

Protocol for Building Field Electrodes

Materials needed for each electrode:

- 1 section of schedule 80 grey PVC plastic pipe, 10" long
(Source: Ayer Sales 315/432-0550)
- 8' length of Belden #8413 microphone cable or equivalent – must be
~1/4" outside diameter, flexible; 2 wire plus braided shield.
- 1 3 pin male DIN connector, preferably Lumberg
(Source: Allied Electronics, 2000 catalog, p. 587)
- 10 oz. tube of clear silicone seal (GE brand or equivalent)
- 12" of 0.020" silver wire (Source: Physics Stores, Clark Hall)
- Fine solder
- Shrink wrap – assorted sizes
- Fine wire-wrap wire
- Roll of vinyl electrical tape, "3M Super 88" (Source: Physics Stores)
- Paper towels

Tools needed or at least recommended:

- Access to band saw, lathe, and milling machine or drill press makes the work quicker and easier.
- Ruler, in inches and centimeters; a tape measure is also fine
- Diagonal cutters, large and small ("nippers")
- Wire strippers: one for cable wires, one for the fine wire-wrap wires
- Caulking gun (for silicone seal)
- Soldering iron
- Small flat bladed screwdriver for DIN connectors
- Large bench vise and small vise or other work holder for soldering.
- Multimeter to check for continuity

Procedure: If you are making more than one electrode, it saves time to prepare all the "blanks" in advance using tools in the metal shop downstairs.

A) Making the blanks:

- 1) With a band saw, cut off the plastic tubing into 10" pieces.
- 2) Measure and mark the center of each blank.
- 3) Measure and mark a position 100 mm out from the center at each end of the blank.
- 4) Using the lathe, cut three shallow grooves completely around the blank at the three marks. Each groove will be about 3/32" wide and 3/32" deep. They will house and shelter the silver wires which compose the contacts.
- 5) Using the mill or a drill press, drill three small holes through the tubing wall, one at each groove. If you use the mill, "V" blocks can prevent the work from rotating as you drill. Each hole needs to be about 1/16" in diameter, but the size is not very critical.
- 6) Smooth off the ends of the blank and the inside of the holes so wires will not snag as they are passed through.

B) Preparing cable and connecting to blank:

- 1) At one end of the 8' cable, measure off 10" and, using a scalpel or a razor blade, cut through the outer insulation down to the braided shield, using care not to damage the shield. Make one long 10" cut from the circular incision to the end of the cable and peel off the outer insulation.
- 2) Prepare the braided shield to become the middle lead. There are two options:

Option 1: Using a push-pin or similar sharp object, unbraid the shield, keeping the strands intact as well as you can. The strands can eventually be twisted, tinned, insulated with shrink-wrap and attached like the other two leads.

Option 2: Carefully pry the strands loose about eight inches from the cable end and cut the strands off with a small diagonal cutter. Unbraid the remainder, twist, tin, cut off to a final length of about 1", and solder to a standard (~20 gauge) insulated multistrand copper wire. Use shrink-wrap to seal the joint and to insulate the exposed portion of the braid. This option reduces time spent unbraiding the shield, and the standard wire is easier to fasten to the silver wire at the blank.

- 3) Remove about 2" of the insulation from the white lead. Make sure it is well twisted and then tin it. This will be the POSITIVE contact at the toe of the finished unit.
- 4) The black lead will be the NEGATIVE contact at the heel of the unit. First, cut off and discard the last seven inches of the wire. Then, remove about 1 1/2" of the remaining insulation. Twist the wire and tin it.
- 5) Cut three pieces of the fine wire-wrap wire, strip off about 1/2" of insulation from each and tin the exposed ends. Push the soldered ends through the drilled holes in the blank and snake them out to the negative end. They will be used to guide the much heavier contact wires through

the hole in each groove. Solder the three guide wires to the appropriate contact wires and carefully pull the three contact wires out to the grooves. If your drilled holes are small, this can be a little tricky. Persevere!

- 6) Cut 3 pieces of silver wire, each 4" long. Connect them, one at a time, as follows: Wrap the silver wire around the groove so that it goes around twice and the ends stick up evenly directly above the hole. Twist the silver wires together with the tinned portion of the contact wire protruding from the hole in the groove. Twist firmly but be careful not to break off the silver wire which is malleable and quite soft. When the joint is solid and the silver seems firmly in position, cut off the jagged, uneven ends and solder the joint. The PVC pipe can be easily melted, so be careful where you hold the soldering iron. Complete all three contacts in this way.
- 7) Wrap each completed contact tightly with vinyl electrical tape. This will prevent the silicone seal from squishing out through the holes when the blank is filled.

C) Filling the blank:

- 1) Put the assembled unit in a vise – be careful not to damage the nice new contacts! It can be horizontal or vertical, but have the NEGATIVE end near you.
- 2) Provide a supply of paper towels for clean up. Be careful not to get the silicone seal on your skin. After using it, wash your hands before touching your eyes – the stuff really burns!
- 3) If the silicone seal is new, cut off the tip to create a small nozzle and puncture the seal so the sealant can escape. Put the tube into the caulking gun. If the silicone seal is in an already open tube, fiddle around until it flows freely – sometimes they are beyond recovery.
- 4) Stick the nozzle in the NEGATIVE end of the blank and slowly and steadily inject sealant until it comes out around the cable at the POSITIVE end. Stop, take the pressure off the gun so it will not continue to ooze, smooth up the sealant at the cable end, and then put the unit in a safe place overnight to set. If the DIN connector has already been attached, the job is now complete; if not, the connector can be added after the silicone has hardened up overnight.

D) Installing the DIN connector:

- 1) Before preparing the cable, disassemble the Lumberg 3 pin male DIN connector and put the long black grommet and lock ring over the cable; loosen the screws which hold the retaining clamp and slide the body of the connector up on the cable – you can forget to do this until you have soldered wires in place and it's too late! The pins on the DIN plug are numbered 1 to 3 on the inside; you will connect the leads as follows: #1 is the white wire (POSITIVE); #2 is the braided shield (GROUND); #3 is the black wire (NEGATIVE). To make the connection as sturdy as possible, the retaining clamp should eventually be tightened around the full diameter of the cable. It is therefore important to remove as little of the outside insulation as possible and to keep the wires to be soldered very short. This is a nuisance but really important.

- 2) Now, remove about 3/4" of the outer insulation; unbraid the shield with a push-pin and fold the strands back – do not twist them yet; remove about 1/4" of the insulation on the black and white leads, twisting and tinning the exposed wires. Note that the solder posts on the DIN plug form a triangle with #2 in the middle. Bring the shield wires loosely together and arrange them, with the black and white leads, to form the correct triangle to facilitate soldering. Remove (i.e. cut off) about half of the wires from the braid so the remainder will fit, twist them and tin them. Before soldering, fit the leads into the DIN pins and nip them to a reasonable length. Now solder each lead in place. Use care not to contact the plastic base of the DIN plug with the soldering iron – IT WILL MELT!
- 3) Reassemble the DIN plug and do a final check to see that the finished unit is O.K. Use an ohmmeter to check for continuity between the silver wire contacts and the corresponding pins in the DIN connector.

Have fun!

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