

Microphones, Hydrophones, Vibration Transducers: Rolling Your Own

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- a) Building a Hydrophone
- b) Building a Vibration Transducer
- c) Building an Insertion Microphone
- d) Building an Ultrasonic Microphone

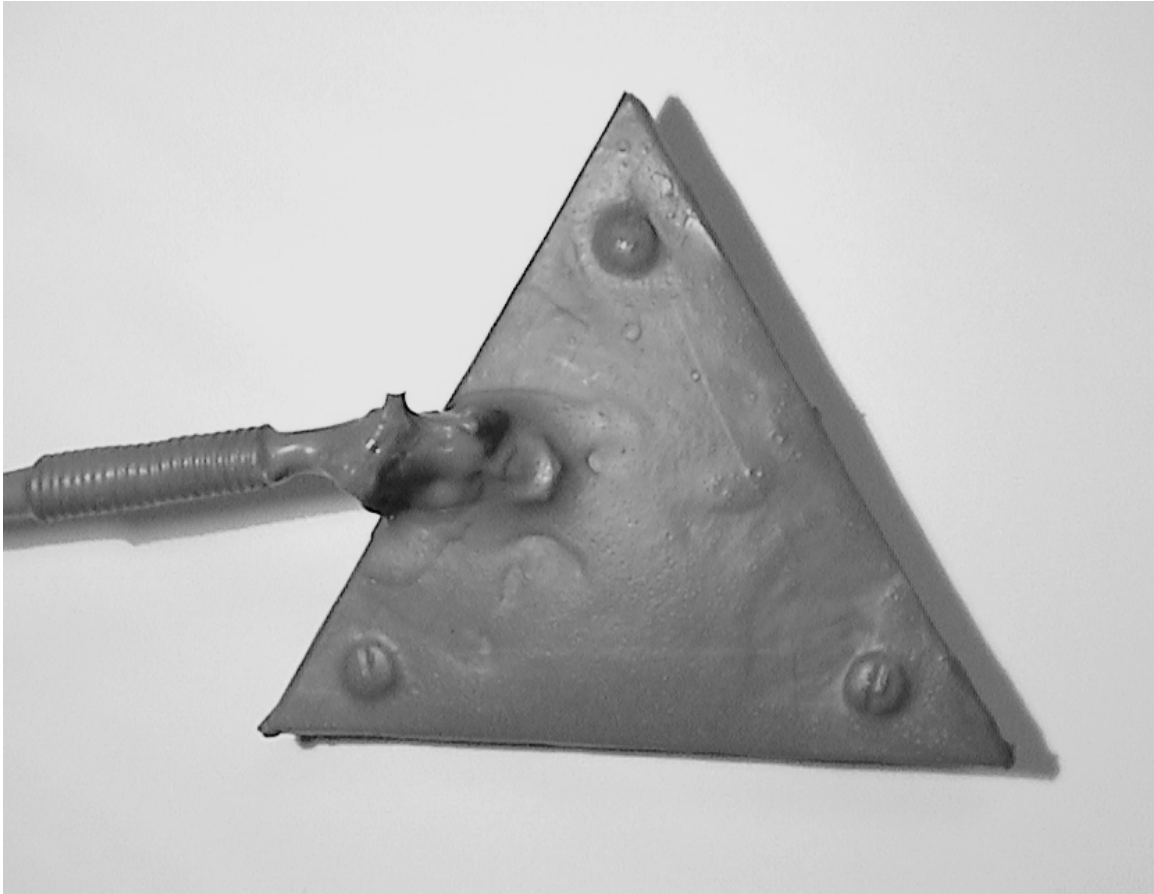
Inexpensive Transducer Solutions for Bioacoustic Monitoring

Conventional soundscape recording necessitates the use of very precise high quality microphones. They function in relationship to a sound recorder (analog or digital) similar to how a lens does to a camera. They are literally the surface membranes that physically vibrate in response to sound phenomena in the world. There cannot be much compromise about their use. Their design and manufacture has been perfected through a century of use and they are generally very expensive instruments. There really is no way around this fact. Professional expectations have set a minimum standard that requires their use in most field recording circumstances. While soundscape recordists will argue about particular models and techniques, they all agree about the need to use tools that maintain a level of technical integrity and define certain aesthetic boundaries.

Recording in acoustical domains other than air is not so clear-cut. Hydrophones, accelerometers, ultrasonic transducers, and other special case devices have mostly been the domain of scientific specialists. Since the phenomena that they are used to study are not a part of our common experience, defining standards is more problematic. Such tools are also very expensive and not necessarily because of the quality of materials or workmanship. They are not made in large quantities because of their limited use by scientific specialists. I first set out to design these tools for myself. As an artist I simply could not afford to purchase the scientific versions. It was after I used them in the field that I became interested in their possible use by others. Although I encourage other people to make them, I really want them to be seen as models for the imagination of others. There are endless ways to do this other than my specific solutions. Other sound

artists have been doing similar things for a long time. My point really is that simple and affordable audio tools can be easily made by amateurs to extend their aural perception into otherwise hidden domains of the natural world. Their construction might allow for the extension of the science of bioacoustics to include activities by amateurs and children, or at least allow them to participate in gathering sonic information about the state of our environment.

Hydrophone



Small inexpensive piezoelectric transducers have become one of the most ubiquitous resources in the world of sound art. Whether purchased at RadioShack, from catalogs of electronic part suppliers, or (as in this case) removed from the innards of a Hallmark greeting card, they are a fantastic source for a simple contact microphone or vibration sensor.

Since they are sensitive to physical vibration through direct contact, they also are applicable for picking up sound vibrations through a liquid acoustical medium such as water. In fact most of the new generation of commercially manufactured hydrophones are made of a slightly more sophisticated version of the same piezoelectric film as these simple transducers. While they certainly have more limitations than their vastly more expensive commercial versions, they still can

make quite effective hydrophones that are very useful for many underwater recording applications.

Start with a piezoelectric transducer from a Hallmark greeting card. They are an especially nice size that gives a better low frequency response. Carefully remove the plastic resonator shell. Be careful when removing the transducer from the card not to break off the wire leads that are already soldered to the two surfaces of the transducer. It is nearly impossible to re-solder the connection to the piezoelectric film surface without the heat causing the film to melt.

Once the device is ready, place heat shrink insulation tubing over parts of the wires in anticipation of insulating any exposed wires after the next steps. Cut two equilateral triangles (at least 4 inches per side) out of acrylic floor tile (3 or 4 mil). Glue a small rubber O-ring (approximately 4 cm interior diameter) in the exact center of one of the triangles (bottom side). Glue the piezoelectric transducer into the center of the O-ring (non-piezoelectric film side down). Cut a hole into the other acrylic triangle for the wire leads of the transducer to feed out of. This hole should be within the interior of the O-ring when the two triangles are aligned. Bring the two triangles together, feeding the transducer wire leads through the hole in the upper triangle. Tape the three edges of the two triangles together keeping them fully aligned. Thin transparent tape works best. Drill holes through both assembled triangles near their vertices about 2 cm inward. Further secure the triangles together with #6 plastic screws and nuts. Their length is not important since you can cut them off later to whatever length you desire.

Prepare a microphone cable (20 feet is good) that is made of single-conductor, shielded wire that is flexible and has external insulation. Solder the lead wire to the film contact of the transducer wires and the shield to the brass. Cover any lengths of exposed wire with the bits of heat shrink tubing and then apply heat to the tubing so that it shrinks tightly around the wires. I anchor this cable to the whole contraption with a thin piece of hardware that can also be taped flush to the edge or surface of the hydrophone. On the other end of the microphone cable, solder an audio connector that is compatible with your recording device.

In order to provide weight to the hydrophone, I wrap heavy gauge lead solder around the microphone cable for a couple inches. This also provides some protection for the vulnerable wires attached to the piezoelectric device. This whole contraption is then dipped in Plasti-Dip for insulation from the water. This is an ingenious product designed for coating the ends of tools to provide a grip surface. It is also a very effective hydrophone insulator. I dip it deep enough to coat everything up past the solder coil. Let it dry for a few hours and then do a second coat. Do this outdoors or in a place with good ventilation since the product is quite toxic if inhaled. Allow it to dry for a day or two and the insulation will be very tight to the surface of the device. The coating has virtually no adverse effect on the vibration sensitivity.

The final hydrophone device is passive and can be plugged directly into the microphone input of the recording system. Total construction cost is approximately \$20 (US) including a microphone cable, greeting card and Plasti-Dip.

Vibration Transducer



This transducer also uses a basic piezoelectric disc found in a greeting card as its primary component. In this case the disc happens to be smaller and taken from a .99-cent greeting card. It can be wired up in the same fashion as the hydrophone but soldered to a much shorter length of microphone cable.

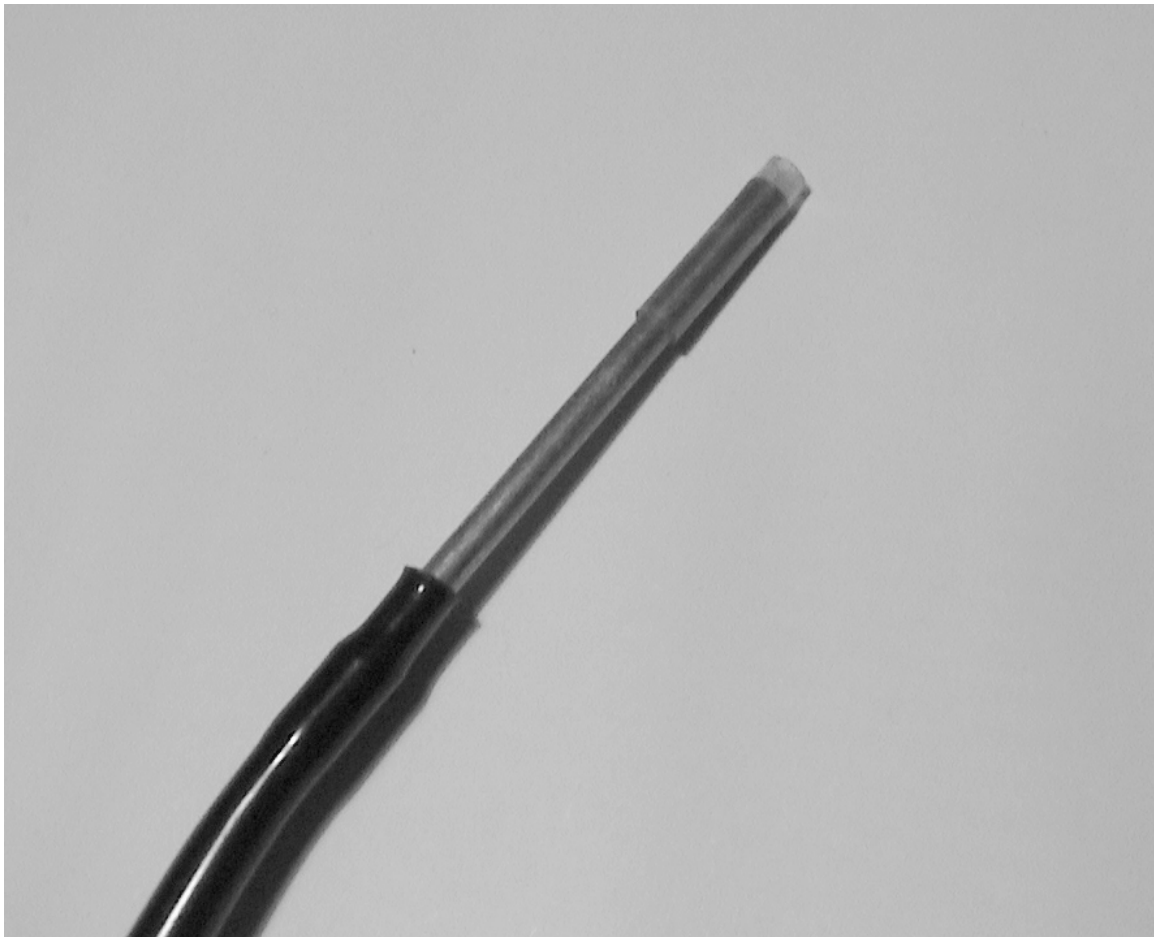
The device also makes use of a cheap meat thermometer with a hollow shaft and a small teflon washer. Remove the glass and innards of the thermometer, taking care to pull out all the wires that connect the thermometer gauge to the interior of the shaft. This should leave a shallow well with a central nut that attaches the shaft and well together. The teflon washer should be the same depth as the well such that its top is flush to the top of the well when seated in it. Glue the washer to the central base of the well with epoxy. Next, glue the piezoelectric disc to the washer, attaching the non-film side of the disc with epoxy. Try to keep

everything centrally positioned through this process and allow everything to dry until fully fixed.

The entire construction can now be dipped in Plasti-Dip in order to stabilize all of the wires and give the unit more strength. I usually dip it deep enough to coat the cable for a few inches up its length and an inch or so of the shaft from the piezoelectric disc.

The final vibration transducer is passive and can be plugged directly into the microphone input of the recording system. The total construction cost is approximately \$10 (US). The device was originally created to insert into tree trunks (through the outer bark into the phloem) for bark beetle monitoring but it has a large number of similar applications.

Ultrasonic Insertion Microphone



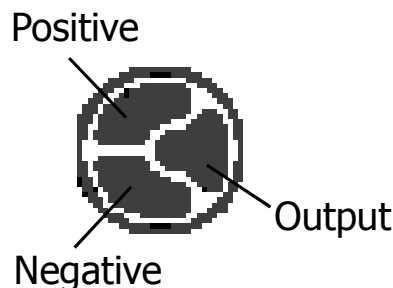
This insertion microphone is a little more complicated than the previous devices. It requires fairly sophisticated soldering skills because of the extremely small microphone transducer involved. In fact, it is regarded as the world's smallest microphone transducer and is primarily manufactured for use in hearing aids.

The Knowles Acoustics FG-3329 electret condenser microphone can be ordered from a number of electronic parts suppliers. Its minute size requires special handling and a magnifying glass for soldering and assembly. You will also need the ink shaft from a standard ballpoint pen, an AA battery holder, some heat shrink tubing, and various sizes of wire.



FG actual size

The first step is to solder three fine wires to the terminals of the Knowles transducer. I use very fine “wire wrap” wire and a fine tip soldering iron to very carefully perform this task under the magnifying glass. I also use three different colors of wire in order to keep track of their termination. The wires only need to be several inches long but do need to extend out the base of the pen shaft once the transducer is seated. Attach one wire to each of the transducer’s terminals.



Knowles Acoustics FG-3329 electret condenser microphone

Remove the ink shaft from the ballpoint pen and cut it off above the middle crimp. Discard the ballpoint section and completely remove any ink from the remaining shaft. Use a small flathead screwdriver or similar tool to slightly flair one end of the shaft such that the microphone element can just be seated down into it, wires first.

These three wires can now be soldered to a two-conductor, shielded microphone cable. Heat shrink tubing should be cut and put in place before soldering so that all of the exposed leads can be insulated. On the other end of the microphone cable you can attach the audio connector of choice and wire up the AA battery clip. Be sure to keep track of the proper termination of the wires. I also place a small piece of plastic tubing over the active end of the ballpoint shaft in order to provide some protection of the recessed transducer.

The device will function for a long time with one AA battery. The total construction cost is approximately \$30 (US). The device is used for insertion into natural cavities such as prairie dog holes or anthills. Because of its small size, the microphone naturally has an ultrasonic response.

Ultrasonic Boundary Microphone (PZM)



This microphone uses the same Knowles FG-3329 condenser microphone element as the insertion microphone. The major difference is that this device uses a special mounting technique that gives the microphone capsule greater sensitivity. The pressure zone microphone (PZM) or boundary microphone uses the concept of on-surface mounting to avoid the tonal coloration problems of other microphone types. Its diaphragm is placed in the narrow “pressure zone” above a mounting surface where incident and reflected sound combine in phase. This technique doubles the effective amplitude giving a 6-decibel increase in sensitivity.

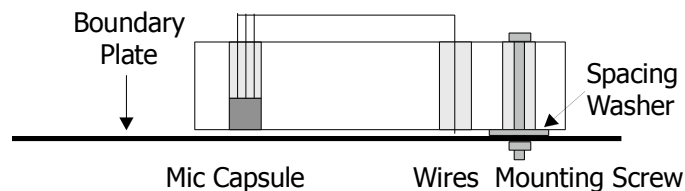
The construction of a boundary microphone is inexpensive when compared with that of other types of microphones. It is basically a metal plate with a mounting

arm that holds an electret microphone capsule in a fixed position above the plate. It has an omni-directional pickup and very flat response. The major contribution that my design adds is its ultrasonic range. This microphone has a frequency response of up to 120 kHz.

The first construction step is the same as the insertion microphone: solder three fine wires to the terminals of the Knowles transducer. The wires need to be long enough to extend through the length of the signal path. Attach one wire to each of the transducer's terminals.

I use a circular electrical plate covering (10 cm diameter) for the boundary surface. Make a small rectangular piece of wood (3 to 4 cm in length, .6 cm in width and depth). Drill three small holes through the wood, two at approximately .5 cm in from each end of the wood piece. Drill the third hole at approximately 1.25 cm from one end. One of the outer holes will hold the microphone capsule and the other a mounting screw. The inner hole will be closer to the mounting screw and is used to thread and hold the wires from the capsule. Choose a drill bit size commensurate with the function of each hole.

Push the microphone capsule with its attached wires down into its hole until the top of the capsule is flush with the opposite wood surface. The wires should be threaded down into the inner hole. I use heat shrink tubing to surround and protect the fragile wires from the capsule.



Drill a hole in the boundary plate towards its outer edge. Mount the wood block to the boundary plate with a spacing washer to provide a small gap between the capsule and the plate. The gap should not exceed 2 mm. Attach the capsule wires to a two-conductor, shielded microphone cable, audio connector, and AA battery clip as in the insertion microphone construction.

The microphone has high sensitivity and a frequency range up to 120kHz. Total construction cost is approximately \$30 (US). The device is excellent for monitoring bats, rodents, insects and general ultrasonic phenomena.