

Everything needed for the build

- 2 midranges.
- 2 tweeters.
- 2 adjustable port tubes.
- 2 sets of binding posts.
- 2 large inductors (1.0 or 1.1 mH)
- 2 small inductors (0.33 mH or 0.35 mH)
- 2 6.8- μ F capacitors.
- 2 2.2- μ F capacitors.
- 2 1.5- μ F capacitors.
- 2 0.22- μ F capacitors.
- 2 10- Ω resistors (10 W).
- 2 6- Ω resistors (10 W).
- 2 perfboards, sized for either small or large components.
- 4 side panels.
- 4 top/bottom panels.
- 2 front panels, with holes drilled.
- 2 back panels, with holes drilled.
- About three feet of speaker wire (18 gauge or bigger is fine).
- 16 screws — #6 x 3/4 inch. (24 if the back will be screwed on.)

Tools and miscellaneous items

Essential:

- Wood glue.
- Clamps or some other means of applying pressure to the parts while the glue dries. (For example, a stack of heavy books or a sleeping roommate.)
- Soldering iron and solder.
- Electrical drill and a 1/8-inch bit.

A hot glue gun is handy, but not essential. Epoxy glue would also work.

If you want to do a nicer job of finishing the exterior:

- Sandpaper — 60 to 100 grit should be fine. If you have power sander or oscillating tool, the smoothing job will go much faster.
- Wood filler.
- Paint (primer and top coat)
- Paint brush or roller.

Assemble your wooden parts



Note that the holes in the front and back pieces have not yet been drilled.

Glue sides, top, & bottom

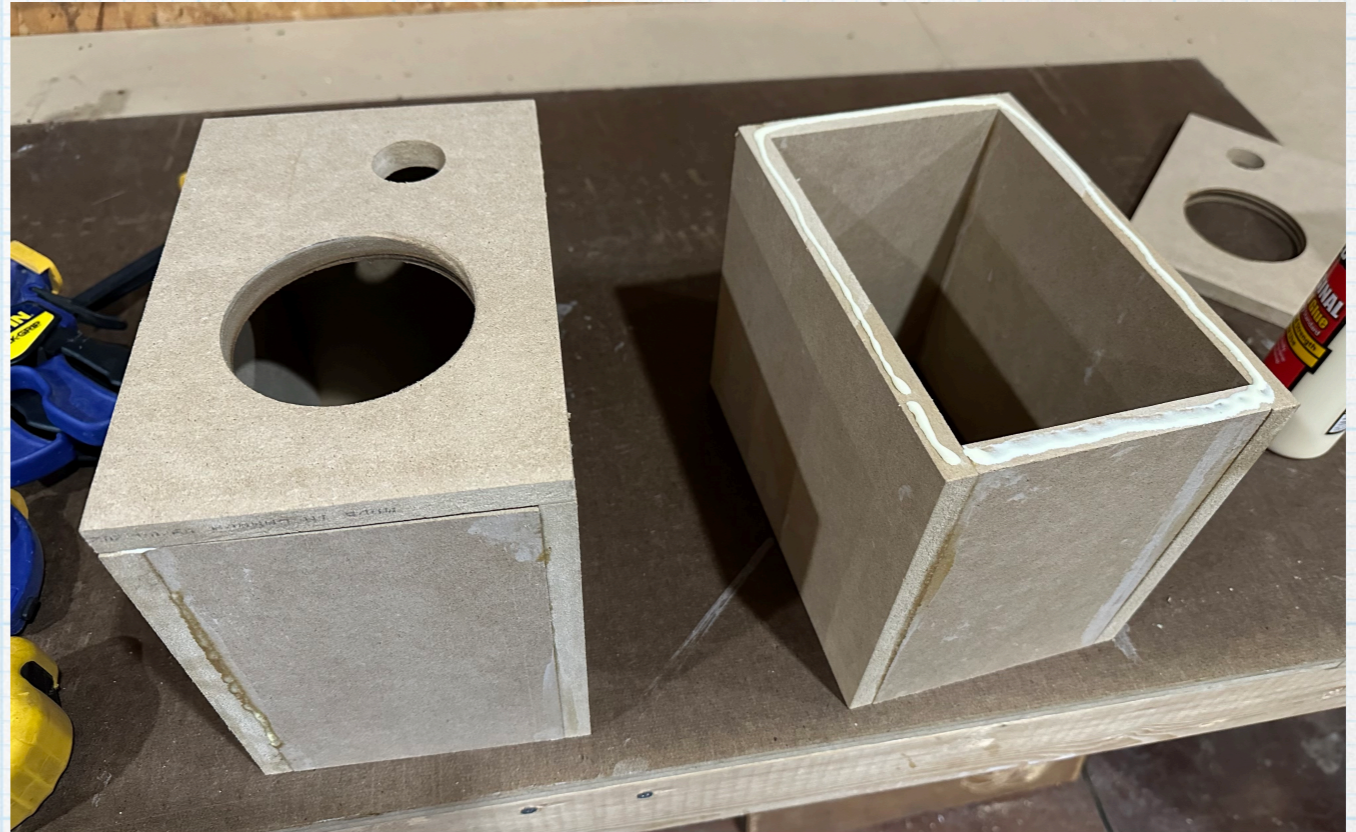
- Make sure that you are gluing the right pieces together. Dry fit everything to see how it all lines up.
- Apply a small bead of glue to the edges of the top and bottom pieces. Not a lot is required — just make sure that the surfaces are covered.
- Glue the top and bottom onto one of the sides. (Top photo.) Then put on the other side.
- Adjust the fit so the edges all line up. The glue will not set up for several minutes, so there is time to slide things around. Better the alignment now means less fiddling later.
- Apply pressure (clamps or books + gravity). Be careful so that pieces don't shift.
- To help keep things square, you can slip the back plate into place. But be careful so that it does become glued in — it needs to remain loose.
- Use a damp rag to mop up excess glue squeezed from the joints.
- Let the glue dry for at least a half hour. Longer is better.



Glue the fronts

Same story:

- Check alignment.
- Apply glue.
- Apply pressure.
- Mop up the excess.
- Wait till the glue dries.



Next dry fit the back plate to make sure that it fits into the backside opening. If it is too big, use sandpaper to shave down the dimensions a bit.

(If it is way too small, you may need to ask for a new piece from GT. Or it may be necessary to fill gaps with wood filler later.)



Glue in back stops

These small pieces will keep the back in place. When gluing them, clamping can be tricky since the small pieces tend to slide around in the slippery glue. It might be better to do one side at a time and just use a small weight (like my tape measure) on each piece to hold it in place while the glue dries. This joint does not have to be super sturdy, so it's not necessary to clamp it tightly.

- On the inside, measure and put a mark 1/2 inch in from the edge. (Or turn the small piece on its side and use that to mark a line 1/2 inch in.)
- Apply glue to the small piece.
- Line it up with your mark.
- Carefully clamp it or use small weight to hold it in place.
- Let the glue dry.
- Turn the boxes over and repeat on the other side.



Finishing the exterior

With all six sides secure, the enclosure is complete, from an acoustic point of view. If you are OK with the slightly unfinished look, you can assemble the rest of the components and the speakers will sound just fine. However, if you want a nicer look, you can paint the boxes in your favorite color.

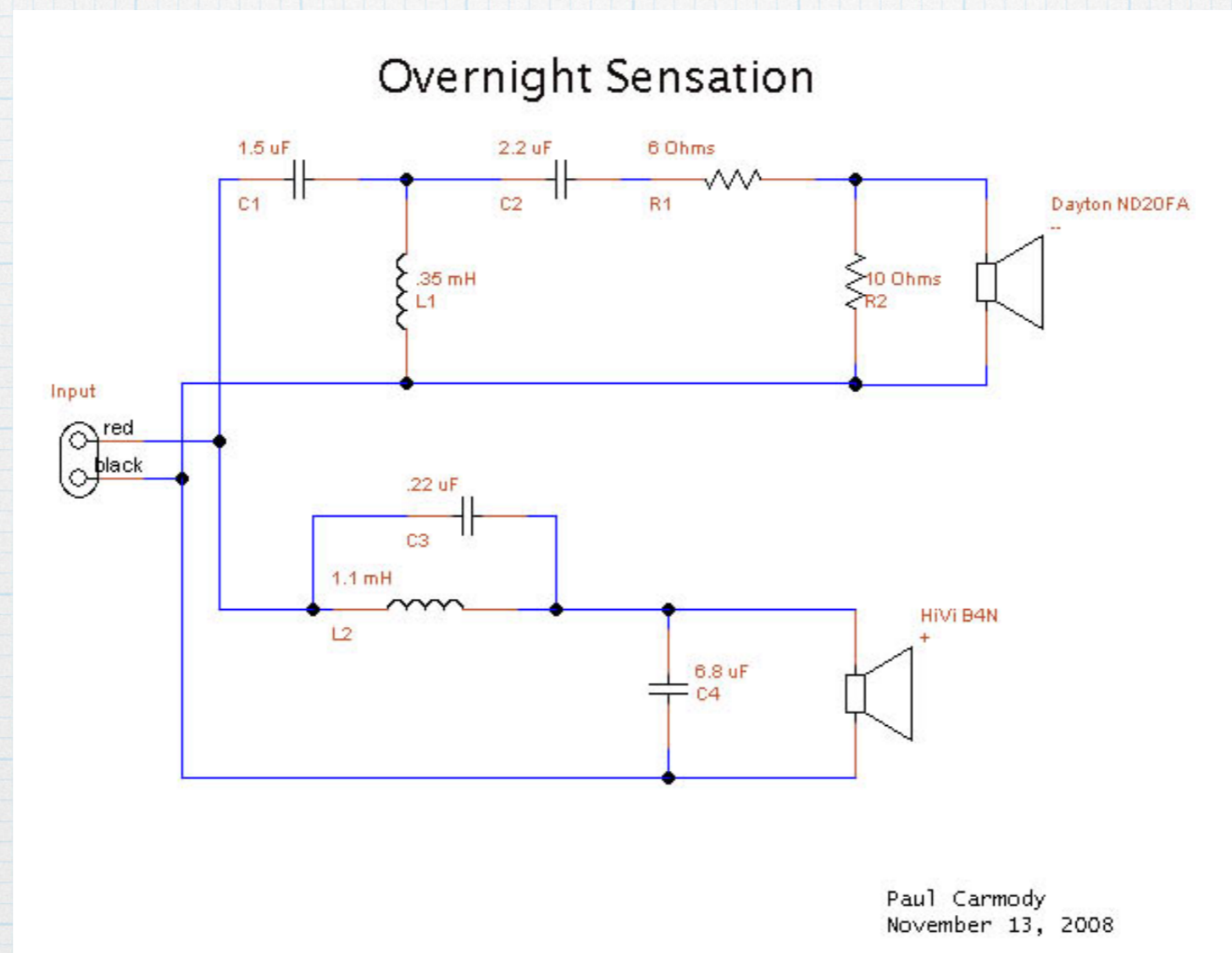
Some suggestions:

- Use wood filler to fill in any gaps or low spots at the corners. Smear on a thin layer and let dry. Then sand it down until it is smooth. This may require two or three applications.
- Sand everything to make all the corners and joints as smooth as possible.
- When painting, use a small roller rather than a brush to get a smoother look.
- Use latex paint — not oil-based! Latex is much easier to clean and dries faster.
- If you primer available, apply a couple of coats to better seal the wood.
- Then apply two or three layers of your chosen top coat. Watch for drips and globs on the surface. Let the paint dry thoroughly between coats.
- Spray paint is (seemingly) easy to apply and one can of paint is probably enough to coat two speakers. However, it is easy to overspray and end up with drips and globs. I recommend spraying several thin coats and then smoothing each coat with a roller or brush.

Building the cross over.

The cross-over components need some sort of a substrate to hold everything in place. The simplest approach to use is “perf-board”, although stiff cardboard or some very thin plywood (hardboard) might would be adequate. (With these other materials, you would need to drill holes for the component leads.)

Another alternative is to design a regular PCB for the cross over and have two boards fabricated. (Refer to the Audio Club meeting of Mar. 25.)



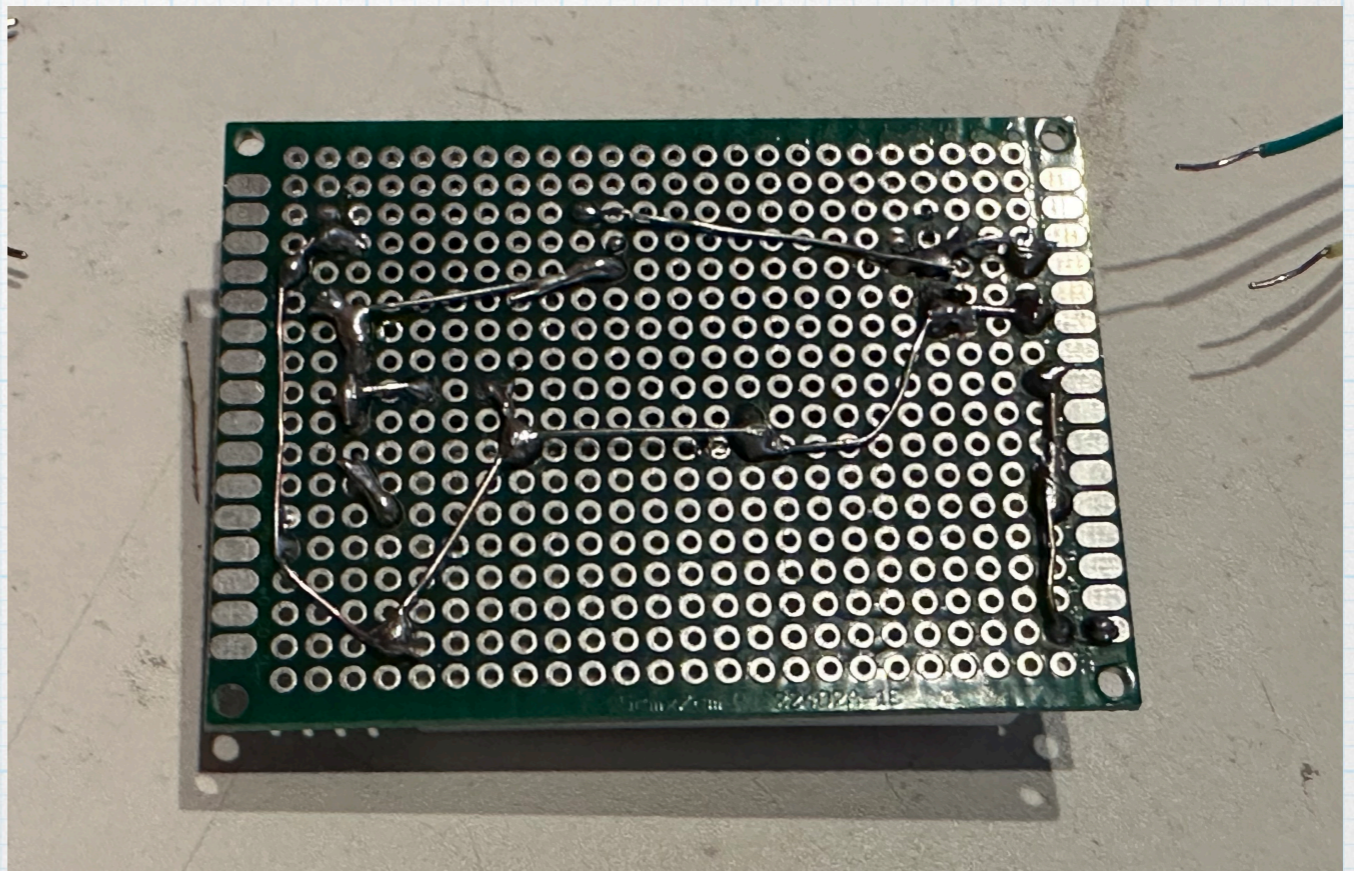
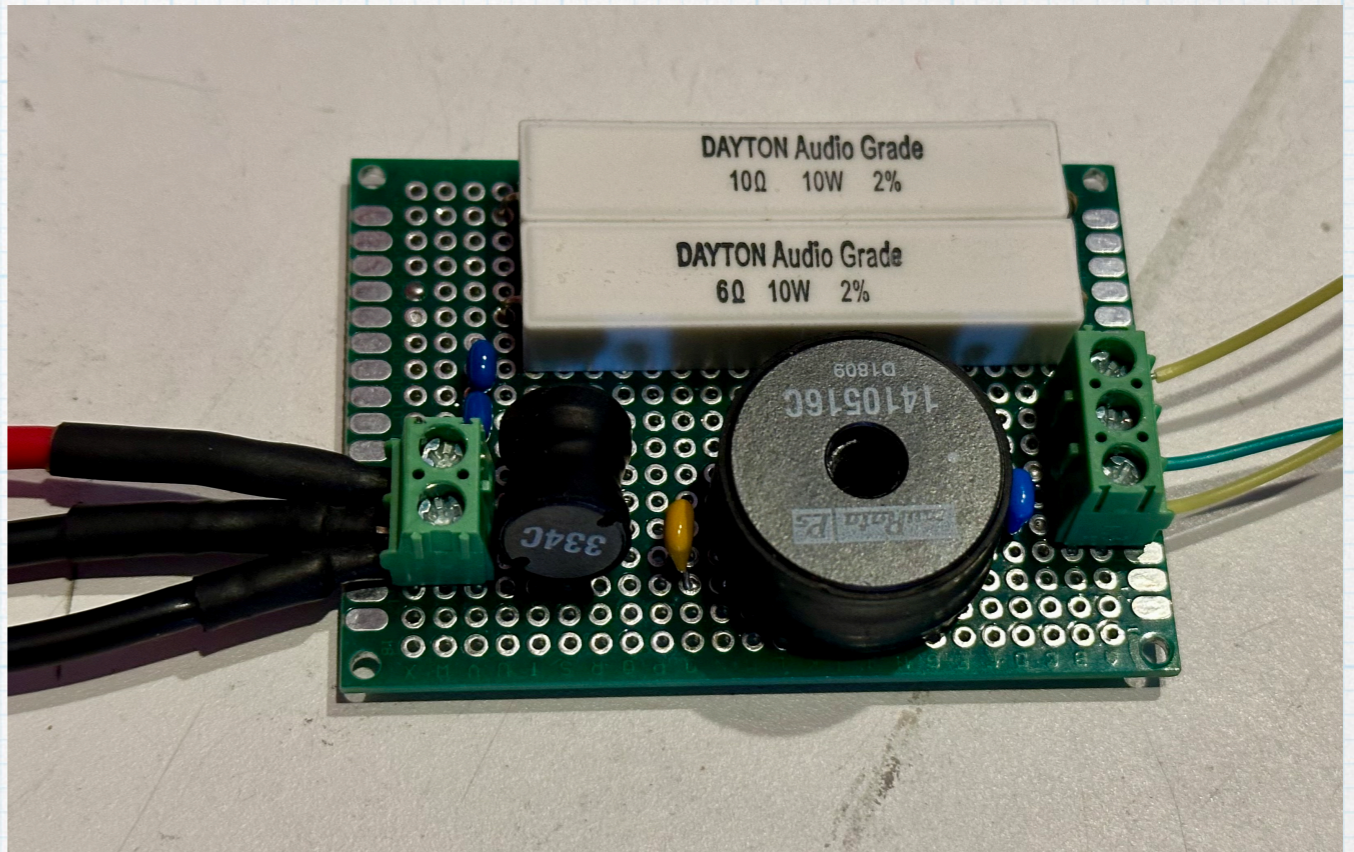
Suggestions when using perfboard.

Perfboard circuits never look as nice as those with a designed PCB, but they are perfectly adequate. In addition, you can have them “right now” — there’s no need to wait one or two weeks or PCBs to be manufactured and shipped.

When using perfboard, the idea is to solder the components in place on one side and then use the leads and jumper wires to make all the connections on the other side.

- Spend a bit of time planning the layout. Sketch a diagram of the component arrangement and the expected path for the connections. Or do a trial-and-error “dry fit” by inserting all components without soldering. (Bend the leads to keep the parts in place.) Re-arrange as needed until you are satisfied with the layout.
- When ready, solder the parts to the board, but don’t cut the leads right away. Often, the leads can be bent over and soldered to make connections. Then trim off any excess.
- The pieces of any leads that were cut can be re-used for connections in other places.
- When using extra jumper wire, make sure that it is big enough to carry the expected currents.

Front and back views of a layout for the cross-over with the small components. This was finished with only one extra piece of lead wire. (The connections shown in the top photo are for testing.)

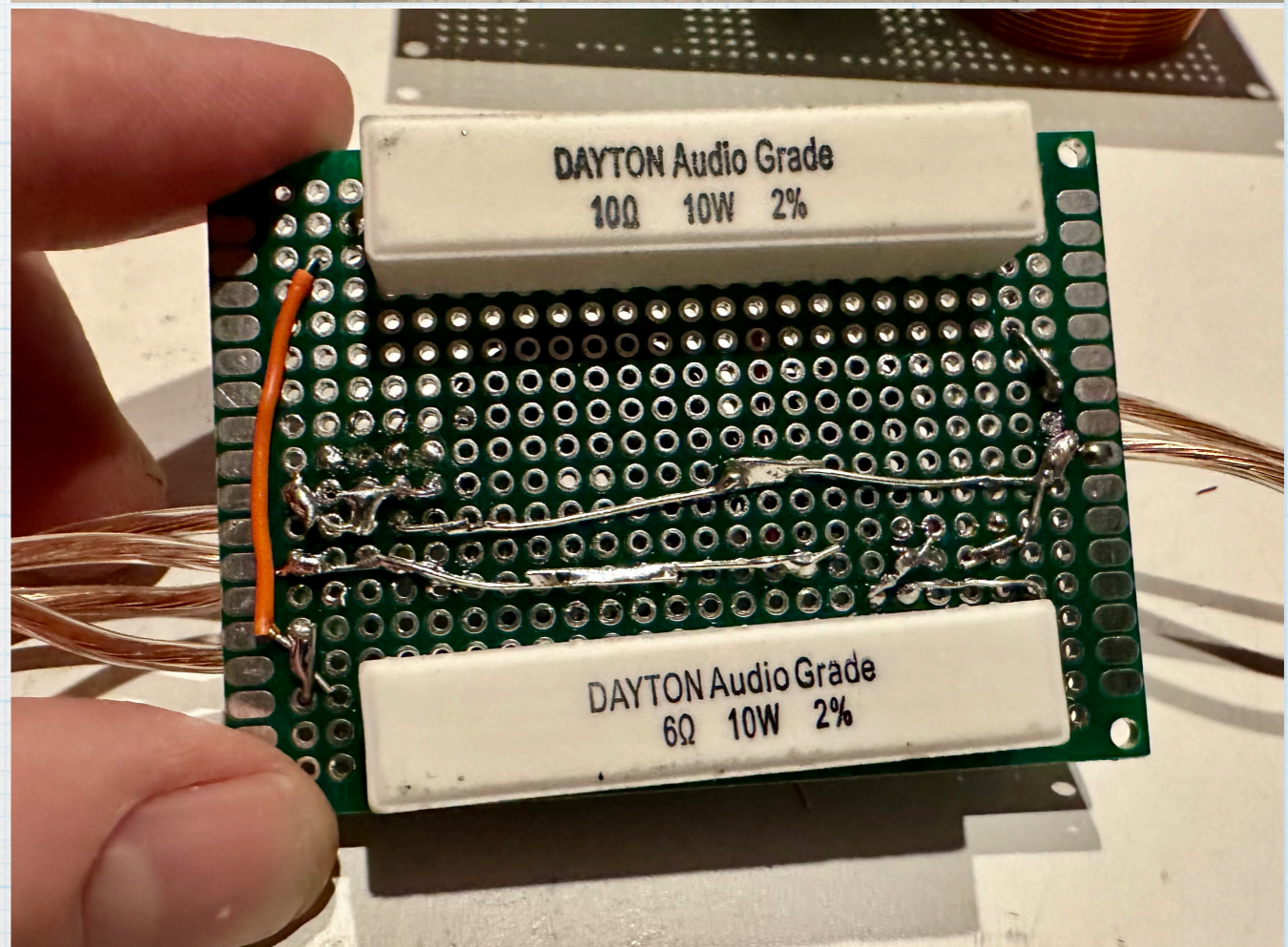
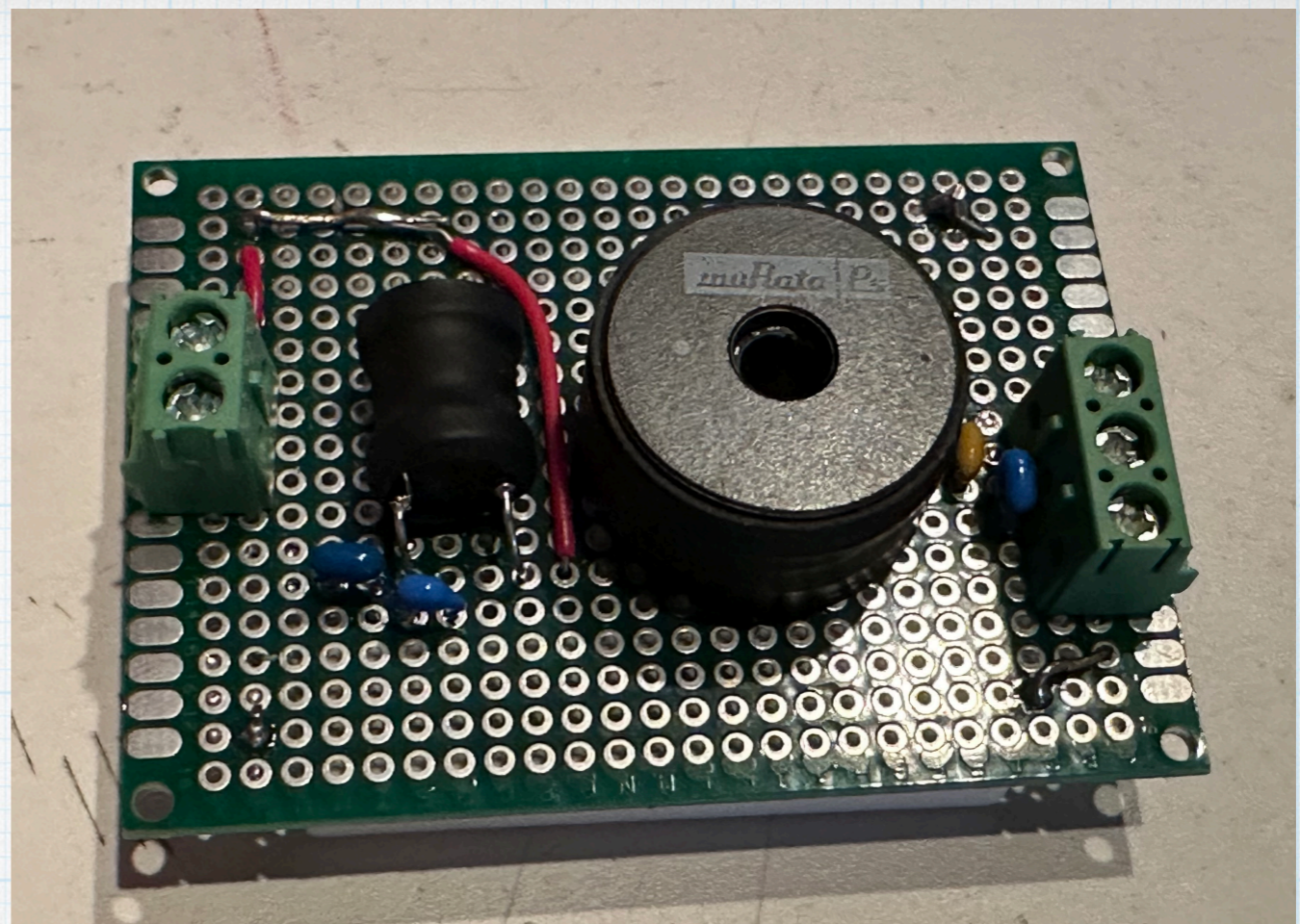


Putting all components one side is not a rigorous requirement.

In this version, the two big resistors are placed on the “wiring” side of the board, leaving a more room to space the other parts on the “component” side.

The bottom-side resistors serve as good mounting surfaces to glue the circuits to the inner surface of the enclosures.

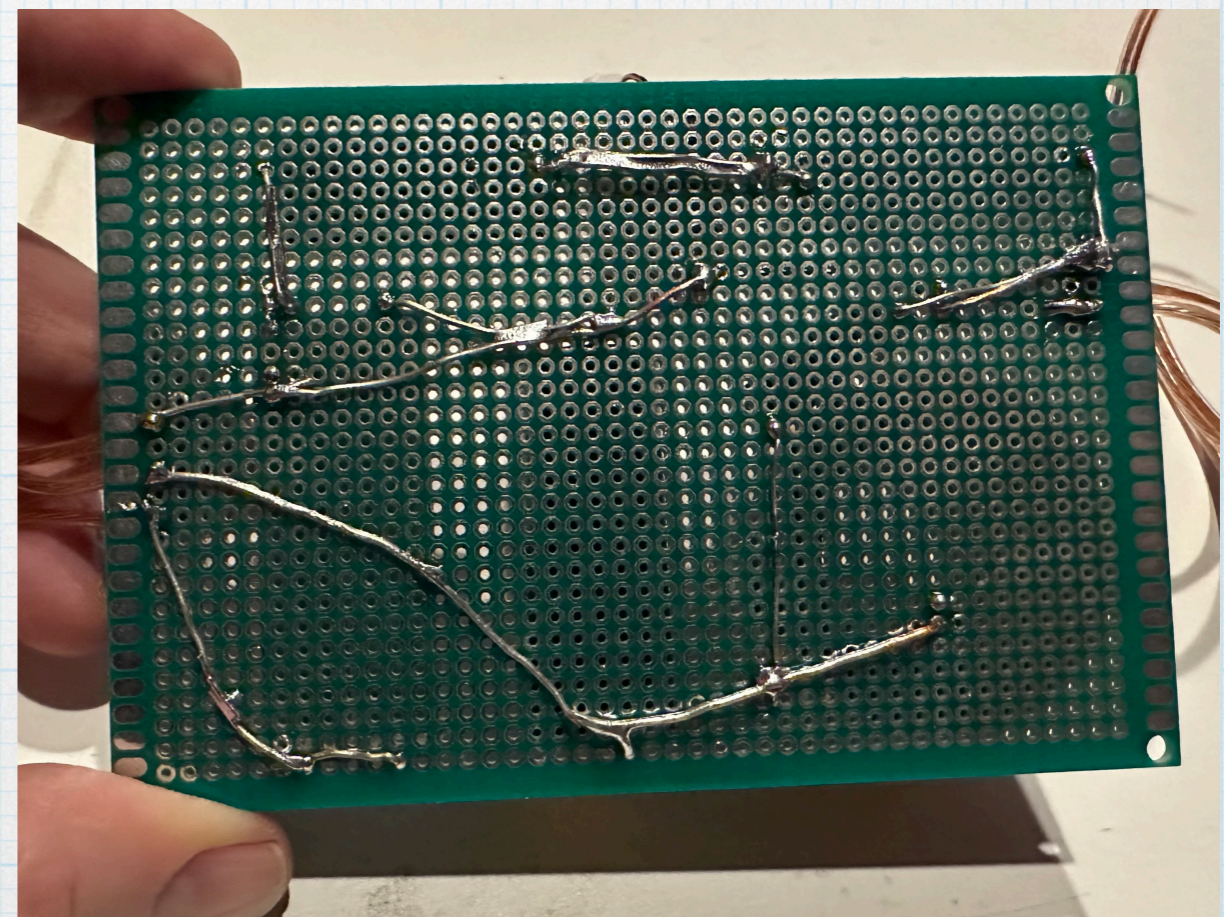
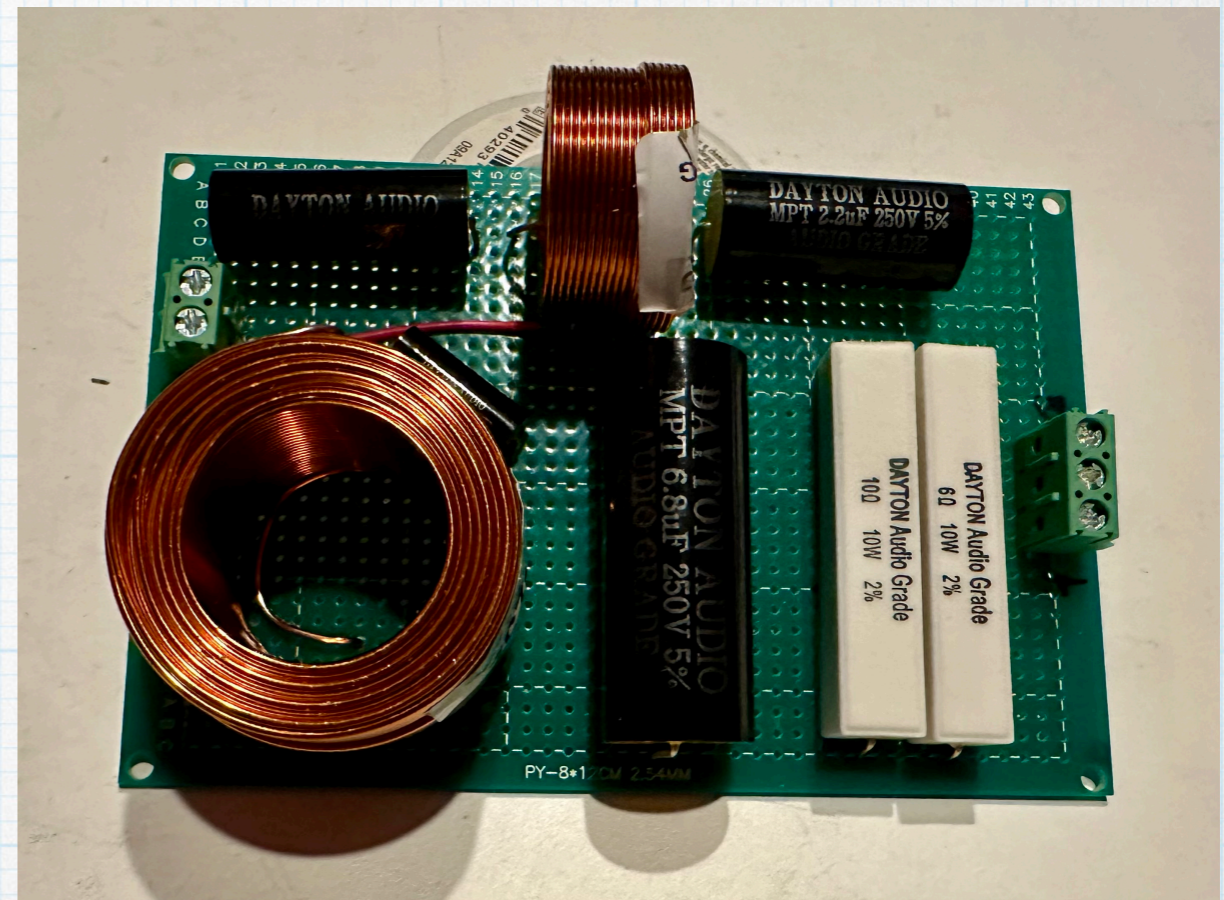
Note that, in this case, a few extra lengths of jumper wire were used.



Here are top and bottom views of the crossover using the larger components.

It is probably a good idea to glue the large inductors to the board to ensure that they don't "unspool" and come off the board. (I used a hot-glue gun to apply a few dabs of glue to each inductor.)

Again, note that the inductor coils are orthogonal to each other, to minimize mutual inductance effects.



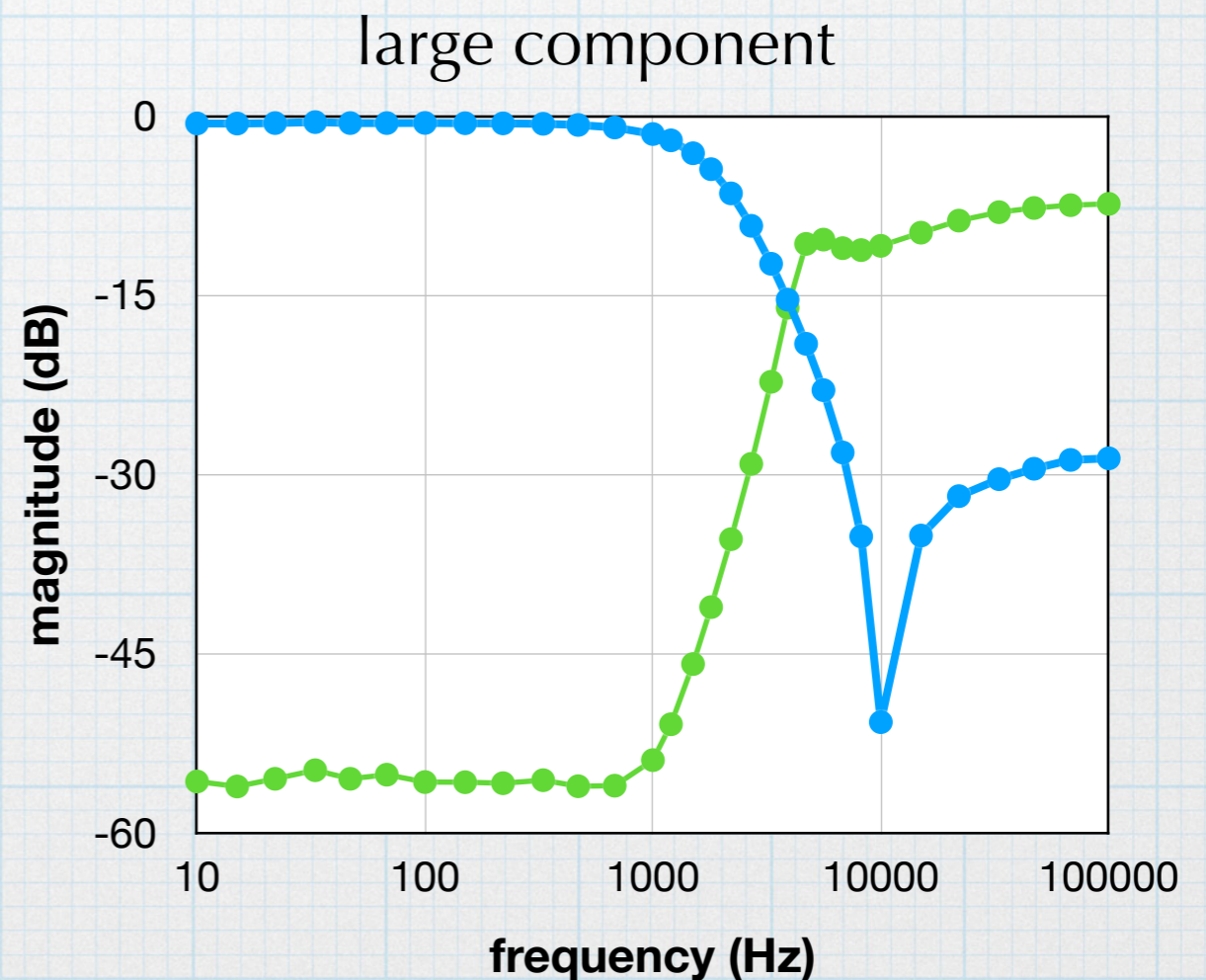
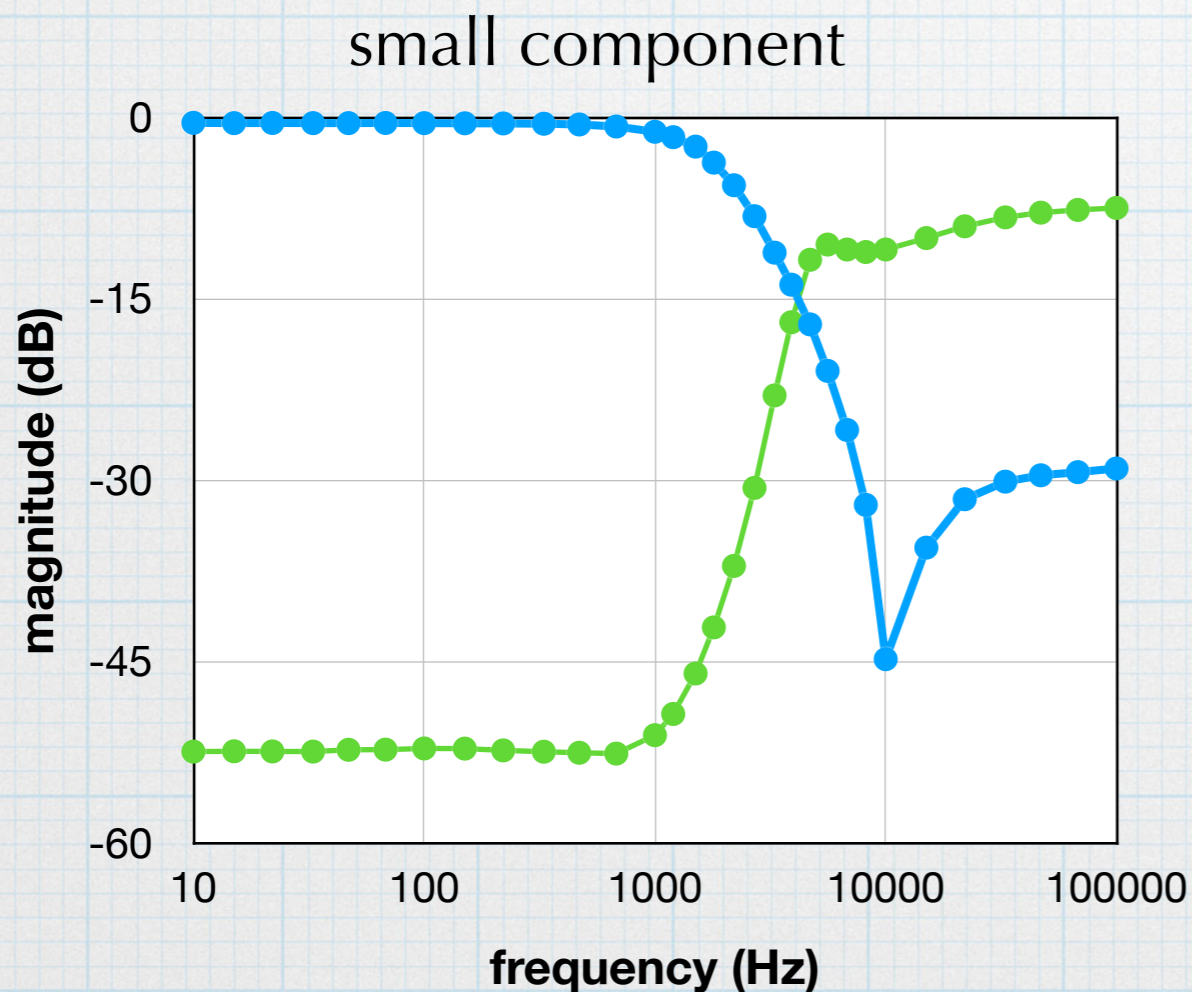
Testing

Before final assembly, it is a good idea to test the operation of the cross-overs.

Below are frequency response plots of both sections (low-pass and high-pass) of each crossover — small component and large component.

The two are nearly identical electrically.

It's not necessary to do a full response, but it is probably a good idea to measure a few frequencies for each section to confirm the low- and high-pass behavior.



Final assembly

All the parts needed for the final steps.



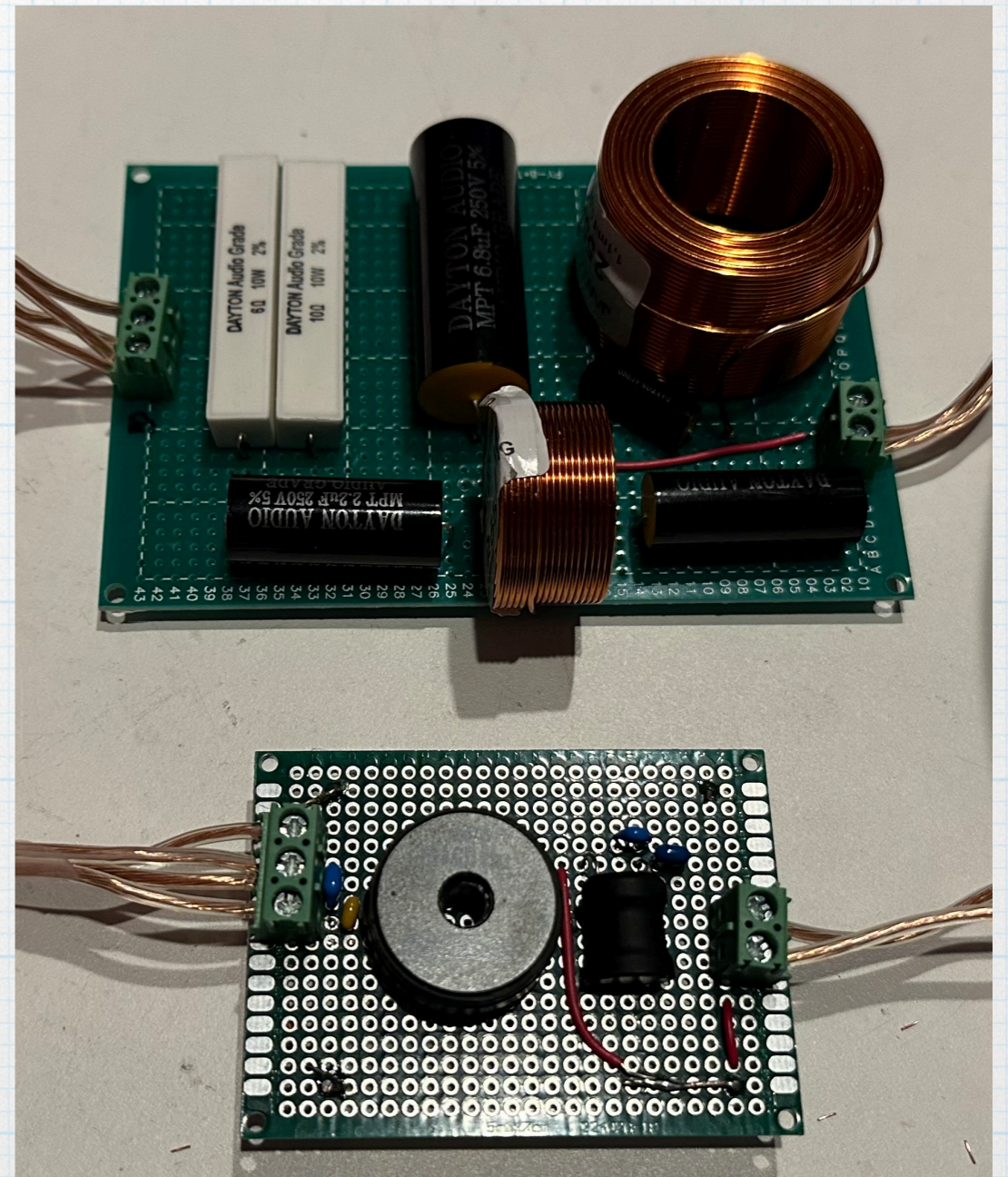
Final assembly

When putting screws into MDF, it has a tendency to “tear out”. To minimize the problem, it is a good idea to pre-drill holes wherever screws will be located. A 1/8-inch bit is probably adequate.

Crossovers

1. Cut three pieces of speaker wire — about a foot long, for each speaker. Strip the ends. The ends can be tinned with solder, if you want.
2. Attach the wires to the circuit boards, using the screw terminal or by soldering them into place. Pay attention to the ground (negative-side) connections, so that polarities are not accidentally flipped.

The photo shows the two crossovers used in “fraternal twins” build, with the wires attached.



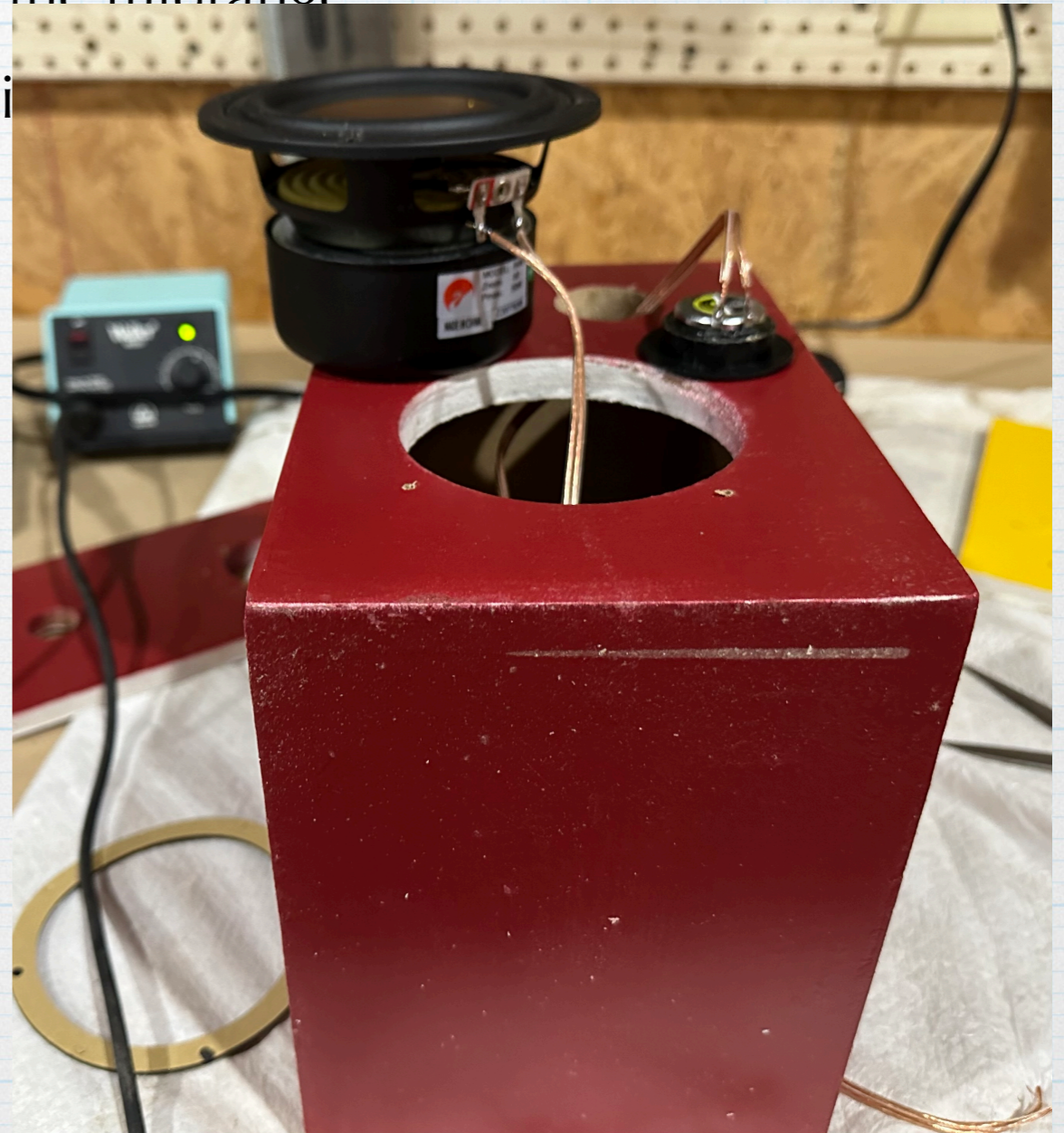
Final assembly (cont.)

3. Attach the circuit boards to the inside bottom of the enclosures. They can be held in place with small screws inserted through the holes in the corners, glued in place — the wood glue would probably work or use a hot glue gun — or with double-sided foam tape, which is my preferred method.

Midrange

4. Attach the foam gasket to the outer rim of the midrange
5. Test fit the midrange in its opening. Pre-dri
6. Remove the midrange, pull through midrange speaker wire, (Be sure to get the right one!), and solder the positive and negative connectors. Again keep track of the polarity.
7. Place the connected mid-range back into the opening and secure with four screws.

Midrange and tweeter soldered to the crossover connections and ready to be put into place.



Final assembly (cont.)

Tweeter

8. Do a gentle test fit of the tweeter. The tweeter will be press-fit in place — there are no screws. Make sure the tweeter will fit into the opening but don't push it all the way in. If the the hole is too small, enlarge it by gently sanding or using a file. In the opening is too big, which would be unusual, it will probably be necessary to glue the tweeter in place.
9. When satisfied that the tweeter will fit, pull through its speaker wire, solder to the positive and negative connectors. Gently push the tweeter all way into its opening.

Port tube

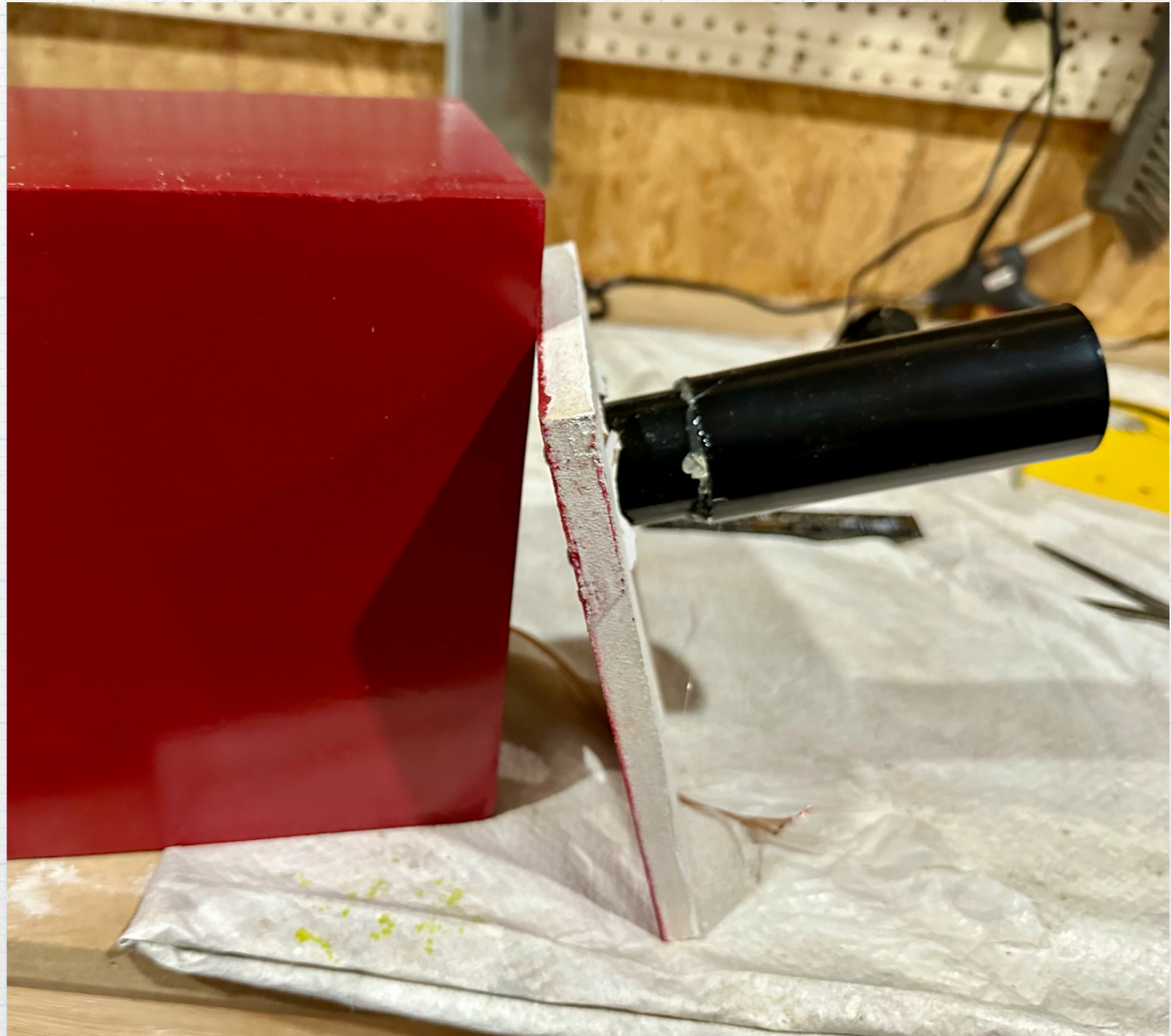
Note the outer tube will not fit through the 1.75-inch hole, so we have to attach the inner tube to the back plate first and then attach the outer tube to the inner.

10. Separate the two halves of the port tube. Put the inner through its opening in the back panel and mark the four openings for the screws. Remove the tube and pre-drill holes for the screws.
11. Put the tube back through the opening and screw it into place.

Port tube (cont.)

12. Insert the outer tube over the inner half, adjust it so that the total length is 6 inches, and secure the two halves of the tube, either by gluing (Again, a hot glue gun works well) or by wrapping something like duct tape around the joint.

Port tube attached to the back plate, with the two halves glued to give a six-inch total length.



Final assembly (cont.)

Binding posts

13. Insert the binding posts through the small holes in the back piece and secure them with the nuts.
14. Solder the wires from the crossover input to the binding posts. Mind the polarity.

Test and then seal it up.

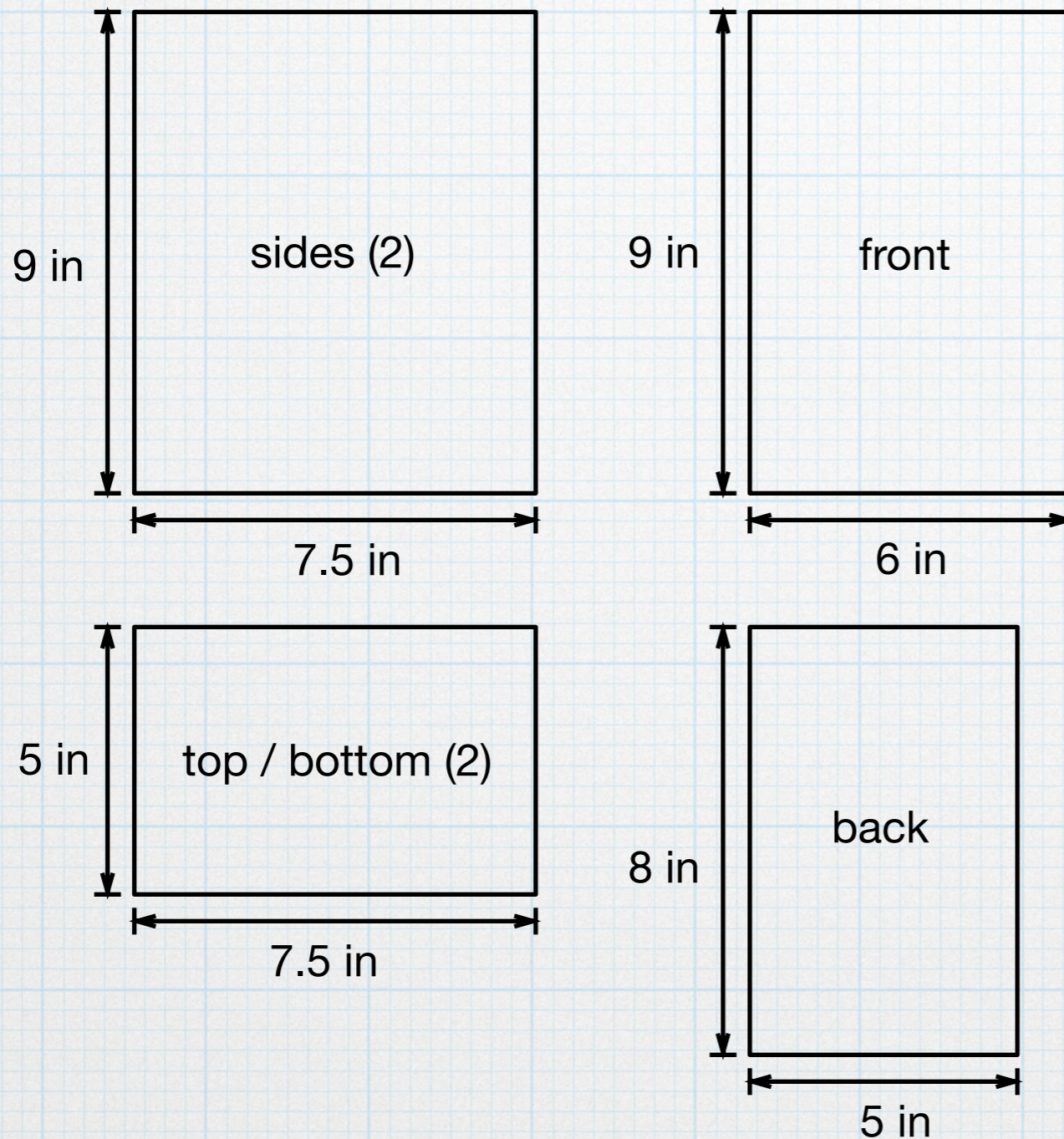
15. Put the back plate into place. Leave it loose for now.
16. Connect the speakers to your amplifier and test them thoroughly. Hopefully, they sound great. If not, you will have to do some debugging. Re-check the crossovers thoroughly, double check all solder connects, and look for any polarity problems.
17. This is also a good time to experiment with adding some damping material to the interior to see if it improves the sound for you.
18. When you are satisfied that the sound is what you want, you should secure the back plate. You can glue it or use screws. To glue it, put a bead of glue around the edges and on the backstop pieces and then press the back in place. Apply some pressure until the glue dries. If using screws, pre-drill holes in each corner through the back plate into the backstops. Then insert screws.
19. Whew! The speaker are complete. Enjoy!

Addendum: Cutting panel from scratch

Extra tools for cutting and making holes:

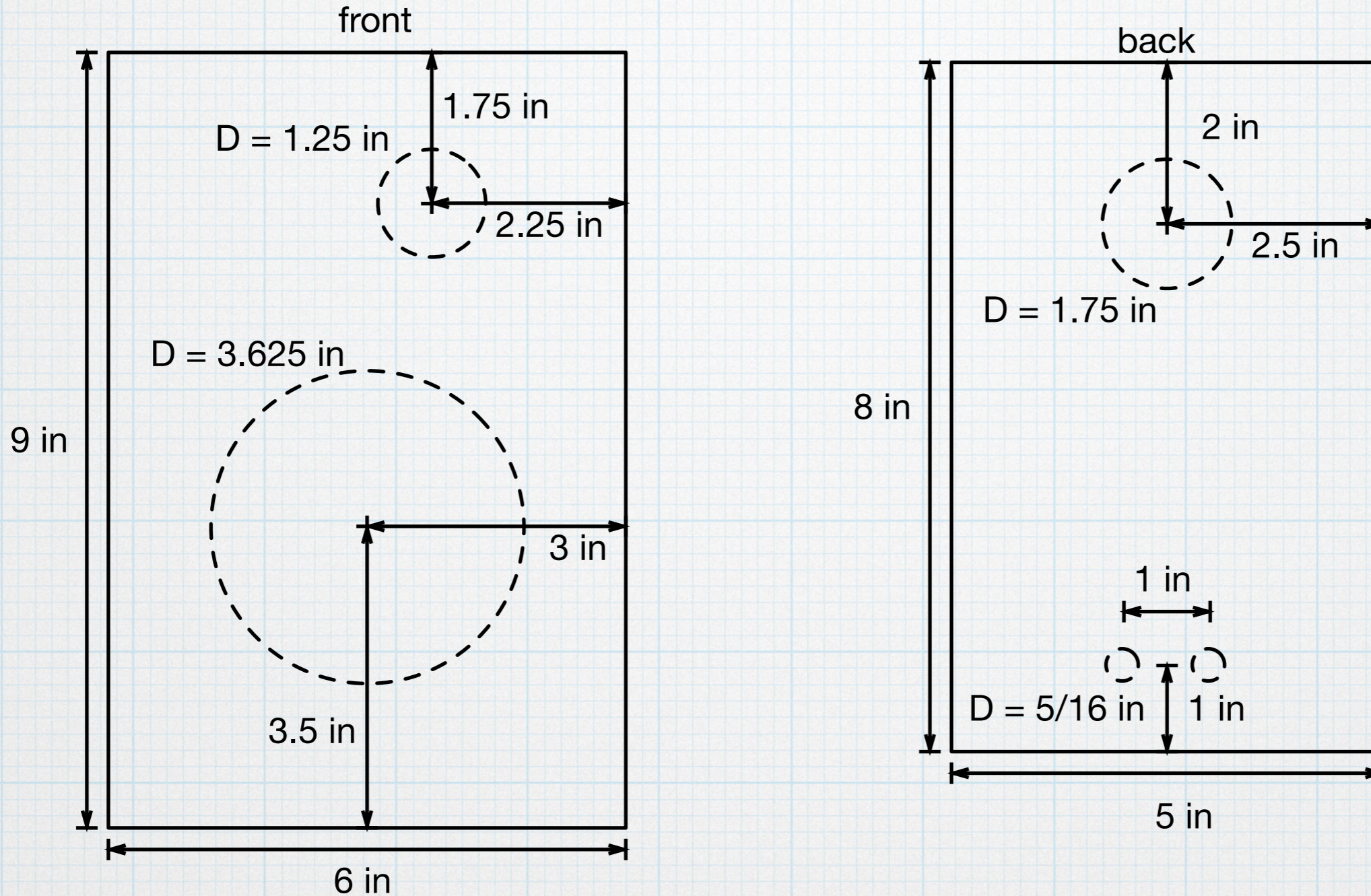
- Tape measure and marking pens. A marking square might be useful here, too.
- A table saw and / or a power miter saw. (And the requisite skills to know how to use them safely.)
- Some way to cut the various holes.
 - Drill: 3.625-inch hole saw for the mid-range, 1.75 inch hole saw for the port, 1.25-inch spade bit for the tweeter, and 5/16-inch twist bit for the binding posts. (If using the Neutrk connector, then a 7/8-inch or 15/16-inch spade bit will work.
 - Or a router (the woodshop kind not the Wi-Fi kind) and a circle-cutting jig for the larger holes (in place of the holes saws) and the spade bits for the smaller holes.
 - Or a jigsaw to cut the larger holes (in place of the hole saws) and the spade bits for the smaller holes.

Six pieces for the box



Also a couple of small pieces - say 1 in x 5 in to serve as “back stops” to hold the back plate in place.

Hole locations



The exact hole locations are not critical. In particular, the tweeter does not need to be offset as shown — since it is sealed, it can go anywhere. Mainly, be sure that holes are not too close to the edges. Also, make certain that the port, which extends inward from the back, does not interfere with the bigger driver, which extends inward from the front — keep one low and the other high. Also note that the fronts should probably be mirror images of each other, if you care about symmetry at all.

Drill the holes.

- Mark the hole centers for the front and back. Double check everything. (Old woodworkers rule: Measure twice, cut once.)
- Use some scrap wood as a buffer — don't drill into the table top.
- The 1 1/4 inch hole for the tweeter is probably a little tight. Test fit it now. If it does not fit, use sand paper or a file to make the hole larger. The tweeter should slide in, but with a tight fit.
- The holes for the binding posts are not shown here. Use a regular 5/16 in bit for those.

