Construction of an Experimental Tetrahedral Ambisonic Microphone

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PLEASE READ ALL OF THESE INSTRUCTIONS BEFORE BEGINNING.

Microphone enclosure construction:

Parts list:
1 Adapter, porcelain lamp socket (flange adapter)
2 Screws, 4-40x5/16 fillister head stainless steel
4 Screws, 4-40x1/4 round head stainless steel
6 Nuts, 4-40 k-lock (or standard stainless steel 4-40 nuts and 4-40 internal lock washers)
1 Adapter, 5/8-27 to 3/8-16 mic stand
1 Washer, 3/8 internal lock
1 Nut, 3/8-16
1 LED – yellow 1/8”
1 Switch, DPDT toggle
1 Shrink tube, 3/8x2, black
1 Shrink tube, 1/2x2½ black
1 Grommet, mic cable
1 24-guage conductors, set of 3 colors
2 Electronic enclosures, Context Engineering 2506

Tools and materials:
1 Phillips screwdriver, small
1 Flat-blade screwdriver, medium
Drill press if at all possible or a large and a smaller hand drill
Drill bit, 1/8-inch diameter (or metric equivalent)
Drill bits (or better yet, a step bit): ¼, 3/8, and 11/16 inch diameters. (Metric equivalents may be substituted as required. See step 18 if substituting for the 11/16” bit.)
Epoxy, fast-setting (be sure it is fresh)
Fine flat file
Fine felt-tip pen
Hack saw
Pliers or 3/8-inch hex wrench
Table (or a large) vise
Small tube of superglue
4 small wood screws, about ½ inch long (not the ones included with the enclosures)
2 heavy rubber bands (for step 27)

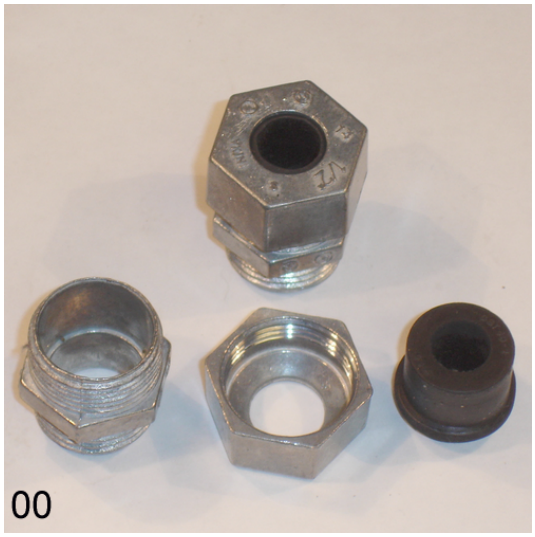
Process with pictures:
Note: Some things are better described in pictures. I tried to do that as much as possible; at times I used the timer on my camera to show things that required my two hands. There are times that the length of the timer was too short to get things in front of the lens, and I will describe those in text! The numbers of each step match up with the picture numbers. Picture numbers are 2-characters wide since most computer programs, even photo software, typically look at alpha-numeric increments rather than numeric ones.

CAUTION! You will be dealing with machinery in this part of the microphone construction. Be careful drilling holes in the metal end plates, especially the large 11/16-inch hole. If you are not sure that you can handle the machine work safely, seek a machinist to help you or do the work for you. Keep hands and hair away from rotating machinery. Always let the rotating machinery completely stop before moving a part.

In describing the sides of the end plates, I will use the terms “inside” and “outside.” The outside is the side of the plate where the 4 corner holes are countersunk. The inside is the side where the 4 holes are not countersunk. While this may seem obvious, it is easy to just pick up the plate, start working on it, and discover later that the outside surface is scratched badly from the rotating pieces of metal around the drill bits.

Also, keep the small screws that come with the enclosures together and in a safe place. You will not need them for a while.

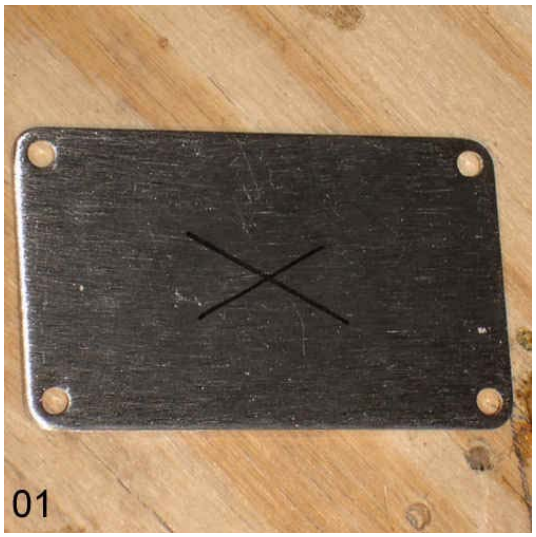
SPECIAL NOTE ABOUT THE RUBBER GROMMET:



00. The grommet is actually the compression insert from an electrical strain relief connector, a device intended to transition a rubber-covered electrical cable to an electrical junction box.

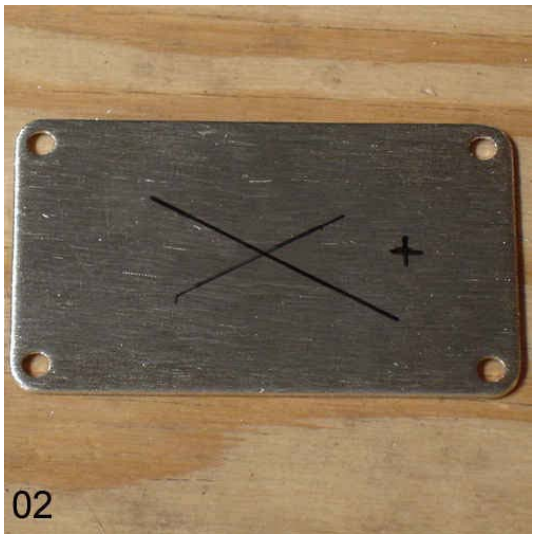
The complete unit is shown at the top of the picture and its 3 parts are shown at the bottom.

Only the rubber grommet is used in this project. I considered using the complete connector for the microphone cable, but there simply was not enough space in the enclosure.

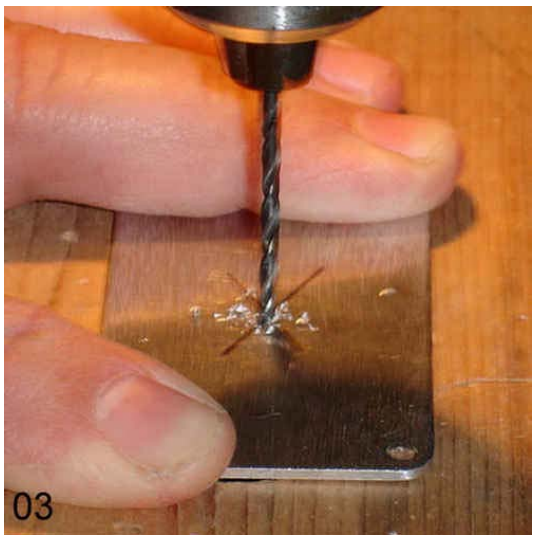


01. Using a felt-tip pen, mark the center of 3 enclosure end plates; one end plate will not be modified. Note that the marks are on the *inside* surface of the plates. Drilling will also be from the inside surface. Clean debris off of the wooden surfaces each time you use the surface to prevent scratching the outer surface of the end plates. Drill the end plates individually rather than stacking them together.

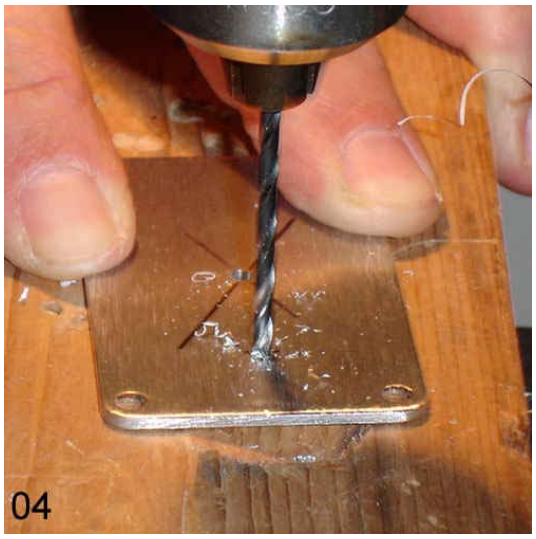
Remember that one end plate will remain blank. Set it aside for safety!



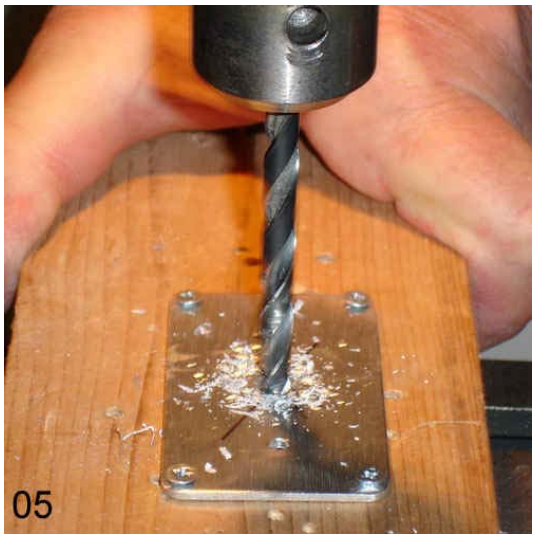
02. Mark 2 of the plates for a second hole ¾-inch *from the center mark* and centered between the narrow edges of the plate.



03. Drill a 1/8-inch pilot hole (from the inside) at the center mark on the plate with only one hole mark. Clean away the debris, including any stuck to the board.



04. Drill pilot holes (from the inside) at the center mark and the second mark on the 2 plates with 2 holes each.



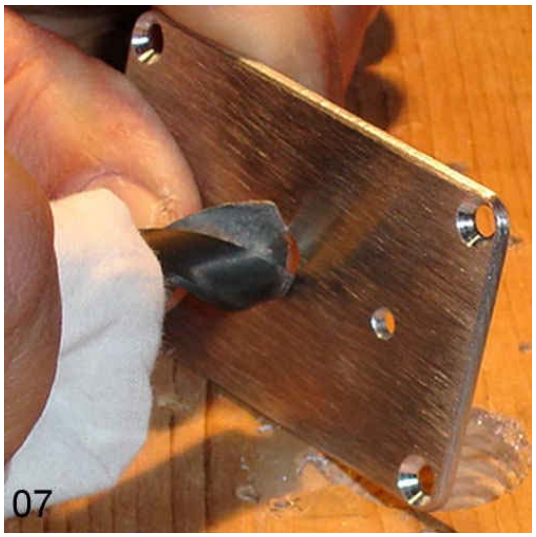
05. For your safety, secure one 2-hole plate to the wood block with 4 small wood screws. Drill a ¼-inch hole in one plate using the pilot hole as a guide.

Remove the plate from the block and set the plate aside. This plate will be used for the power switch and indicator.

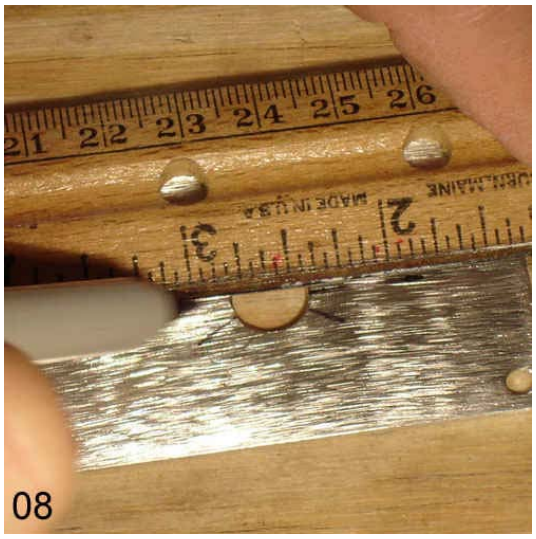
06. Secure the other 2-hole plate with the 4 small wood screws. Drill a 3/8-inch hole in the center hole only. Remove it from the block. This plate is for the stand adapter and the mic cable.

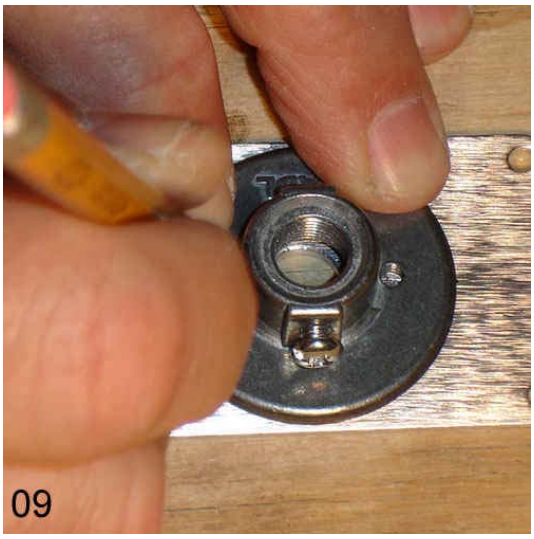
Secure the second plate (it should have only one drilled hole) to the wood block and drill a 3/8-inch hole. This plate will be for the tetrahedral mount.

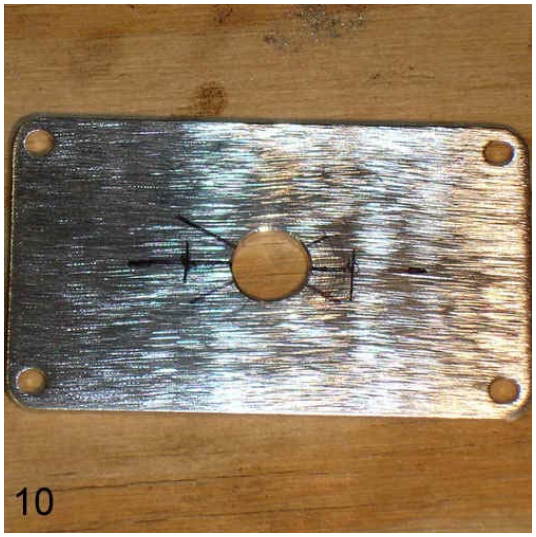
Remember one end plate will remain blank.



07. “De-burr” both sides of the holes on all of the plates, using a larger drill bit (perhaps ½ inch). It would be wise to hold the de-burring drill bit in several layers of cloth or a handkerchief to keep the bit from cutting your fingers. De-burr both sides of the plate.



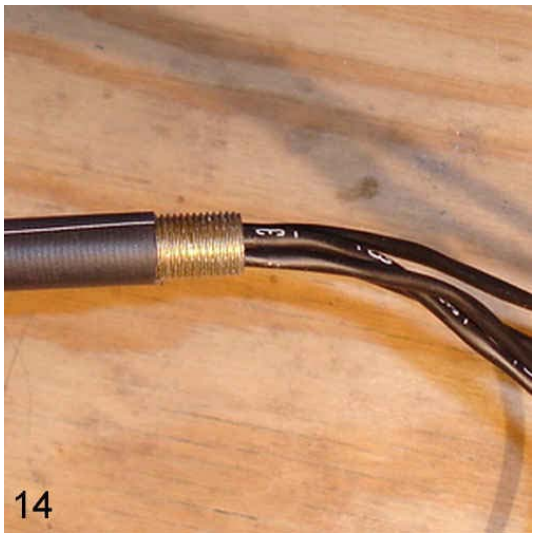




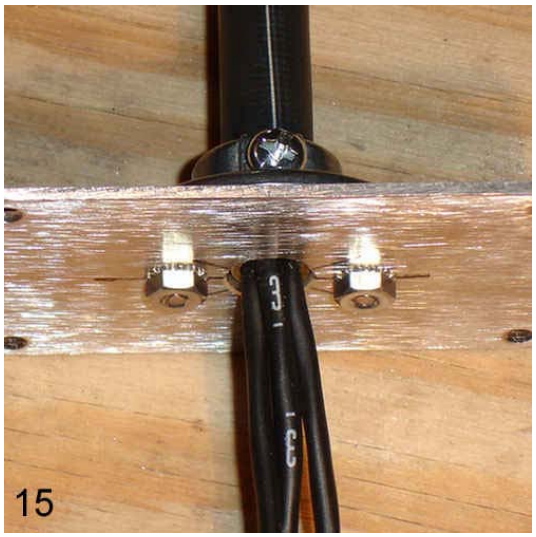
08-10. Using the plate with the single 3/8-inch hole, mark a centerline across the hole in parallel with the long edges of the plate (inside, yes?). Center the flange adapter over the center hole and align the two small screw holes over the newly marked line. Mark the hole positions on the plate with a pencil through the holes on the adapter. Remove the flange adapter and re-mark the holes with the felt-tip pen. With the flange adapter, check that the cross marks are visible through the small screw holes. Correct, if necessary.

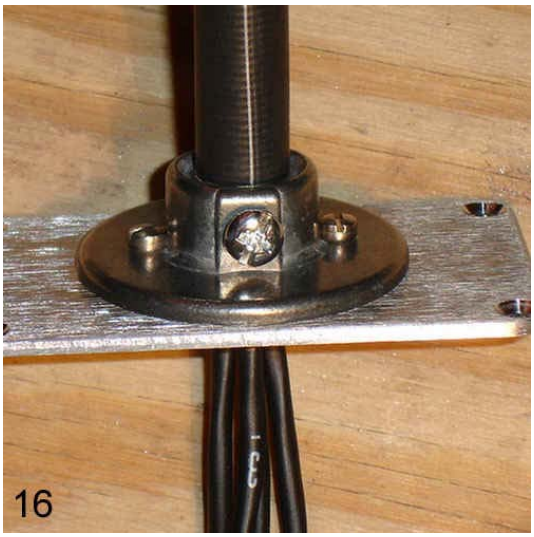
11. Use a 1/8-inch drill bit to drill a hole at each cross mark. De-burr the holes on both sides of the plate. Shown is the 3/8-inch bit used for de-burring.

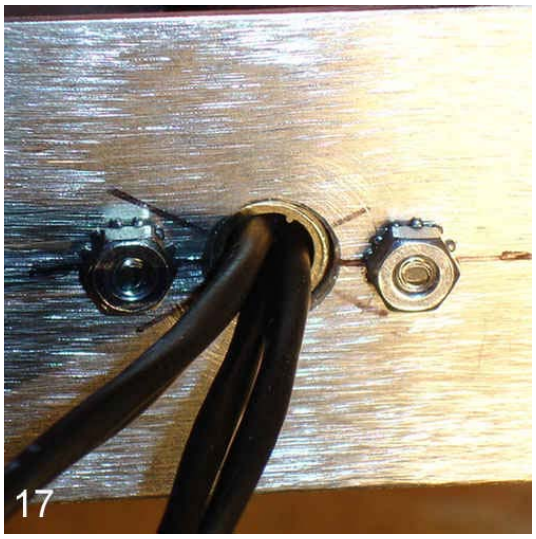
12-13. Mount the flange adapter to the outside of the plate with 2 4-40x5/16 fillister head screws and 2 4-40 k-nuts (a k-nut has a captive washer). Center the flange adapter with the set screw perpendicular to the long edge of the plate before tightening the screws.



14. Cut the shrink tube ½-inch from the bottom of the all-thread pipe with an X-Acto knife. (Note: Your shrink tube may not have a white line.)

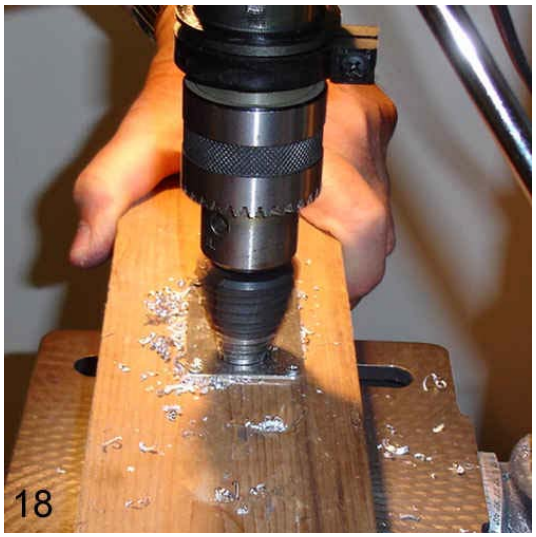






15-17. It is time to mount the tetrahedral frame to the top end plate. Back out the set screw (don't need to remove it) and thread the 4 wires from the capsules through the top of the flange adapter. Screw the pipe in until the shrink tubing meets the top of the flange adapter boss. Visually line up the rotation of the tube so that a midline between the front 2 capsules (1-LFU and 2-RFD) face front; that is, pointing toward the same far off place as the set screw. Snug the set screw to hold the pipe in place.

Note the circular scratches on the inside of the end plate in Figure 17. Masking tape would have prevented the scratches, and this an example of why all drilling should be from the *inside* of the plate. Set this part aside for now.



18. Find the end plate with the 3/8-inch hole and the pilot hole. You should have another unused plate left with a ¼-inch hole and a pilot hole. Secure the plate with the 3/8-inch hole and a pilot hole to the piece of wood with all 4 small wood screws.

You are going to drill an 11/16-inch hole at the location of the *pilot hole* located ¾-inch away from the center hole of the plate. An 11/16-inch hole is a large hole, and the bit can become wobbly in a hand drill. A drill press is the best way to do this. If you have any doubts, ask a machinist or someone experienced in machine work to help you.

NOTICE!!! THE GROMMET SHOULD *NOT* EASILY SLIDE INTO THE HOLE. The shank diameter of the rubber grommet is slightly greater than hole you will drill. It will be *pressed* into the hole with a tight fit.

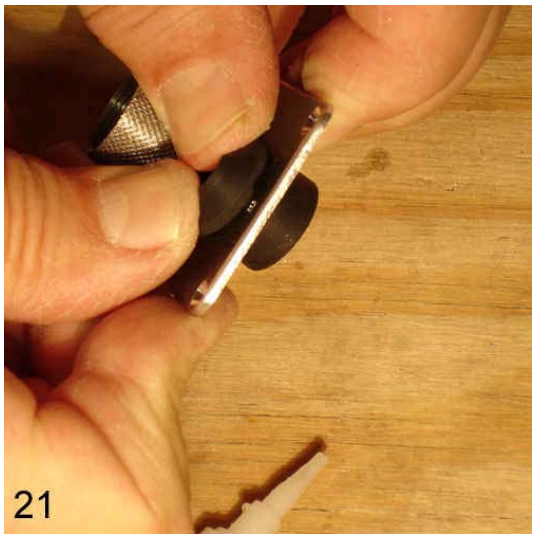
If you are using a step bit, be sure you do not overstep the hole. When approaching the correct diameter, stop the drill, measure the diameter with the rubber grommet, and repeat one step size at a time.

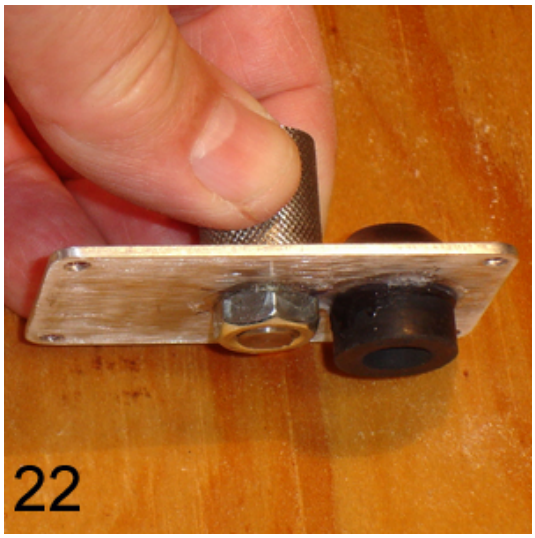
If you are using an 11/16-inch bit, first drill a 3/8-inch hole from the pilot hole. If you have a ½-inch bit, drill the hole out to ½ inch, then drill the 11/16-inch hole.

De-burr the hole. If you do not have a larger drill bit, use a knife or file. Be careful not cut yourself and to not scratch the outside surface of the end plate.

19. Gather the mic stand adapter, 3/8 lock washer, 3/8-inch jam nut, grommet, and the tube of superglue.

20. Place the 3/8-inch lock washer on the screw end of the mic stand adapter. The lock washer will go on the *outside* of the plate. Remember the outside is the side with the countersunk holes in the corners. Install the adapter through the plate and screw on the nut. Before tightening the nut, center the lock washer under the edge of the adapter. Use a piece of cloth (multiple layers of a handkerchief works well) to protect the knurling from the jaws of pliers and tighten the nut against the plate.

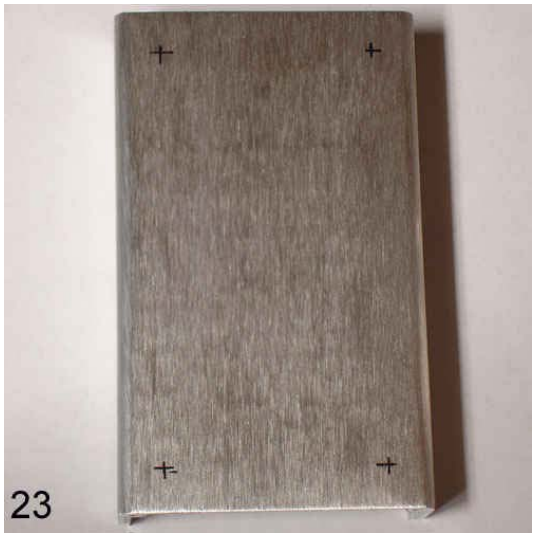




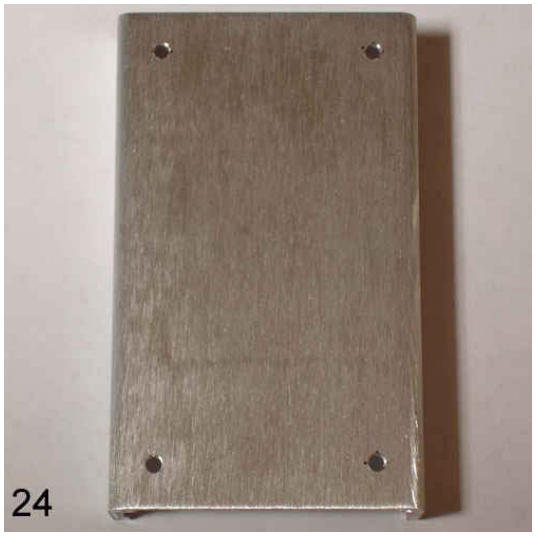
21-22. From the *outside* of the plate, press the grommet into the hole. You may need to put the rubber shank in first at an angle, then encourage the rest by pushing the edge into the hole a little at a time. Once the shank is about halfway into the hole, put a light ring of superglue around the inside of the lip of the grommet.

(Do not get the superglue on your fingers. You can glue your fingers together!) Press the grommet into the hole until it is against the plate. On the inside of the plate, apply another light ring of superglue around the grommet shank. Set this assembly aside to dry. Always wash you hands thoroughly after using superglue.

I will call the enclosure body parts "clamshells." Note that both halves are identical. One is rotated 180-degrees. They mate in a tongue and groove fashion.



23. On the outside of one of the clamshells, mark 4 locations 3/8 of an inch from each corner. Recheck your markings. (This section is the only time you can mark on the outside of the box! By the way, ordinary rubbing alcohol will remove the ink from most "permanent" markers.)

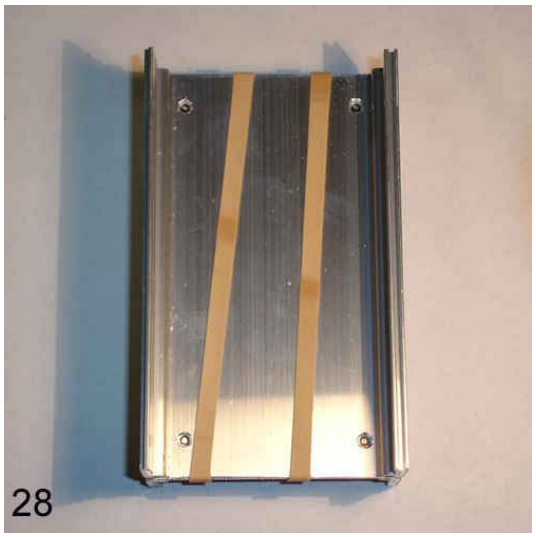


24. Drill a 1/8-inch hole at each of the 4 marks. De-burr the holes on both sides.

25. Mate two of the clamshells. This will assure that one is properly inverted.

26. Now, separate them and put the 2 clamshells back-to-back without rotating the vertical relationship.

27. Use 2 heavy rubber bands to hold the clamshells together as shown. Match them up lengthwise and tap the sides on a flat surface to be sure they are in line.

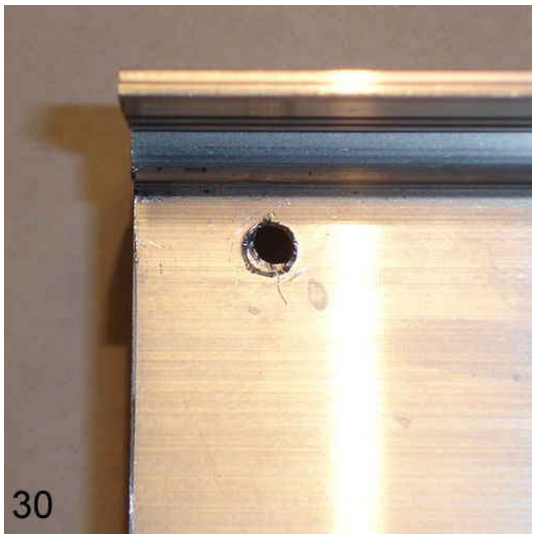


28. Mark the holes. Be careful not to change the alignment between the two parts. With a felt-tip pen, put a single line across one end of the two pieces while they are banded together. This will assist you in realigning them after you drill the holes.

29. Drill 4 holes using a 1/8-inch bit. When starting a hole, just touch the metal with the rotating drill bit and check that it is in the center of the hole mark. After drilling, de-burr the new holes.

Place the two clamshells back to back (The line you drew on the end of the clamshells lines up, yes?) and insert 2 4-40x1/4 roundhead screws through the holes that most closely line up. Install 2 4-40 k-lock nuts, but leave them loose. Line up the edges of the clamshells both vertically and on their side using a flat surface. While on their side against a flat surface, tighten the 2 screws snugly. If one or both of the remaining holes line up correctly, add the screw(s) and nut(s).

NOTE: The 1/8-inch drill bit is slightly oversized for a 4-40 screw. However, this will allow the clamshells to be more precisely aligned. Now is the time to make this adjustment and to make the finished microphone look like a precision device.



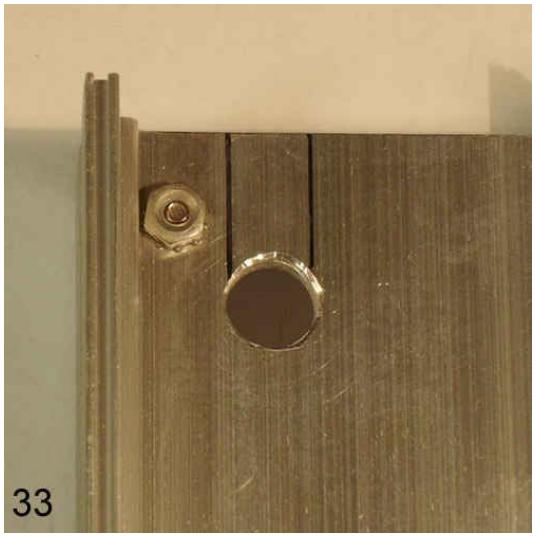
30. Oops! If one or both remaining holes do not line up well enough to clear a screw, re-drill the offending holes while the 2 clamshells are still mounted back to back.

31. Now install any remaining screw(s) and nut(s). Tighten all 4 screws.

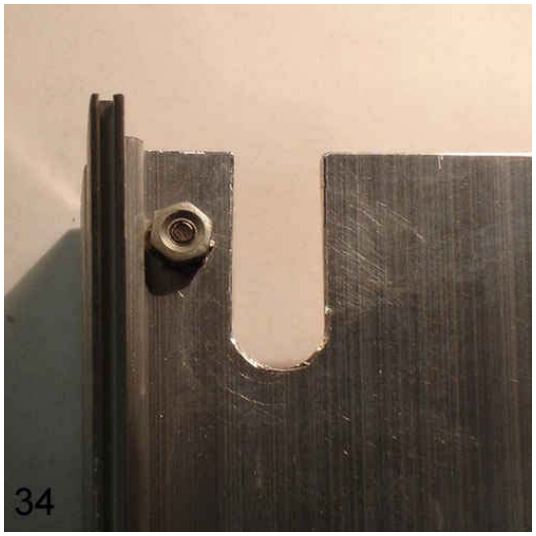
32. On the flat surface of the nut side of the clamshell assembly, measure and draw a line ¾-inch from and parallel to the *outside* of the side edge of the clamshell. Measure down and draw another line (as shown in the figure) ¾-inch from the clamshell edge.

Drill a 1/8-inch pilot hole through both clamshells at the intersection of these lines. Drill a 3/8-inch hole using the pilot hole as a guide. Use a 3/8-inch bit, not a step bit. De-burr the hole on both sides.

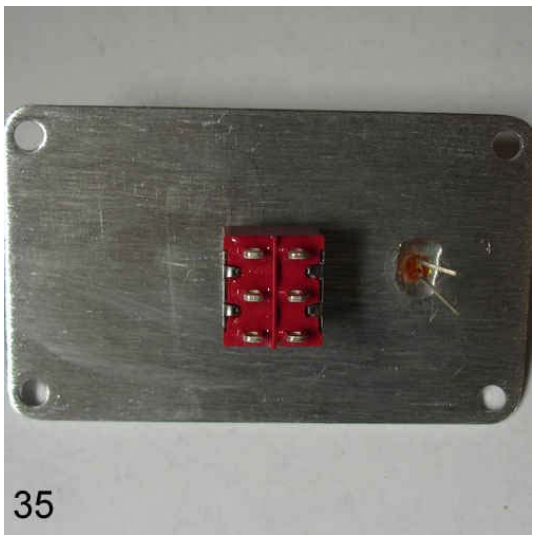
NOTE: While the exact placement of this hole and the saw cuts below are not critical, be as true to the lines as possible. When you show off your work to someone later on, you want your work to be neat.



33. Draw a line from each edge of the hole to the top edge of the flat plates as shown.

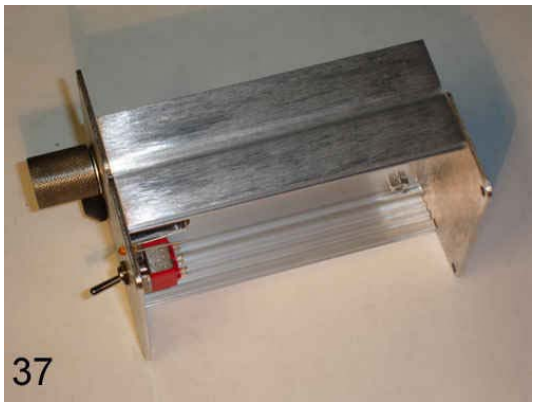


34. Clamp the clamshell assembly in a table vise, but not so tight as to damage the edges of the clamshells. Next, cut down each line with a hacksaw. For better rigidity of the cutting surface, I suggest that you cut the right-hand line first. With a fine flat file, clean the burrs from the sawed edges and leave a smooth edge. Thoroughly clean all of the metal chips and dust from the assembly. Set this assembly aside for the moment.



35-36. Install the DPDT toggle switch in the remaining drilled plate. There should be 2 nuts provided with the switch. Install one to about half way along the thread. Place the lock washer on the thread. Insert the switch shaft through the plate from the inside and put the other nut on the thread outside of the plate. If masking tape is available, I suggest you put some on the outside of the plate to protect the plate from being scratched. Orient the switch as shown in Figure 35. Use a hex wrench or pliers to carefully tighten the outside nut. Avoid letting the edge of the tool touch the plate.

Mix a small amount of epoxy. Insert the LED into the hole. With a toothpick, place a tiny amount of epoxy against the LED and plate on 2 edges of the LED. Rotate the LED one turn to distribute the epoxy around the hole. Be sure the longer lead is down as shown in Figure 35. Place the plate outside down on the edges of the clamshell assembly. Let the epoxy set for 30 minutes. Take a 30 minute break.



37. After the epoxy has setup, attach the blank end plate to the clamshell on the nut side and on the end opposite the internal cut you just made. Use 2 of the short self-tapping screws provided with the enclosures. Do not overtighten the screws. Now attach the end plate with the switch and LED to the opposite end of the clamshell assembly with 2 screws.

Now attach the end plate with the mic stand adapter and grommet to the end of the assembly with the switch. Use 2 more of the self-tapping screws.

A note about the self-tapping screws: The manufacturer of the enclosures used 4 of the self-tapping screws to hold the end plates during shipment. These 2 holes have threads started, the remaining 4 holes of each enclosure do not. If the clamshells you selected for this assembly had holes started (you can see them from the end of the enclosure), you "threaded" deeper into the holes in the final step above. Similarly, when you remove screws and put them back, it is important to put the screw in place and *unscrew* lightly until you feel the thread of the screw step past the thread of the hole. You can then screw it in place, carefully letting the screw seek the original thread groove.

If you simply start screwing in each time, you could easily start a new set of threads in the hole. Each time, you cut material out of the hole and the screw will eventually no longer grip. This is especially important for 4 of the screws of the battery compartment, which will be removed and reinstalled each time you change batteries. It will be equally important for the electronics compartment since one end plate secures the entire microphone to the microphone stand and the other secures the tetrahedral to the electronics compartment.

Congratulations on another job well done. The next step is to "stuff" the pc boards.

Rev. 20120227 – extensive editing, added Figure 00 and information about the grommet