

A DO-IT-YOURSELF HRTF HEAD

Ron Tipton – January 2015



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You can build an economical HRTF head binaural microphone starting with a styrofoam wig holder. I chose a life-size male head, see the Parts List for details, because the ears are acoustically important and I could not find a lady's head model with ears. In fact, one online vendor complained about this. She markets lady's hats and explains that ears are needed for a proper display.

This head model was formed in a two-part mold, front and rear, and the two halves did not perfectly fit. A small ridge remains and it should be removed with a light sanding using 150 grit sandpaper. The ridge is probably not an acoustic problem but its removal looks nicer. Next, give the head model at least two coats of water-based acrylic paint to help stabilize the rather delicate surface. The color is not an acoustical factor, so take your pick. It is important to test the paint on the model's bottom surface to make sure there is no adverse reaction such as dissolving the styrofoam. I had some Glidden flat, matte, interior paint tinted "tan suede glove" which worked fine – see Photo 1.

When the paint is dry, you need to make holes for the microphone wiring. The head I chose had a "carrot shaped" hole (Photo 2) extending from the bottom center to about an inch below the line between the centers of the ears. Having this hole saves a lot of work, but if your head lacks this feature, you must make one. Use a small spoon or hobby knife. It doesn't need to be very large in diameter but you do need room to work on it. The hole in my model started at about a one inch diameter at the base and tapered to about a half-inch. As I mentioned, my center hole was not "deep" enough so I had to extend it about an inch with an iced-tea spoon which I made narrower with a belt grinder.. The depth needs to be opposite a line between the centers of the two ears to accommodate the microphone wiring. I found it convenient to hold the head upside down in a soft, fluffy towel in my lap between my legs while doing this "excavation."

Great care is needed for this next step and the soft towel may help. You need to drill a small hole from the center of each ear into the center hole. Conventional drill bits do not work well on styrofoam so don't try it. Make the two holes with a length of thin-wall brass tubing, 3/16" outside diameter (see Parts List). Even though it's thin-wall tubing, it needs to have a cutting edge. Use a file or belt grinder to "sharpen" one end and then use a small, round jeweler's file to remove the burr from the inside of the tube. This will leave a sharp cutting edge. Starting at the center of each ear, twirl the tubing with your fingers, pushing gently, until it has penetrated about a half inch. Remove the tubing from the hole and push out the piece of styrofoam with a length of stiff wire or small dowel rod. Continue in this manner until you have made both holes. It's really easy and the holes have surprisingly smooth walls – however...styrofoam is a peculiar material. It is composed of fairly small "pellets" that are pressed together to form the molded object so the finished product is not necessarily homogenous. A firm surface is needed for the microphone cartridge to seat properly so using a small, artist brush carefully paint the inside of the ear holes to a depth of a 1/4" or so with the same paint you originally used on the head.

Continue to apply paint coats until you have a smooth surface for the microphones. This will save a lot of grief later on!

Next, you will need to make up the microphones using the parts in the Parts List, Figure 1 and Photo 3. Place a 1/4" diameter colored adhesive "dot" from an office supply store over each microphone face before putting them into the model. This is helpful in case there is some leakage of the liquid rubber in a later step. The painted styrofoam in my model was both soft enough to push each microphone assembly into the 3/16" diameter hole from outside each ear and also firm enough to hold it in place. The outer microphone surface should be flush with the styrofoam surface or slightly indented but it should not protrude. (A later step will further stabilize the microphones and wiring with the liquid rubber.)

When the microphone assemblies are in place in the ears, carefully fish the four wires out through the central hole with a hooked piece of solid wire. Drape the free ends over the head base and secure them with a bit of masking tape. Leave them a bit loose so they don't pull the microphones any deeper into the styrofoam. Check to make sure the microphones are still properly positioned.

For the next step, chose a bowel size you can line with a soft towel that will hold the head upside down (Photo 4). You will also need a disposable measuring cup. Refer to the Parts List and combine 2 ounces each of Liquid Rubber Parts A and B in the measuring cup. Put in 2 ounces of Part A and then add Part B for a total of 4 ounces. Stir until well mixed. Then SLOWLY pour the mixture into the head's center hole. Pour about a half ounce and allow time for it to settle. Then another half ounce and wait... and so on until its level leaves about an inch of space for the wire splices. The mixed pot life is supposed to be 30 minutes but try to finish in 15 or so because it does start to thicken. (You won't need all of the liquid rubber mix but it's difficult to accurately mix a smaller amount. Another indication of this dysfunctional world – you mix the two Parts by volume but the container contents are given in weight! Dow-Corning has some excellent flexible potting material but it's much more expensive than the suggested liquid rubber.)

Wait for the rubber to set, at least 6 hours, so leave the head upside down in the bowel. Check for leakage around the microphones. If you find any, carefully remove it and the protective "dot" with a hobby knife. (You might also have to retouch the paint in the ear when the rest of the project is completed.) Using a small, round jeweler's file, make a groove in the styrofoam base from the center hole to the rear edge. The groove should be just large enough for the microphone cable, an 1/8" diameter if you use the cable in the Parts List. (Photo 5).

Refer to Figure 2 and Photos 6 and 7 and connect the two ground wires together and to the ground wire in the microphone cable. Connect the two "hot" microphone wires to the microphone cable using shrink tubing on the wire splices. Leave a bit of slack in the center hole wiring and lay the microphone cable in the groove you prepared in the step above.

As shown in the Photo 8, I suggest a bottom plate made from a 1/2" thick sheet of Bakelite, drilled (# 7) and tapped (1/4"-20) for tripod mounting and drilled and tapped for a 6-32

machine screw to anchor the microphone cable. Place the head model on the base plate and trace around it with a fine-line marker. Saw around the line and then smooth the saw cut with a file or, better, a belt grinder. Lightly sand-paper the side of the bottom plate that will attach to the head's base for better adhesion (Photo 8). I chose ½" thick Bakelite for the weight, the head model is very light, but 3/8" or even 1/4" thick would be OK and would cost a little less.

With the head still upside down in the bowl, apply some ordinary construction caulking compound to the head's base (as an adhesive) and then lightly press the base plate into position. Let it stand upside down for about 24 hours. Remove from the bowl and trim away any caulk that oozed out. Put the cable clamp on the microphone cable, position the clamp over its tapped hole and secure with a 3/8" 6-32 machine screw and #6 flat washer (Photo 9).

Again referring to Figure 2 and Photo 6, add a 3.5 mm, stereo phone plug to the free end of the microphone cable. The microphone cartridges in the head need 2 to 10 VDC for operation. This is supplied by portable digital recorders (such as the Tascam models) or by a stereo microphone preamplifier designed for electret condenser microphones (such as the TDL model 432 or a pair of model 411 mono preamps).

Styrofoam is a bit difficult to work with but all the above steps can be successfully completed with patience. I have built two of these heads and, truthfully, the second one was easier because of what I learned on number one. I have tried to describe each step completely enough to make your project go well.

For best results, the microphone cartridges should be matched for sensitivity so you have a balanced output from the head. You can do this by purchasing at least ten cartridges and measuring their sensitivity but I will offer a partial kit with a matched pair and with the wires already connected. Please check online at www.tdl-tech.com/diy-hrtf.htm.

Do It Yourself – HRTF Head PARTS LIST

Quan 1 – White Male Styrofoam Head with Face, 12" (or equal)
Amazon (sold by Mid States Beauty) about \$10.00 including shipping

Small quantity of water based acrylic paint, your choice of color

Quan 2 – Panasonic electret condenser microphone cartridge, type WM-61A, Do Not
Substitute – Ebay about \$2.00 each

Quan 4 – 14" lengths of AWG #24 stranded wire, Teflon insulation
Three different colors: 2 with same color for ground wires plus two other colors for left
and right side microphones.
www.ebay.com/bhp/teflon-wire

Quan 1 – 6 foot length (or other length if preferred) 2-conductor, shielded cable
Mouser # 566-8451-100 (100 feet) about \$30.00 plus shipping

Quan 1 – 3.5 mm stereo phone plug
Mouser # 171-3200-EX about \$2.00 plus shipping

Quan 1 – Nylon cable clamp
Mouser # 561-C0125 about 12 cents

Quan 1 – 6-32 x 3/8" machine screw plus # 6 flat washer for use with the machine
screw for attaching cable clamp to base – local hardware store

Quan 1 – Tube of construction caulking compound to attach the head to the base
Home Depot or other local source

Quan 1 – 6" x 6" x 1/2" thick Garolite (Bakelite) sheet for base
McMaster-Carr (www.mcmaster.com) # 8525K32 about \$11.00 plus shipping

Quan 1 – Smooth-On silicone mold making kit, OOMOO30
Amazon about \$30.00 including shipping

Small amount of shrink-tubing for wire-splice insulation (microphone wires to shielded
cable)

Needed for use as a tool:
3/16" OD thin-wall brass tubing (one, 1 foot long piece)
McMaster-Carr # 8859K22 about \$2.00 plus shipping

***** Check www.tdl-tech.com/diy-hrtf.htm for a project parts kit

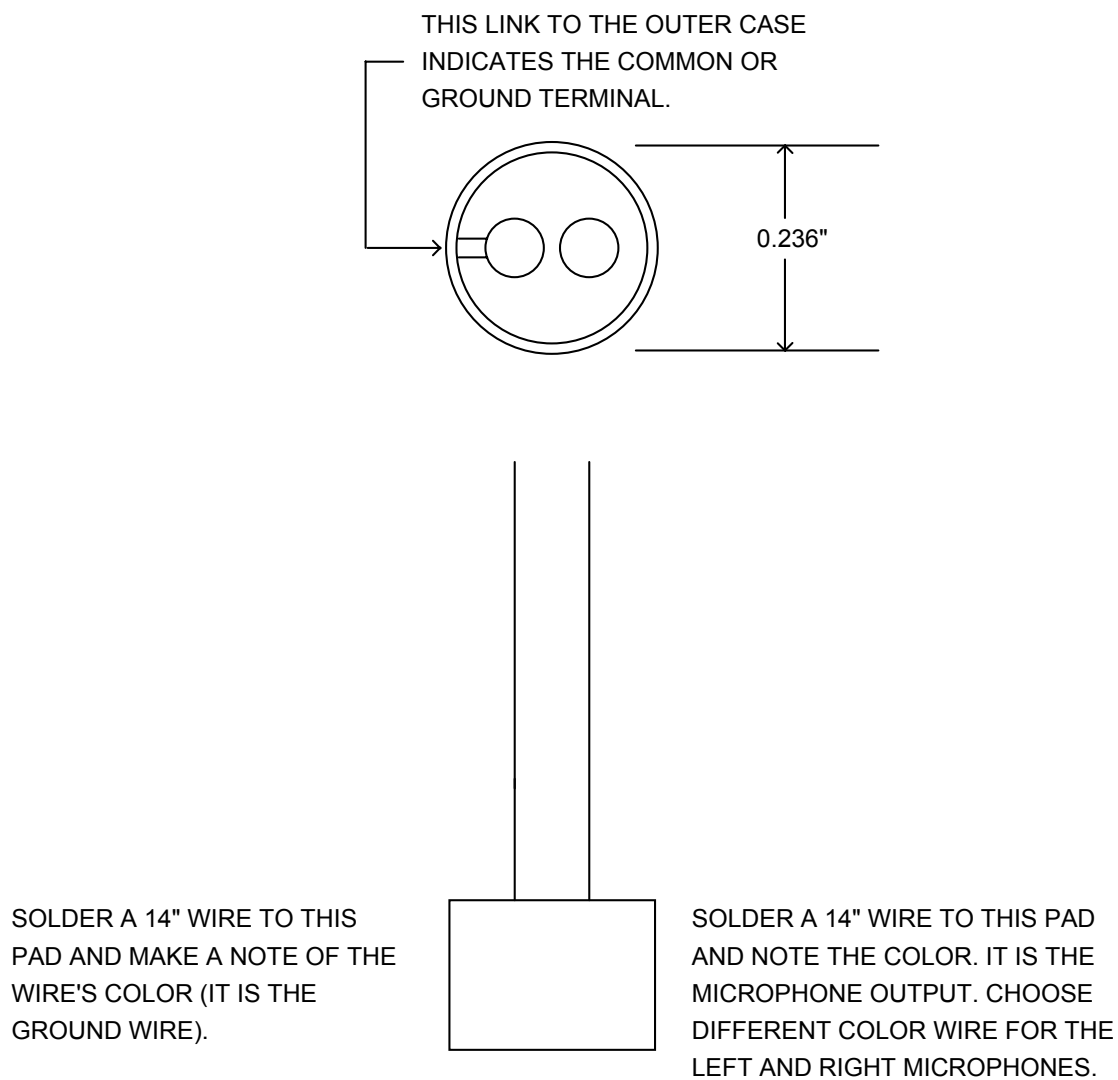


Fig. 1 -- This shows how to connect the wires to the Panasonic WM-61A microphone cartridge for use in the HRTF Head.



Photo 1 – In this photo, “Fred” has had two coats of water-based acrylic paint with a light sanding (220 grit sandpaper) between coats. I rather like the “Tan Suede Glove” color.



Photo 2 – This head was made with a center hole that simplifies the project because the microphone cable will exit here. If your head does not have this feature, you will have to provide it – see text. I tested the paint on the bottom before painting the entire head.

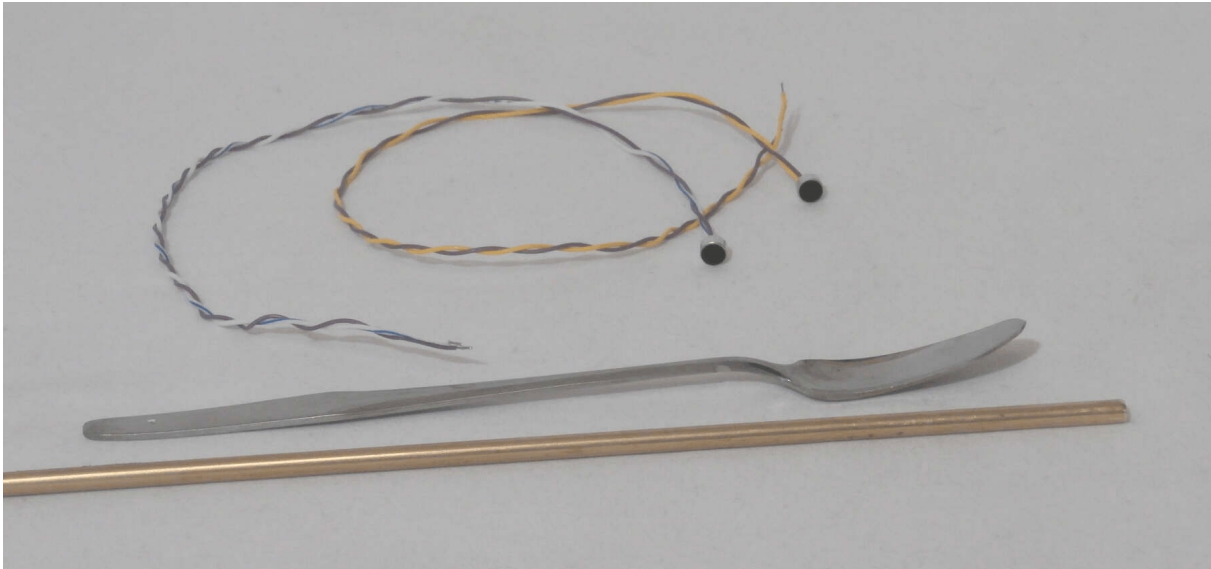


Photo 3 – Panasonic WM-61A microphone cartridges with 14 inch twisted wires attached. Also shown are the modified iced-tea spoon used to extend the head's center hole and the sharpened 3/16" OD thin-wall brass tube used to "drill" the ear holes for the microphones.

The wires must be shortened before splicing them to the microphone cable but the 14" length makes it easier to fish them out through the center hole.



Photo 4 – With the head model upside down, slowly pour the liquid rubber mixture into the center hole until the level is about an inch from the top. This leaves space for the splices connecting the microphone wires to the shielded microphone cable. The rubber takes about 6 hours to cure.

Part A is pink and Part B is blue so it's fairly easy to get them well mixed.

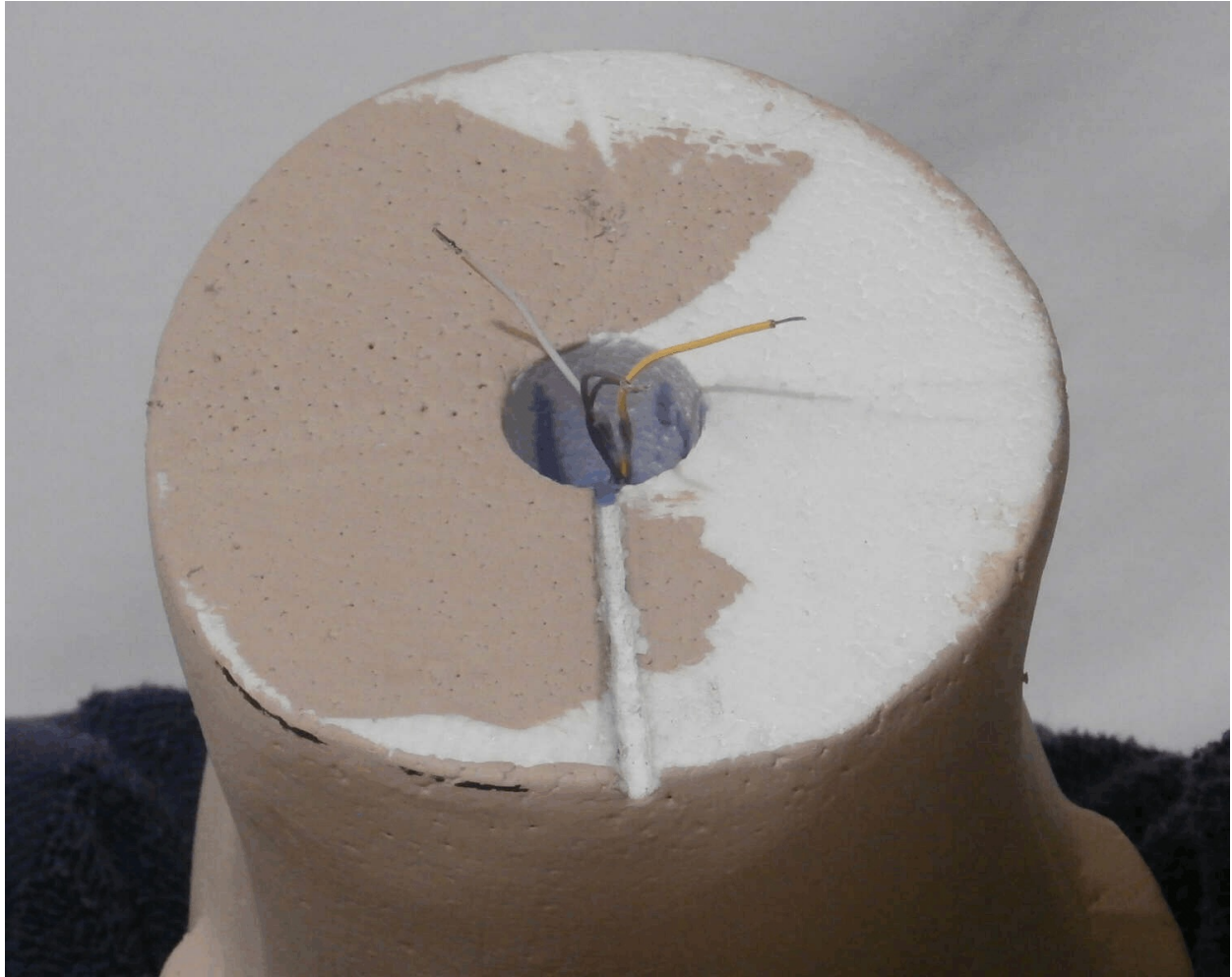


Photo 5 – This photo shows the groove for the microphone cable easily made with a small, round jeweler's file. To get the size right, just lay the cable in the groove. The long microphone wires made it easier to fish them out through the center hole, but they must be cut to about a 2" length before splicing them to the microphone cable.

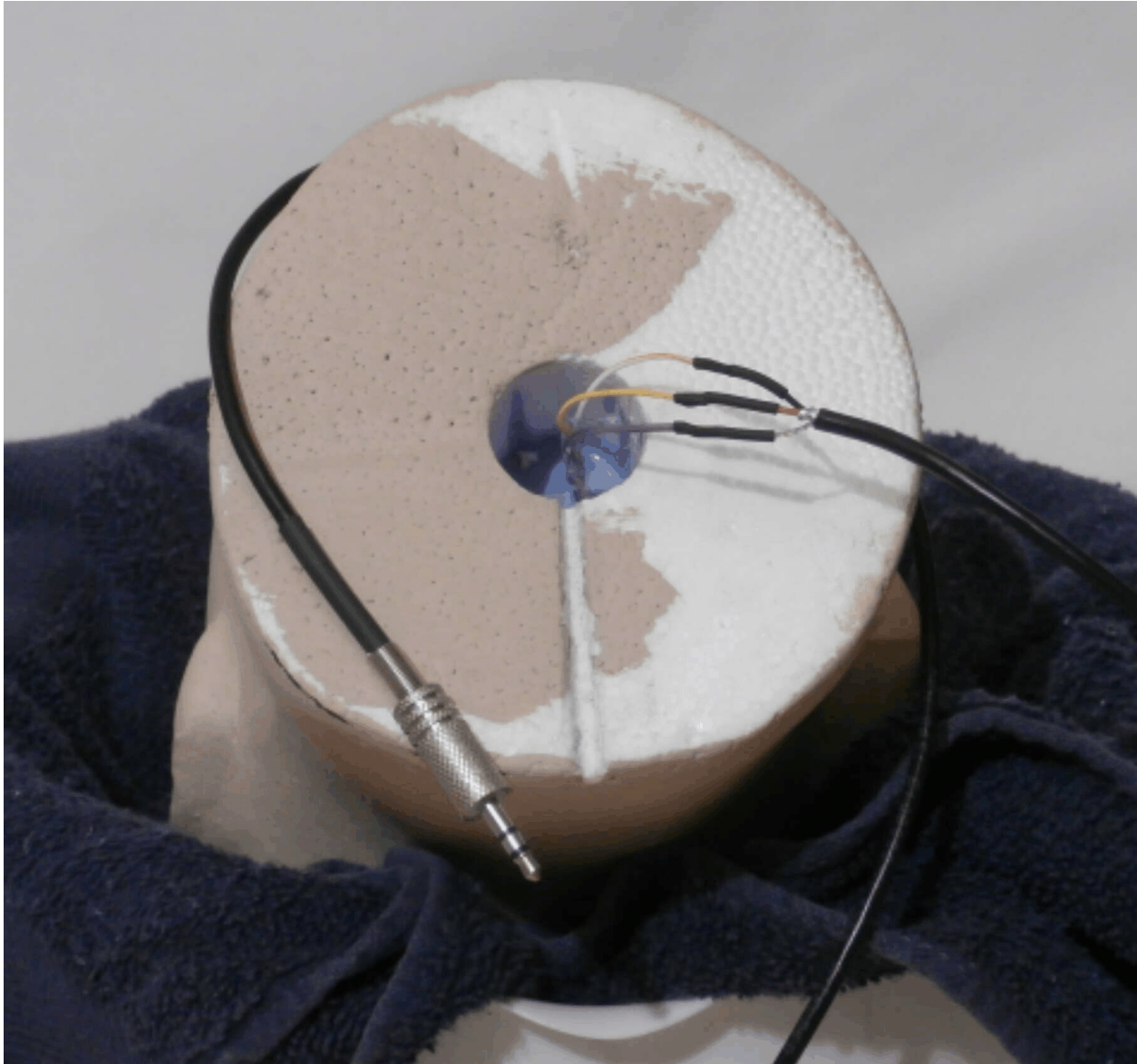


Photo 6 – Strip about a 1/2" of insulation from both microphone ground wires and twist them together, then apply a light solder coat to the joint. Strip about a 1/4" from the other two microphone wires and from the two wires in the microphone cable. Tin all the bare ends. Slide three lengths of 3/32" shrink tubing over the microphone wires and solder the connections. Make SURE the right-hand mic wire connects to the red wire in the cable and the left-hand mic wire goes to the black. Slip the tubing pieces over the joints and shrink them with your heat gun. Try to not melt any of the styrofoam!

This photo also shows the 3.5 mm stereo phone connector attached to the other end of the microphone cable. The suggested cable has a foil shield with a bare ground wire. The bare ground wire is soldered to the connector shell. The red wire goes to the connector ring (Right) and the black wire goes to the tip (Left).



Photo 7 – When the wires have been spliced, they are tucked into the center hole and the microphone cable is laid in its groove.

The bottom plate, shown in Photo 8, is drilled and tapped and then cemented in place with construction caulking compound.

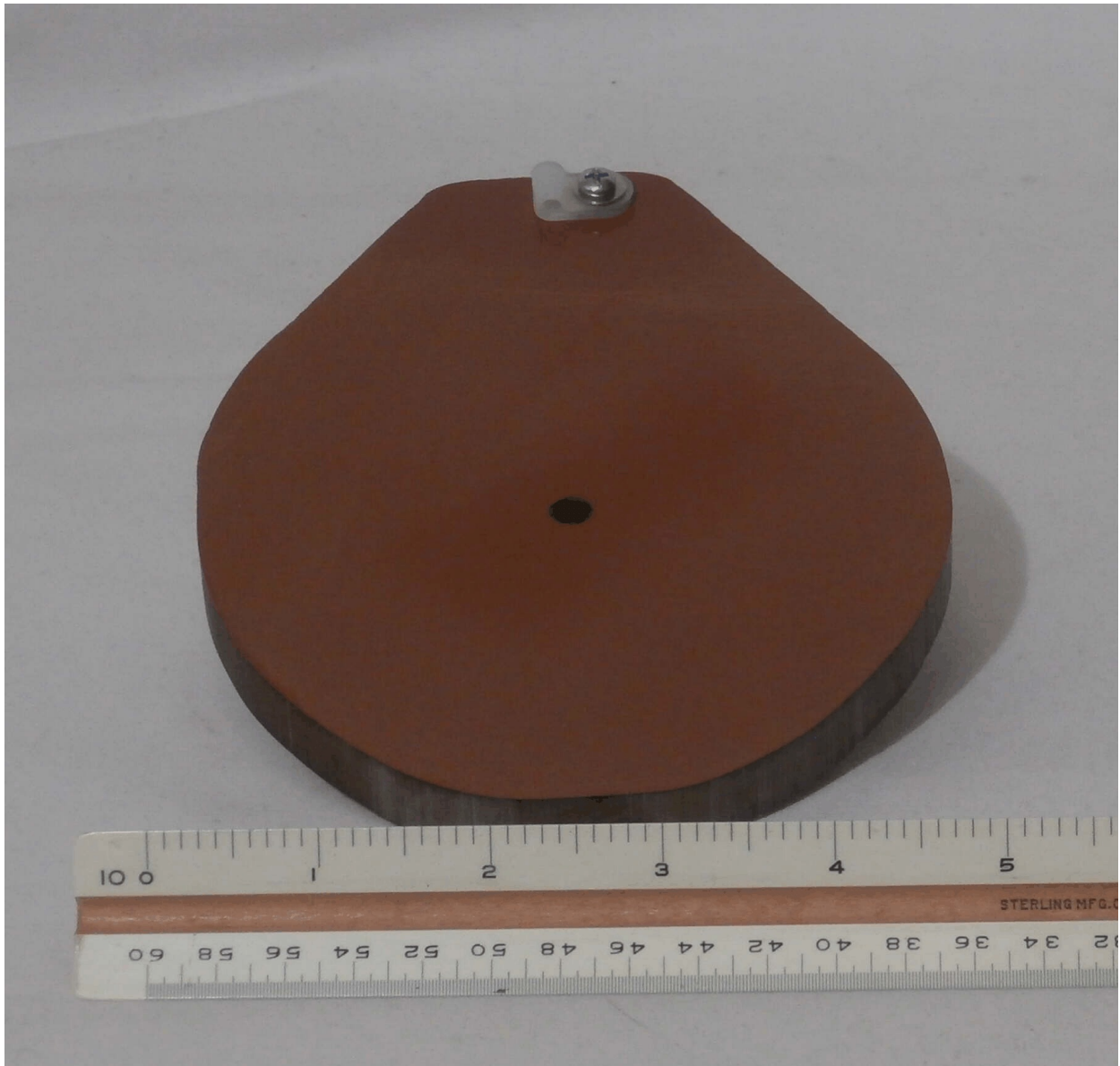


Photo 8 – Place the nearly completed head on the Bakelite base and trace around the model with a fine-line marker. Cut to the line and smooth the saw cuts with a belt grinder or file. As shown, leave a “projection” at the rear side for attaching the nylon clamp to anchor the microphone cable. Locate the base center (about 2-1/2" from each side and 2-3/4" from the front center), drill with a # 7 drill and tap 1/4"-20 for a tripod mount. Drill and tap the hole for the nylon clamp as shown, for a 6-32 x 3/8" machine screw. The Bakelite surface is very smooth so lightly sand it for better adhesion.



Photo 9 – Allow 24 hours for the caulk to set, then trim off any leakage and attach the microphone cable to the base plate. Your HRTF head is now ready for testing and use. Enjoy!