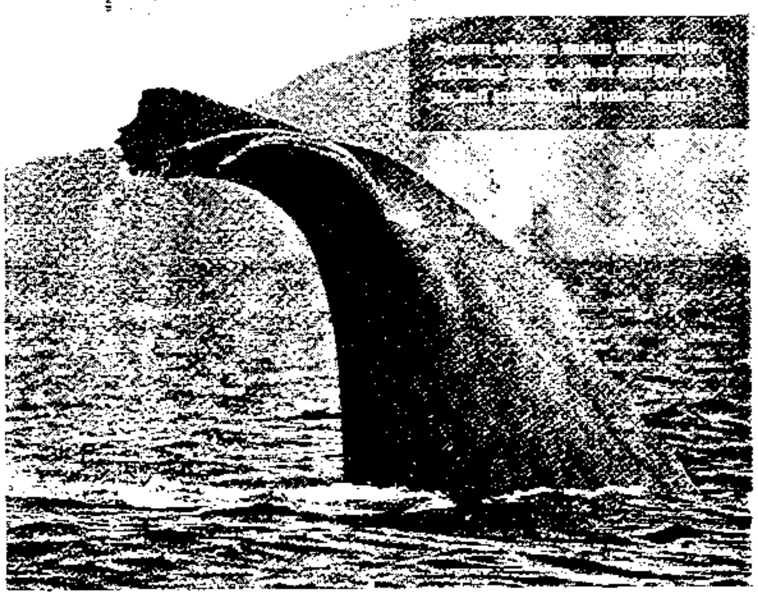
Eavesdropping on Whales

BIOLOGISTS have joined forces with acoustic engineers to track populations of whales by the sounds they make. Such acoustic monitoring can even identify individuals within a group.

At the University of Washington in Seattle, electrical engineering doctoral student Michael Dougherty has created a computer program that analyzes the loud clicking sounds made by sperm whales. "To a human, a sperm whale underwater sounds like a very large clock ticking," he says. But to his software, each click has a distinctive pattern—so distinctive that the program can correctly identify an individual whale with 98.4 percent accuracy after listening to only five clicks.

Previously, researchers have had to identify a particular whale using photographs taken from boats at close range in good weather. But the underwater microphones used in Dougherty's experiment can hear whale clicks from 3 miles away and can transmit data via radio to land-based labs.



So far, Dougherty has tested his technique on only 10 whales off the coast of Norway. But if he can prove it works for a larger population, the technique could be used to study whale behavior, locate migration routes, and determine how whales are affected by the explosions associated with oil exploration.

Acoustic monitoring could also benefit northern right whales, the world's most endangered large whales. Researchers at MIT Sea Grant's Center for Fisheries Engineering Research in Massachusetts are testing a prototype buoy that combines an underwater microphone with electronics that differentiate the calls of right whales from other sounds in the ocean.

Currently, large ships are required to notify the U.S. Coast Guard when they enter whale habitat along the East Coast, but the Coast Guard has to rely on aircraft sightings to determine the latest whereabouts of right whales. In the future, buoys could automatically send radio signals warning ships to steer clear of the whales.

The buoys could also transmit the actual vocalizations, which could someday allow the MIT scientists to identify individuals. If you want to hear a right whale, go to *web.mit.edu/seagrant/audio/rightwhale1.wav*.—*D.S.*