Science: Each One Teach One! – Hydrophones

Activity Time: 50 minutes
Preparation Time:
Team size: three – four members/team

OVERVIEW
This activity is designed to be conducted with 10 – 12 members in teams of three or four. The purpose is to have members practice stripping, twisting, and soldering wire—skills they will need with they build hydrophones. Members are divided into teams, and each team is assigned one of the following stations, stripping wire, twisting wire, and soldering wire. They spend 10 minutes reading about and practicing their skill. After 10 minutes, members rotate through each station to learn about the skill as each team teaches the skill they learned.

OBJECTIVES
Members will be able to:
1. work as a team to read written information, record notes, and practice the skill, wire stripping, twisting, or soldering, they have been assigned.
2. work as a team to teach other members how to strip, twist, or solder wire.
3. explain how the skill at each station relates to building hydrophones.

RECOMMENDED ASSESSMENT STRATEGIES
There are several methods to assess member knowledge. First, use the Evaluation Form to take notes on accuracy as you observe members teach about their station materials. Second, choose members to demonstrate what they learned at each station, and record accuracy on the Evaluation Form.

MATERIALS (*Requested from partner)
Group 1: Stripping Wire
- ❑ (6) Pieces of 9-strand cable (2 pieces used by the teaching team to practice and 4 pieces will be used when they teach other members how to strip wire)
- ❑ (4) Wire strippers
- ❑ Instruction Sheet*
- ❑ Tray to hold materials

Group 2: Twisting Wire
- ❑ (2) Pieces of 9-strand cable, with each wire stripped
- ❑ Instruction Sheet*
- ❑ Tray to hold materials

Group 3: Soldering Wire
- ❑ (2) Pieces of 9-strand cable, with each wire stripped and different wires twisted together
- ❑ (4) Soldering irons
- ❑ (4) Spools of solder
- ❑ Sponge or towel
- ❑ Instruction Sheet*
- ❑ Tray to hold materials

ADVANCE PREPARATION

1. Cut the number of pieces of cable that you will need for the lesson. You should have the following:
   - (6) 8 – 10 inch long lengths of cable with the insulation removed from both ends
   - (2) 8 – 10 inch long lengths of cable with the insulation removed and the wires on both ends stripped
   - (2) 8 – 10 inch long lengths of cable with the insulation removed and the wires on both ends stripped and twisted together

2. Sort materials onto trays.

3. Set up one table with chairs for each team. Have materials and instructions ready to set on the tables after roll is taken and instructions are given.

4. Take roll, and record the names of the participants.

5. Divide the club into two groups, and send one of the groups to the Tech Room to work on their Web pages. Divide the remaining members into teams of three or four. (See ***TEACHING TIPS*** for a suggestion on how to efficiently divide members into teams).

TEACHING TIPS

1. Review and practice all three skills before the meeting so that you can help the members if they have any problems.

2. Make sure that you have taken roll and given verbal instructions before dividing members into teams and handing out materials. This way, they will listen to your instructions without the distraction of the materials in front of them.

3. Divide members quickly into teams by counting off numbers. If you have three stations, count off members with numbers one through three. Repeat until all members have a number. Have all of the number ones work together, all of the number twos work together, etc. This will leave valuable time for learning content as well as ensure that members have the opportunity to work with different people.

PROCEDURE

1. **Introduction (5 minutes):** Have each team sit together at a table. Show the members an example of the hydrophone they will build, and ask the members if they can identify it and explain how and why it is used. Explain that they will work in teams to following directions to build their own hydrophone. In order the build the hydrophone, they must be able to strip, twist, and solder wire. During this activity, teams will learn and practice how to do the different skills. At the end of the research time, they will test their knowledge by teaching each other how to strip, twist, and solder wire.

2. **Exploring (10 minutes):** Hand out the materials for each station, and have each team read through their instructions. If necessary, demonstration each skill to each team. Give them ten minutes to complete their task.

3. **Teaching (30 minutes):** Have all members gather at the wire stripping station. Divide the members from the wire twisting and wire soldering teams into pairs. The wire stripping team has ten minutes to teach their skill to the other members. They can provide each pair with a piece of cable with the ends stripped. After ten minutes, have the members take their stripped wire with them as they rotate to the wire twisting station to learn from the wire twisters how to twist wire. Divide the members from the wire stripping and the wire soldering

teams into pairs. The wire stripping team has ten minutes to teach their skill to the other members. After ten minutes, have the members take their stripped and twisted wire with them as they rotate to the wire soldering station to learn how to solder wire. Divide the members from the wire twisting and wire soldering teams into pairs. The wire soldering team has ten minutes to teach their skill to the other members. At the end of 30 minutes, each pair should have stripped, twisted, and soldered wire.

4. **Conclusion (5 minutes):** Have each team clean up their station. If time, show the members the hydrophone building instructions so that they are familiar with the format and pictures before they begin building the hydrophones.

Group One: Stripping Wire Instruction Sheet

Materials

- ❑ (6) Pieces of 9-strand cable (4 pieces will be used when you teach other members how to strip wire)
- ❑ (4) Wire strippers
- ❑ Tray to hold materials

Instructions

Use the wire strippers to strip the ends of all of the strands of wire on both ends of the cable. You should have 18 stripped wires (nine on each end of your wire).

Using Wire Strippers

In the beginning, you may find it easier to strip a bit more wire than you may need and then cleanly snip off any excess copper. With more practice, you will get the amount of stripped wire right without having to clip off any excess. You don't want to strip a wire to find that you don't have enough to work with and then have to go through the trouble of unbending it and tugging a piece of insulation over a bend or kink. Aside from being inefficient, the fewer times you bend and unbend copper wire the better.

Step 1:

Choose the color wire you want to strip. Bend the other wires out of the way. Insert the wire into the proper stripping hole and close the handles. The tool's cutting action should be crisp.

Step 2:

Sometimes you can slide the stripping tool forward and push the insulation off the wire. Other times you need to grip the insulation just on the other side of the cut and pull the insulation off the wire. Do not grip the insulation on the end of the wire because you are liable to chew up the copper. If you find the insulation does not slide readily off the wire, you have either not severed it completely or you are gripping the insulation too firmly with the pliers. The serrations on the plier tips are quite sharp, and they will dig through the insulation and into the copper beneath if you apply too much pressure.

Group Two: Matching and Twisting Wire Instruction Sheet

Materials

- ❑ (2) Pieces of 9-strand cable, with each wire stripped
- ❑ Tray to hold materials

Instructions

Connect the wires by twisting two colored wires together as follows:

- Red to red
- Black to brown
- Yellow to orange
- White to purple
- Green to blue

Group Three: Soldering Wire Instruction Sheet

Materials

- ❑ (2) Pieces of 9-strand cable, with each wire stripped and different wires twisted together
- ❑ (4) Soldering irons
- ❑ (4) Spools of solder
- ❑ Sponge or towel
- ❑ Tray to hold materials

Instructions

Solder each of the twisted pairs of wire together.

Tips for Soldering

Good soldering is a skill that is learnt by practice. The most important point in soldering is that both parts of the joint to be made **must** be at the same temperature. The solder will flow evenly and make a good electrical and mechanical joint **only** if both parts of the joint are at an equal high temperature. Although it appears that there is a metal to metal contact in a joint to be made, very often there exists a film of oxide on the surface that insulates the two parts. For this reason, it is no good applying the soldering iron tip to one half of the joint only and expecting this to heat the other half of the joint as well.

1. When the iron is hot, apply some solder to the flattened working end at the end of the bit, and wipe it on a piece of damp cloth or sponge so that the solder forms a thin film on the bit. This is tinning the bit.

2. Melt a little more solder on to the tip of the soldering iron and put the tip so it contacts **both** parts of the joint. It is the molten solder on the tip of the iron that allows the heat to flow quickly from the iron into both parts of the joint. If the iron has the right amount of solder on it and is positioned correctly, then the two parts to be joined will reach the solder's melting temperature in a couple of seconds.

3. Now apply the end of the solder to the point where both parts of the joint and the soldering iron are all touching one another. The solder will melt immediately and flow around all the parts that are at, or over, the melting part temperature.

4. After a few seconds, remove the iron from the joint. Make sure that no parts of the joint move after the soldering iron is removed until the solder is completely hard. This can take quite a few seconds with large joints. If the joint is disturbed during this cooling period, it may become seriously weakened.

The hard cold solder on a properly made joint should have a smooth shiny appearance and if the wire is pulled it should not pull out of the joint.

It is important to use the right amount of solder, both on the iron and on the joint. If there is too little solder on the iron, it will result in poor heat transfer to the joint. If there is too much solder on the iron, you will suffer from the solder forming strings as the iron is removed, causing splashes and bridges to other contacts. Too little solder applied to the joint will give the joint a half finished appearance: a good bond where the soldering iron has been, and no solder at all on the other part of the joint.

Remember it is much more difficult to correct a poorly made joint than it is to make the joint properly in the first place. Anyone can learn to solder, it just takes practice.

Each One Teach One! **Evaluation Form**

Date: _____

Content Topic (from Informal Education Center): _____

Number of meetings when content was already discussed: _____

Number of Members participating: _____

Instructor: _____

Instructions: Indicate the number of times a skill is demonstrated accurately or inaccurately during the teaching section of the activity.

Artifact	Teaching Accuracy		Learning Accuracy	
	Accurate	Inaccurate	Accurate	Inaccurate
#1				
#2				
#3				
#4				
#5				
#6				
#7				

Note: Make sure that you are familiar with the skill before the activity so that you can evaluate the accuracy of the demonstrations.

Science: Building a Hydrophone

Time: 3 sessions (more if required)
Participants: Member group of 3 - 4 members

OVERVIEW
Teams follow written instructions to build hydrophones.

BACKGROUND INFORMATION
Just as microphones are used to listen to sound in air, devices called **hydrophones** are used to listen to sound under water. Microphones convert sound in air into electrical signals. The electrical signals can then be amplified, recorded, played back over loudspeakers, and transmitted over telephone lines. The electrical signals can also be used to measure the characteristics of the sound, such as amplitude and frequency. Similarly, hydrophones convert sound in water into electrical signals that can be amplified, recorded, played back over loudspeakers, and used to measure the characteristics of the sound. Hydrophones listen to sound, but do not transmit any sound.

Most hydrophones are made from a piezoelectric material. This material has a special property that allows it to produce small electrical signals when squeezed, that is, when it is exposed to pressure changes. Because sound is a pressure wave, it can be detected by a piezoelectric element. Under the pressure of a sound wave, the piezoelectric element flexes and gives off electrical signals. These electrical signals can be recorded and later analyzed with computer programs to determine the properties of the sound wave, including amplitude and frequency. Some hydrophones, called omnidirectional hydrophones, record sounds from all directions with equal sensitivity. Other hydrophones, called directional hydrophones, have a higher sensitivity to signals from a particular direction. Directional receivers are most often constructed using a number of omnidirectional hydrophones combined in what is called an array. Directional hydrophones are typically used in systems for locating and tracking objects.

Hydrophones are specially designed for underwater use. They are normally encased in a rubber boot to provide protection from seawater. Hydrophones can be mounted in several different ways. They can be attached to a boat, towed, or placed in a fixed position underwater.

CONTENT OBJECTIVES
Members will be able to:
1. explain what a hydrophone is and how it is used to gather sound.
2. follow written directions to build a hydrophone.

RECOMMENDED ASSESSMENT STRATEGY
Use discussions, observations during the building, and completed hydrophone to assess student mastery of the objectives.

MATERIALS
Introduction Materials for whole group
- ❑ Example of completed hydrophone with amplifier and speakers
- ❑ (3) Containers of water for demonstrating and testing
- ❑ Tuning forks
- ❑ Towels

Hydrophone Building Materials for each team Container

- ❑ Condenser microphone element
- ❑ 1/8" mono phone plug
- ❑ Audio amplifier/speaker
- ❑ 9 Volt Battery
- ❑ "C" cell battery holder
- ❑ "C" cell battery 15 feet of audio cable
- ❑ 1 foot each of three different colors of #24 insulated wire
- ❑ Film canister with hole drilled in lid
- ❑ Black electrical tape
- ❑ Wire strippers
- ❑ Silicone seal
- ❑ Soldering iron & solder
- ❑ Mineral oil
- ❑ Weight
- ❑ ***Building a Hydrophone*** instructions with pictures
- ❑ Pencils

ADVANCE PREPARATION

1. Purchase the materials, most of which can be bought through Radio Shack (see the **Building a Hydrophone Materials List**).
2. Make one hydrophone to use as an example when introducing the activity.
3. Sort the materials into one kit for each team.
4. Make two copies of the ***Building a Hydrophone*** instructions for each team.
5. Fill the container with water and set out the hydrophone and tuning forks. Have towels handy in case of spills.
6. Divide group into teams of three to four members.

TEACHING TIPS

1. Buy an extra set of materials to build a hydrophone before the first hydrophone building meeting. This will give you the opportunity to identify areas in the instructions that might be difficult for the members. In addition, you need a finished example to show the members.
2. Make color copies of the ***Building a Hydrophone*** instructions.
3. Make sure that each team writes the names of the members on the instructions and kit. Since the activity runs over three meetings, they need to make sure that they can identify their supplies.
4. It is important to rotate between the teams to help them when problems arise. The most difficult aspect of facilitating this lesson is helping the members to manage their frustrations. In addition, teams will most likely need help determining which wires should be twisted and soldered to each other and figuring out how to troubleshoot the problems that will arise—especially when they test the connections during step 13.
5. Make sure that the teams DO NOT solder their wires until they have tested their connections.
6. If you conduct the ***Each One Teach One*** activity before this activity, the members will have experience wire stripping, twisting, and soldering.

PROCEDURE

1. **Engage (10 minutes):** Show the members the completed hydrophone, and tell them that they will work in teams to construct one. Knock a tuning fork, submerge it in the container, and have the members listen. Demonstrate how the hydrophone works by putting it in a container of water with a vibrating tuning fork. Have the members listen. Briefly explain how a hydrophone works, tracing the sound from the tuning fork to the amplifier.

2. Divide the members into their groups, and send them to a table. Hand out the ***Building a Hydrophone*** instructions along with their equipment. Remind them to take an inventory of their supplies to make sure that they have everything and to review all the instructions before beginning. REMIND THE TEENS THAT THE SOLDERING IRONS ARE HOT AND CAN BURN. THEY NEED TO BE VERY CAREFUL.

3. **Building (120 minutes):** Have each team begin building their hydrophones. Help teams figure out how to solve any problems that arise.

4. **Cleaning Up (5 minutes):** Make sure that each team records on their instruction sheet the point at which they stopped working for the day. Have them store their supplies in the container to continue working on them or for when they plan to use them.

5. **Testing their Hydrophones (15 minutes):** Have each team use the containers of water and the tuning forks to test their hydrophones. Make sure that they know how to troubleshoot any problems. They will need to bring their completed hydrophones to the Ocean Institute to use during the Sound Safari field trip.

Tips for Soldering

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Building a Hydrophone Ordering List

Quantity	Radio Shack Item Number	Description
1	270-092c	Condenser Microphone Element*
1	278-513	Audio Cable, 2 conductors (#24) plus shield * 25+ feet
1	274-286a	Two conductor, 1/8" mono phone plug*
1	277-1008c	Mini Audio Amplifier/Speaker*
1 roll	64-2352	Black tape, rubber electrical (NOT PVC tape)*
1	270-402	Battery holder , fits 1 "C" cell*
1	23-871	Battery, "C" cell, Alkaline*
3 ft.	N/A	Wire, Insulated, #24, 1 foot orange, white, blue*
1	N/A	35 mm plastic film canister
¼ cup	N/A	Vegetable or mineral oil
1	N/A	9V battery for amplifier/speaker**
1	N/A	Soldering iron and solder*
1	N/A	Wire stripper*
1	N/A	Silicone seal

*These items can be found at Radio Shack

Building a Hydrophone Instructions

A **hydrophone** is an underwater microphone that will listen to, or pick up, the acoustic energy underwater. Unlike microphones that are designed to work in air, the hydrophone is a special pressure transducer that is highly sensitive to underwater sound vibrations.

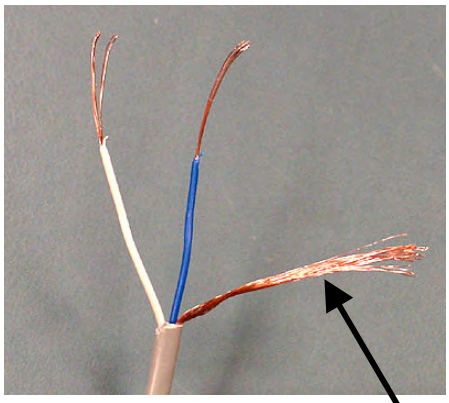
Materials

- ❑ Condenser microphone element
- ❑ 1/8" mono phone plug
- ❑ Audio amplifier/speaker
- ❑ 9V battery
- ❑ "C" battery holder
- ❑ "C" battery
- ❑ 10 feet of audio cable
- ❑ 1 foot of three different colors of #24 wire
- ❑ Film canister with hole drilled in top
- ❑ Black electrical tape
- ❑ Wire strippers
- ❑ Silicone
- ❑ Soldering iron & solder
- ❑ Mineral oil
- ❑ Weight
- ❑ ***Building a Hydrophone*** instructions
- ❑ Pens

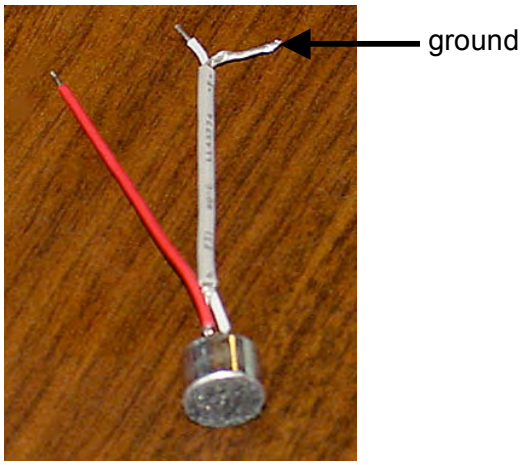
1. Strip the end of the audio cable so the three wires are exposed (in this case, blue, white, and ground {copper}). Strip the ends of the two wires (blue & white) about 1 cm.

   What are the colors of your wires?

   - _____
   - _____
   - _____



2. Strip the ends of the wires connected to the microphone element so that three wires are exposed (in this case, red, white, and ground {copper}).



3. Make a hole in the lid of the film canister the width of the audio cable.

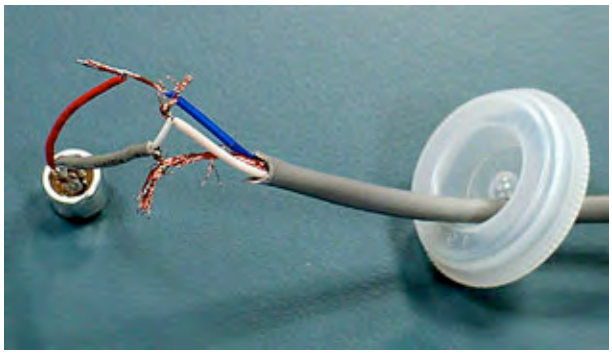
4. Thread the audio cable through the hole.

5. Connect the wires by twisting the two together, as follows:

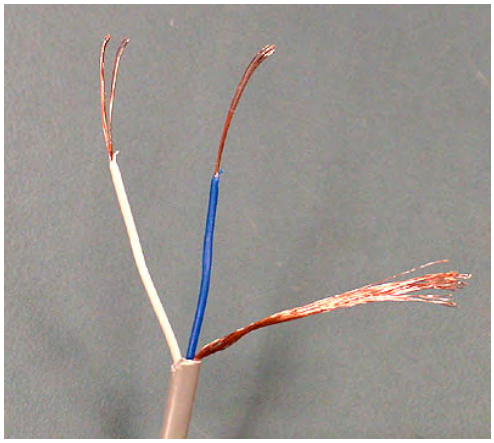
    - Signal from the audio cable to the signal from the microphone element (in this case, white to white)

    - Power from the audio cable to the power from the microphone element (in this case, blue to red)

    - Ground wire from the audio cable to the ground wire from the microphone element



6. Strip the other end of the 25-ft. audio cable so the three wires are exposed. Strip the ends of the two wires (blue & white).



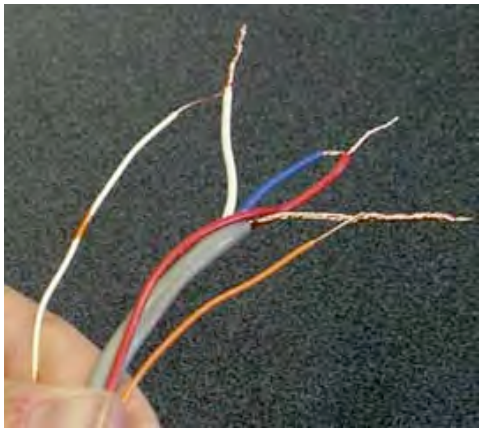
7. Strip both ends of two of the insulated #24 wires (make sure you have two different colors, i.e. orange and white).

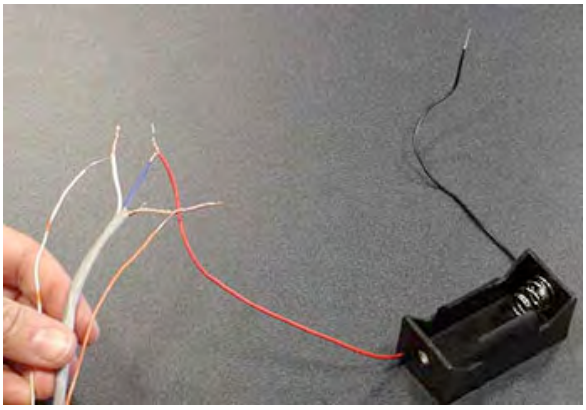
8. Connect the wires as follows:

    - One end of the insulated #24 wire to the audio cable signal wire (in this case, white to white)

    - One end of the other colored insulated #24 wire to the ground wire from the audio cable (in this case, orange to ground)

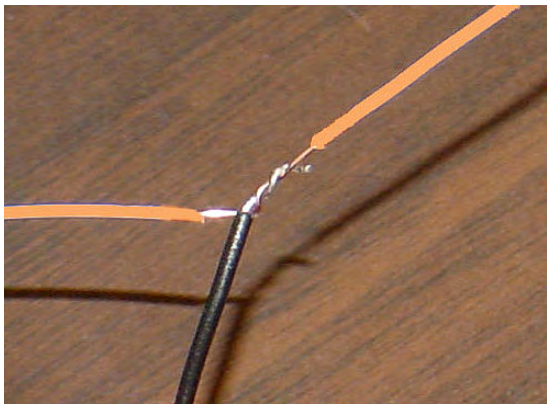
    - Power from the audio cable to the wire from (+) end of the battery pack (in this case, blue to red)





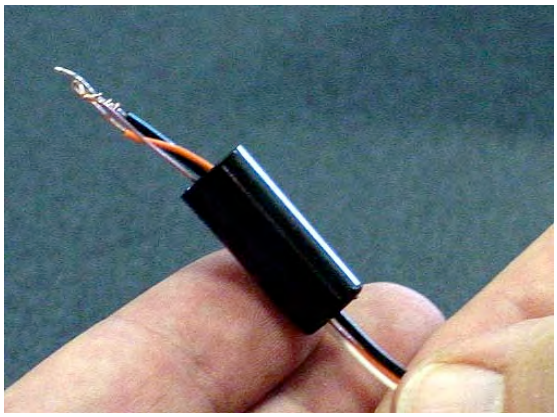
9. Strip a centimeter long piece in the middle of the 2nd insulated #24 wire (in this case, orange, ground) about an inch down from the end.

10. Connect the wire from the black (-) end of the battery pack to part of the orange, ground insulated #24 wire (in this case, black to orange).

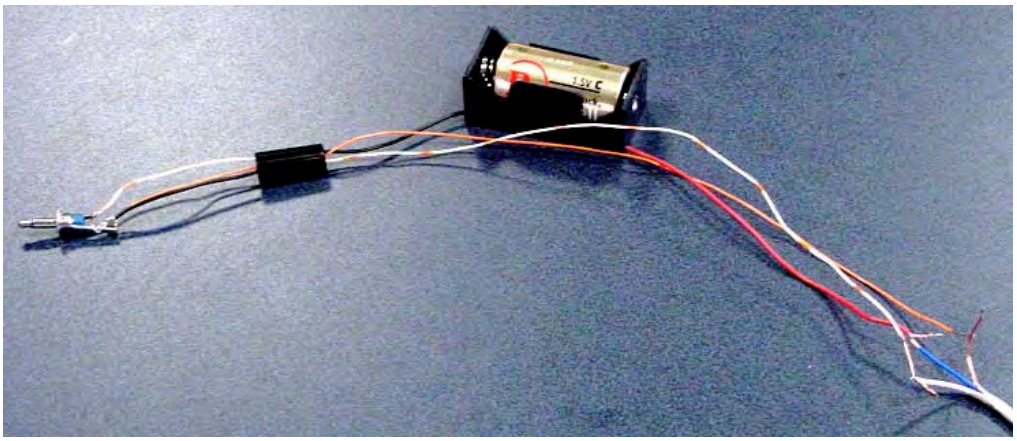


11. Feed the other ends of the two insulated #24 wires through the cover of the phone plug.
12. Connect the signal insulated #24 wire (in this case, white) to the smaller piece of the phone plug (in this case, white to phone plug), by feeding it through the little hole in the phone plug and twisting.

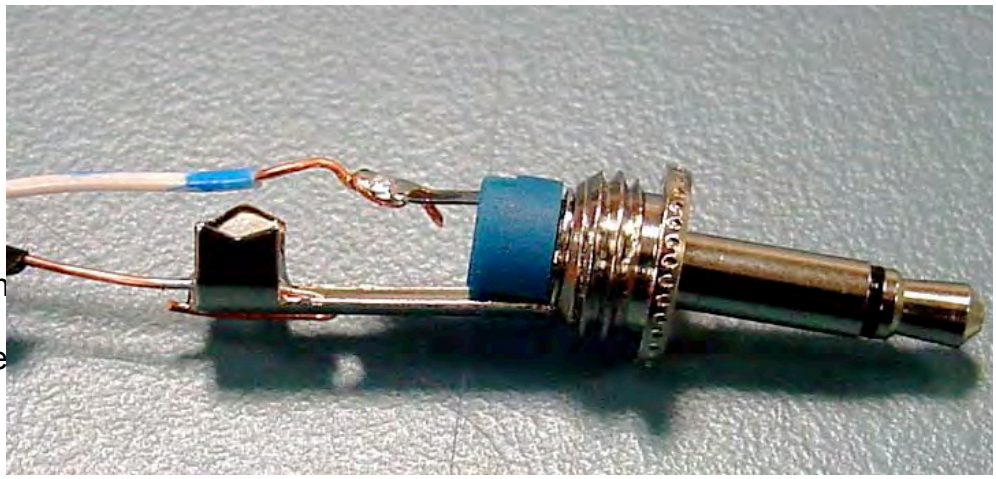
13. Connect the ground wire (in this case, orange) to the longer piece of the phone plug (in this case, orange to phone plug).



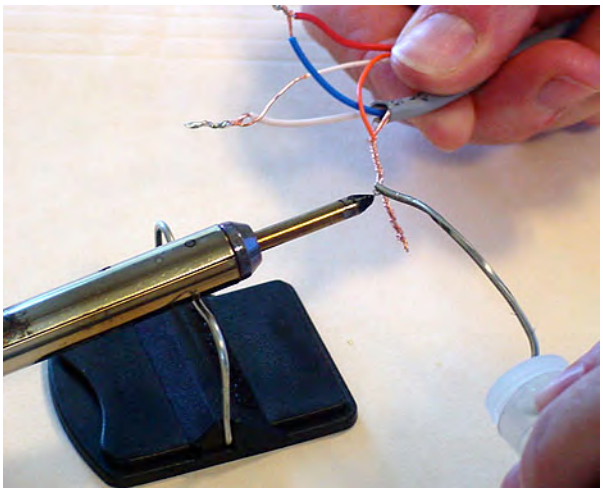
14. Add batteries to the battery pack and speaker/amplifier, put the phone plug into the speaker and test connections. If it works, remove batteries and continue with step 14. If it does not work, find the wiring fault.



15. Solder the ends of the 2 insulated #24 wires to the phone plug (in this case, white and orange).

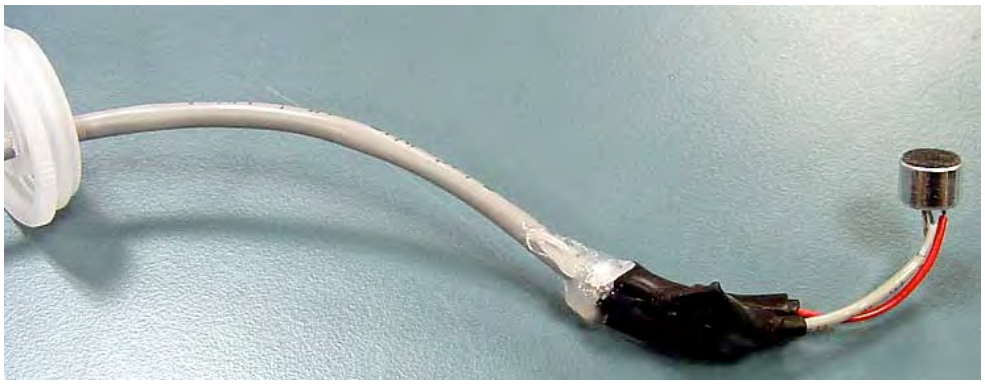


16. Put th
17. Solde



18. Using the black rubber electrical tape, tape around each of the soldered ends, so that no piece of the wires is exposed.

19. Put silicone seal over the end of the audio cable that connects with the end of the microphone element (these ends should already be soldered and taped).



20. Put silicone seal underneath the lid of the film canister where the hole was made for the audio cable. Put a blob of silicone seal on the top of the lid as well.

21. Fill the film canister to the very top with mineral oil.

22. Place the lid on the film canister. Try not to get any air bubbles. Having an air bubble may cause the film canister to compress and change shape due to the pressure in deep waters. This should be done over a sink so excess mineral oil can spill over.

23. Wipe film canister down with soap and water to remove excess mineral oil.

24. Using the black tape, tape the lid onto the film canister.

25. Plug the phone plug into the amplifier/speaker.

26. Attach a weight to the film canister. This will allow the film canister to sink.

Notes:

- The first couple of times the hydrophone is placed into water, a little of the oil may leak from the lid of the film canister. This oil is leftover from the assembly process. Place the hydrophone into a container of water to get rid of this leftover oil before putting it into a fish tank or the ocean.

- It is important to attach the weight a little above your hydrophone. The oil in the canister allows the hydrophone to float, so a weight (heavy rock, lead fishing weight, etc.) will enable the hydrophone to sink to a good depth.

Electrical Schematic