Building of the First Woodbug

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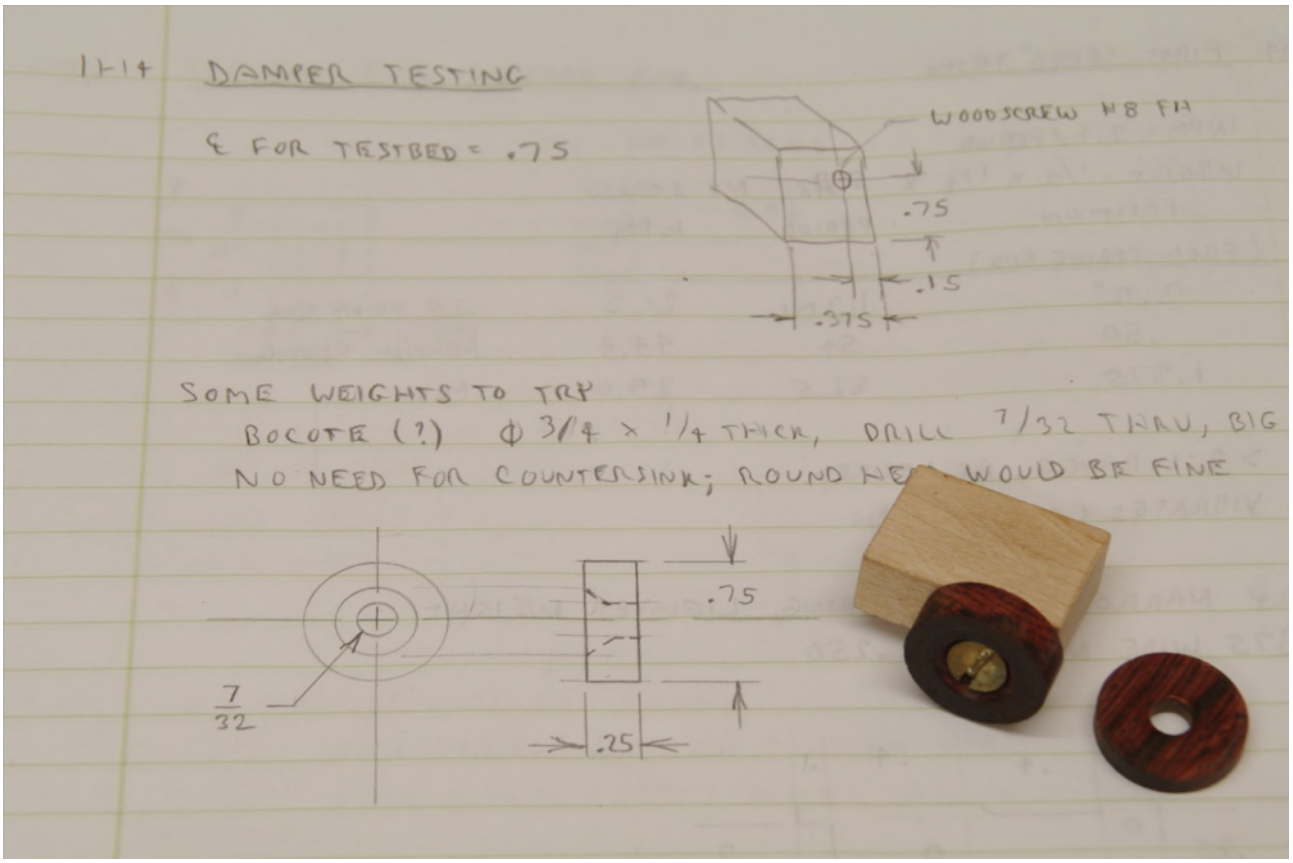
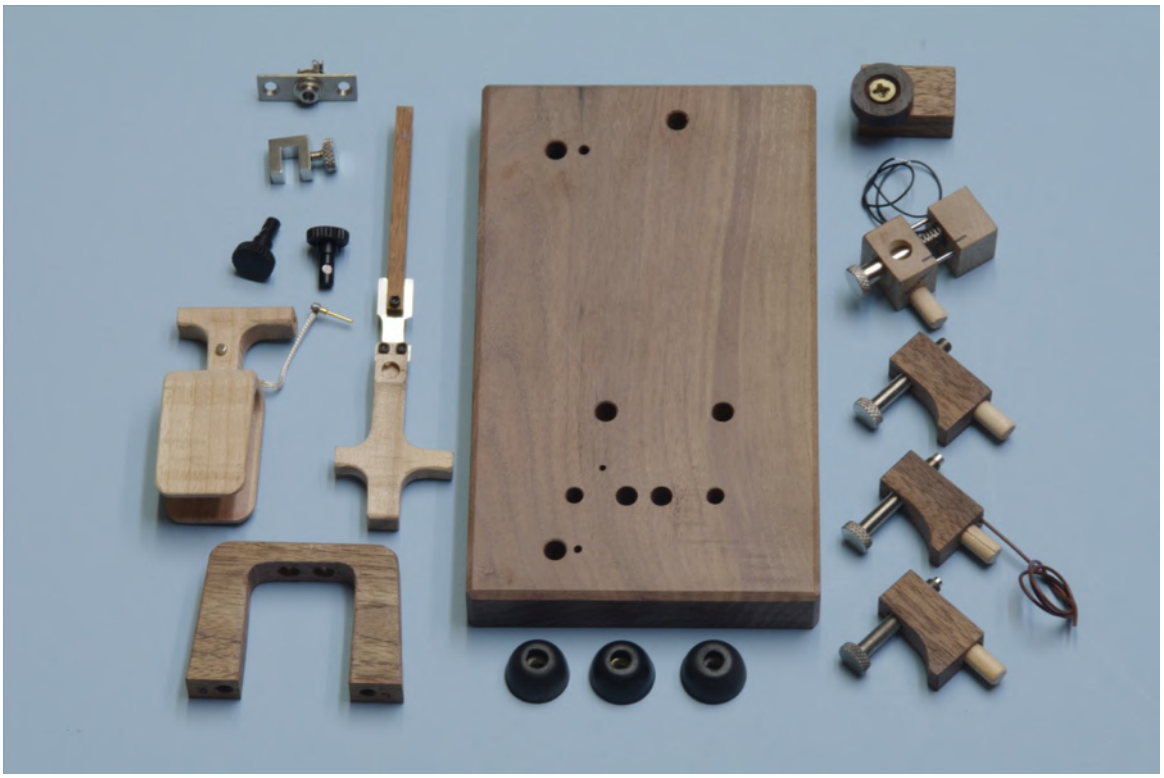
Photos from development and fabrication of the Model 1 Woodbug, built in late 2015.

Component testbed. This was used to try out various mainsprings, weights, and in this photo, magnetic reed switches as the dot detector. I had also experimented with magnetic return springs but never liked the way they behaved.

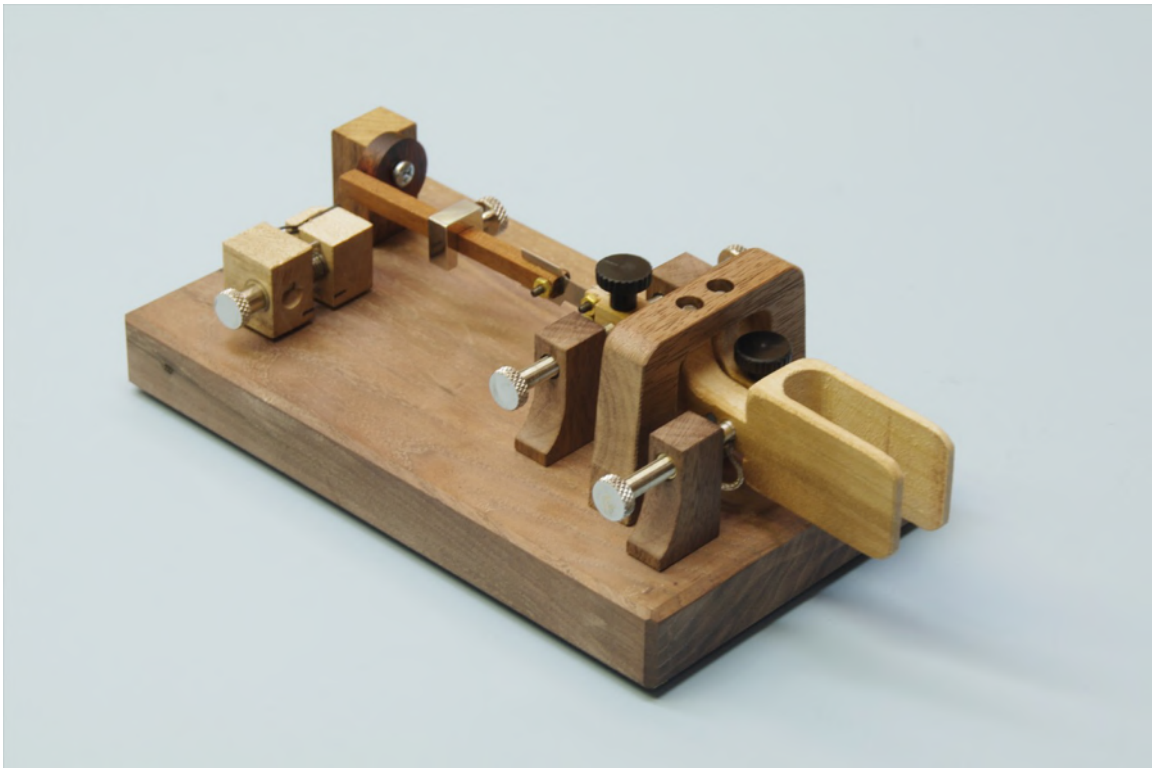


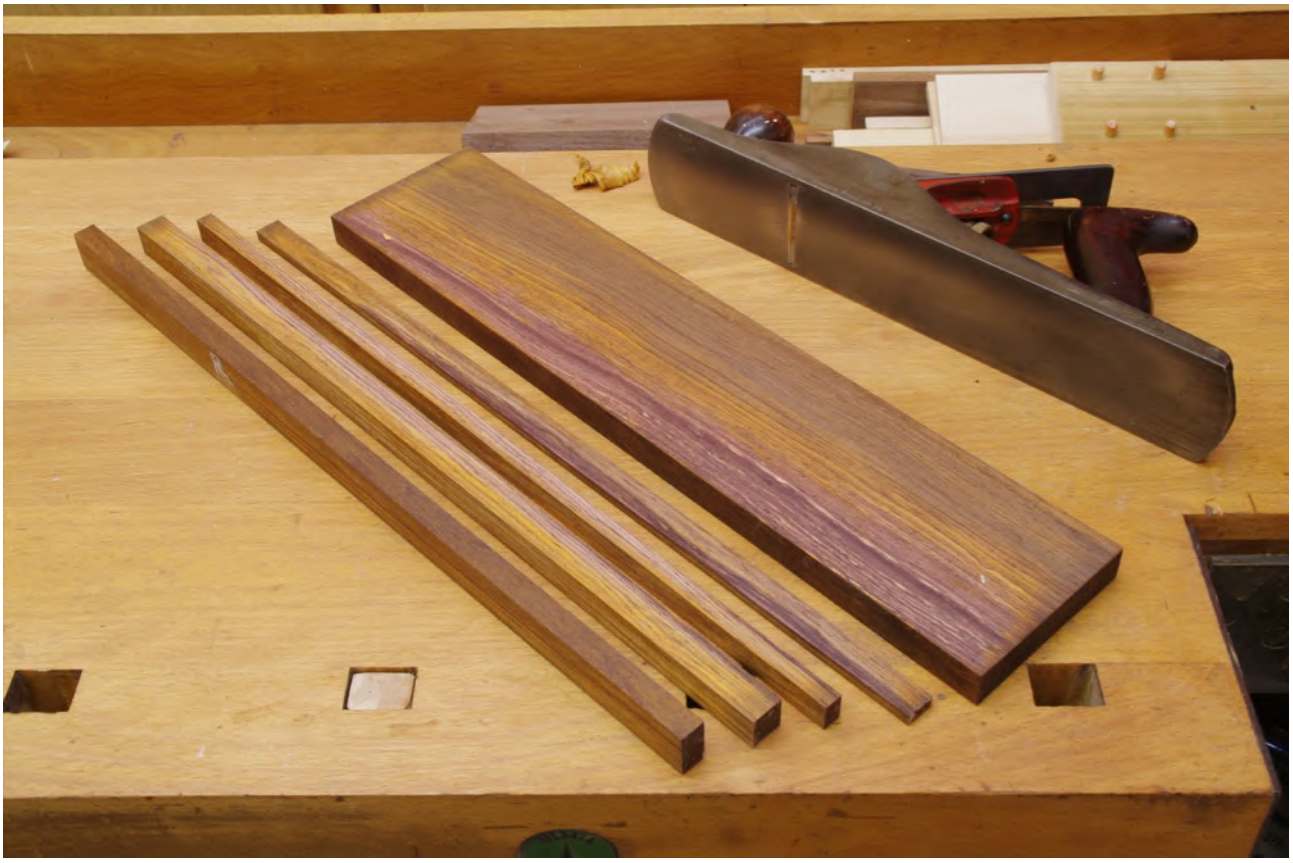
One of several damper test articles. I made quite a few, emulating classic bugs as well as some new ideas. None of them worked well because of the very low inertia of the Woodbug pendulum. The final solution was a soft polymer pad.

Adjustable dash contact. I make all my screws with #10-56 threads. In this case, a brass sleeve was being tested. In the final model, it was a two-part sleeve with brass as the electrical contact and acetal (with undersized threads) to add drag. The contact is machined from Sterling silver and is pressed into the screw.

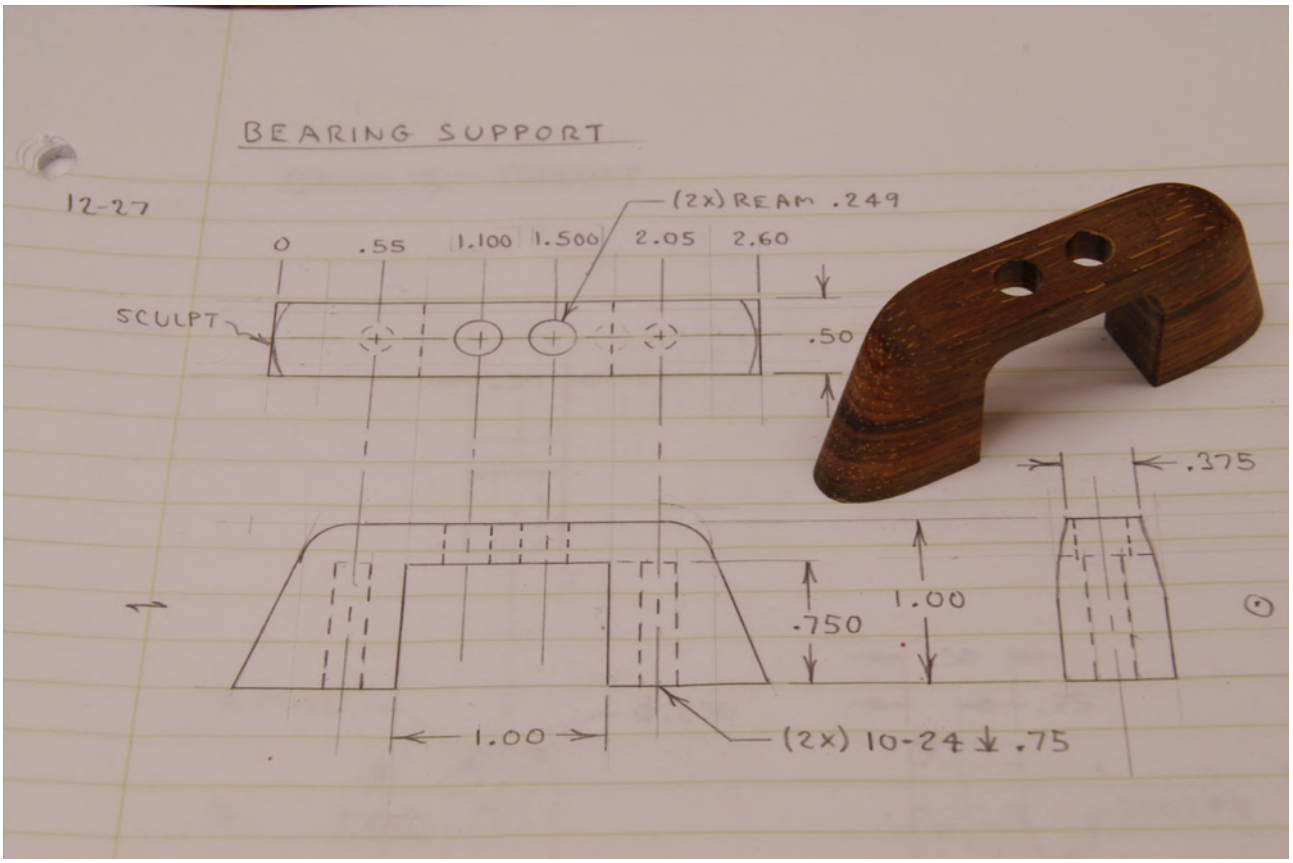


All the parts for a preliminary test bug. No attempt was made at detailing or finishing, but rather it was to prove that the geometries were right and everything worked together properly. By this time, I had nearly all my machining fixtures and methods worked out. I still have this bug and it actually works very well.

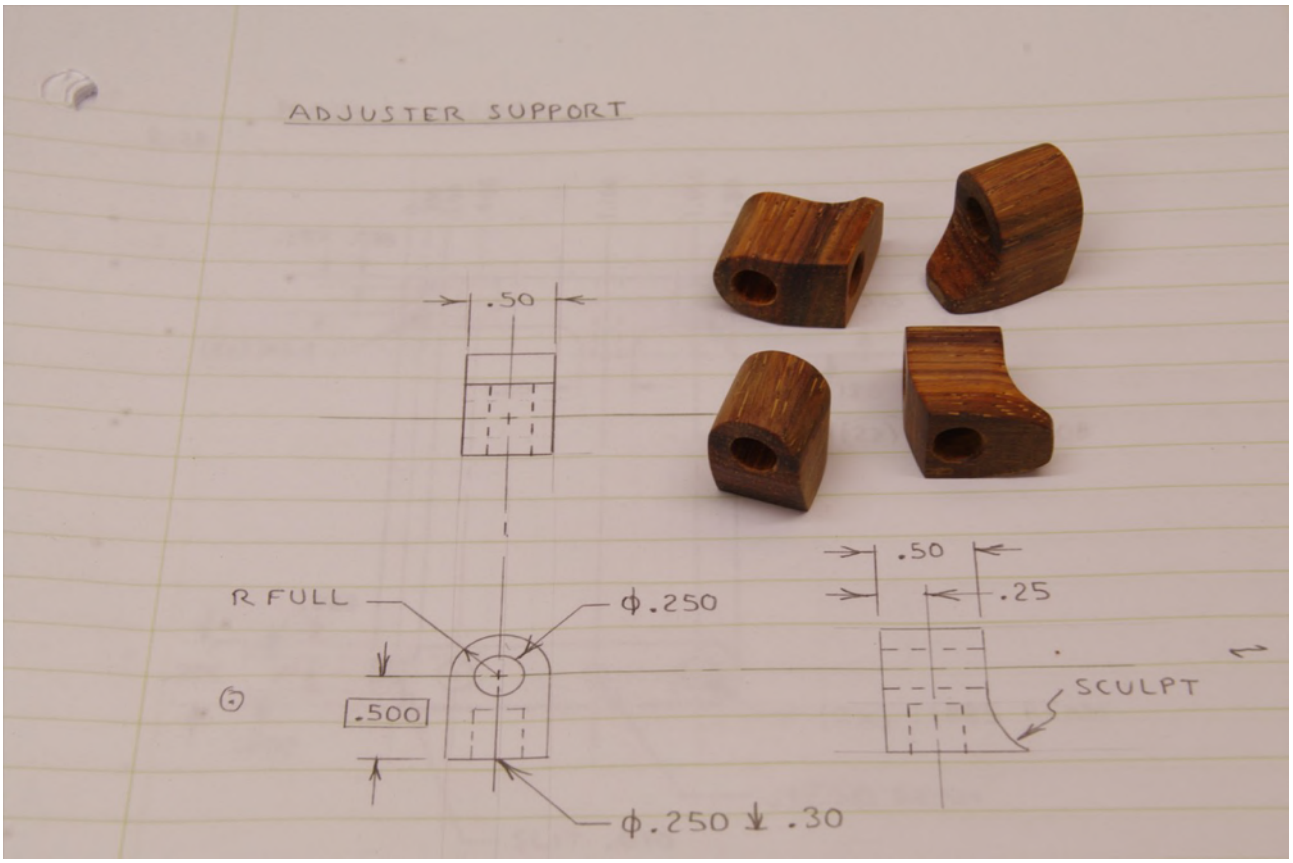




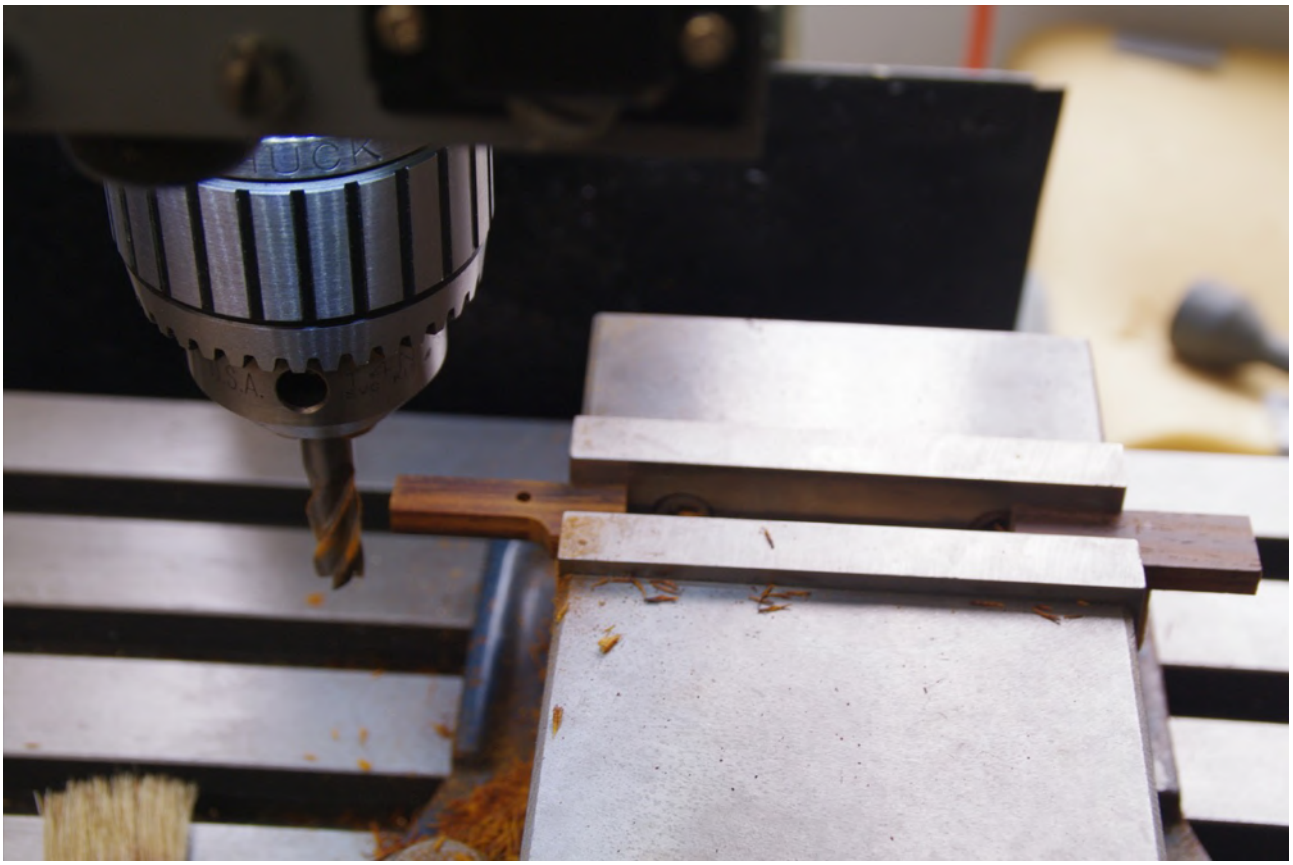
Preparing cocobolo stock. Dimensions were held to very close tolerances. Curiously, I’m really more of a woodworker than a machinist. The jack plane belonged to my grandfather, who was a genuine Swedish carpenter.



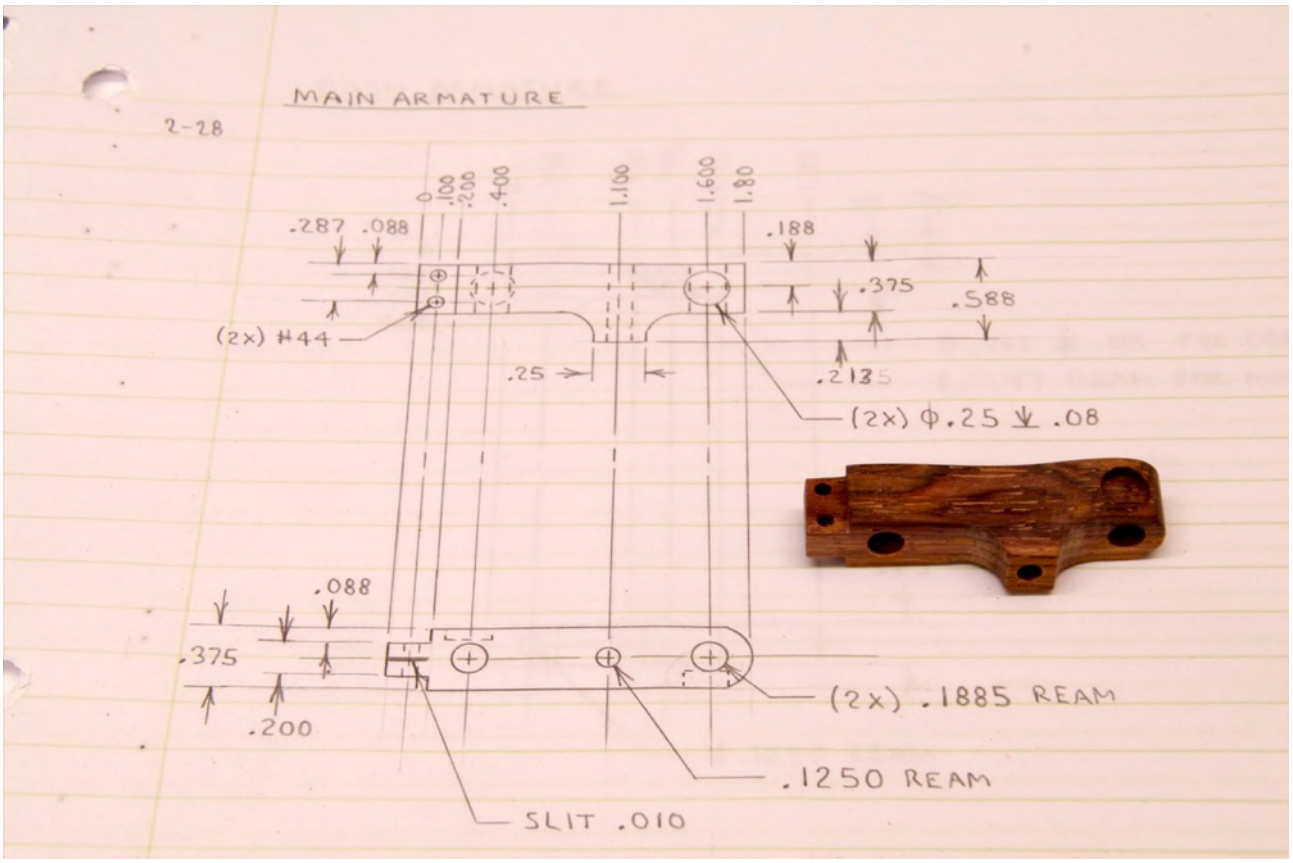
The bearing support bridge. Sealed ball bearings are pressed into the holes and a top cap is later glued on lightly in case it ever needs to be removed. Another pair of bearings are pressed into the base. The part is carefully contoured.



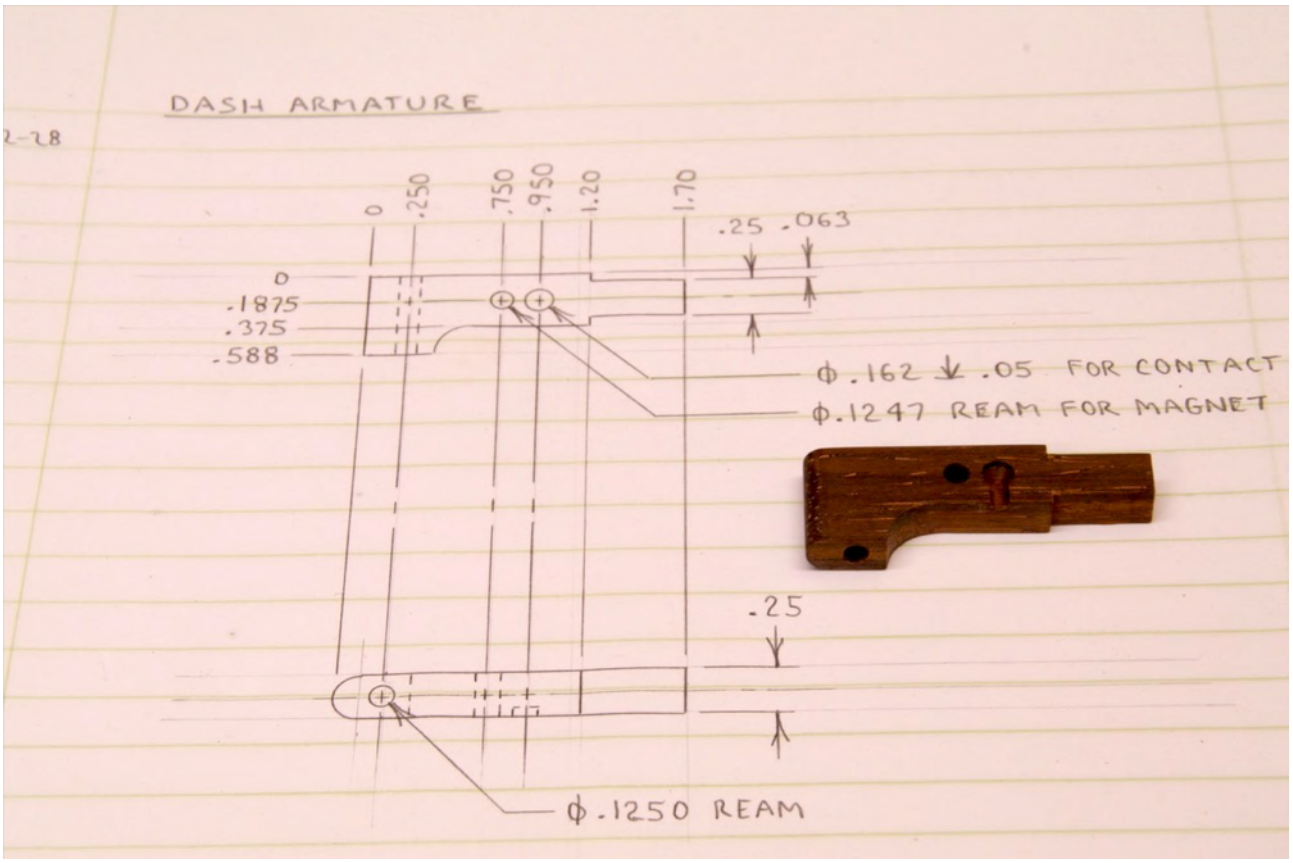
Adjuster supports. There were quite a few steps in making these and the detailing took a long time. When I went into “production” for the five Model 2 Woodbugs, these parts took more time than anything else because there were so many.



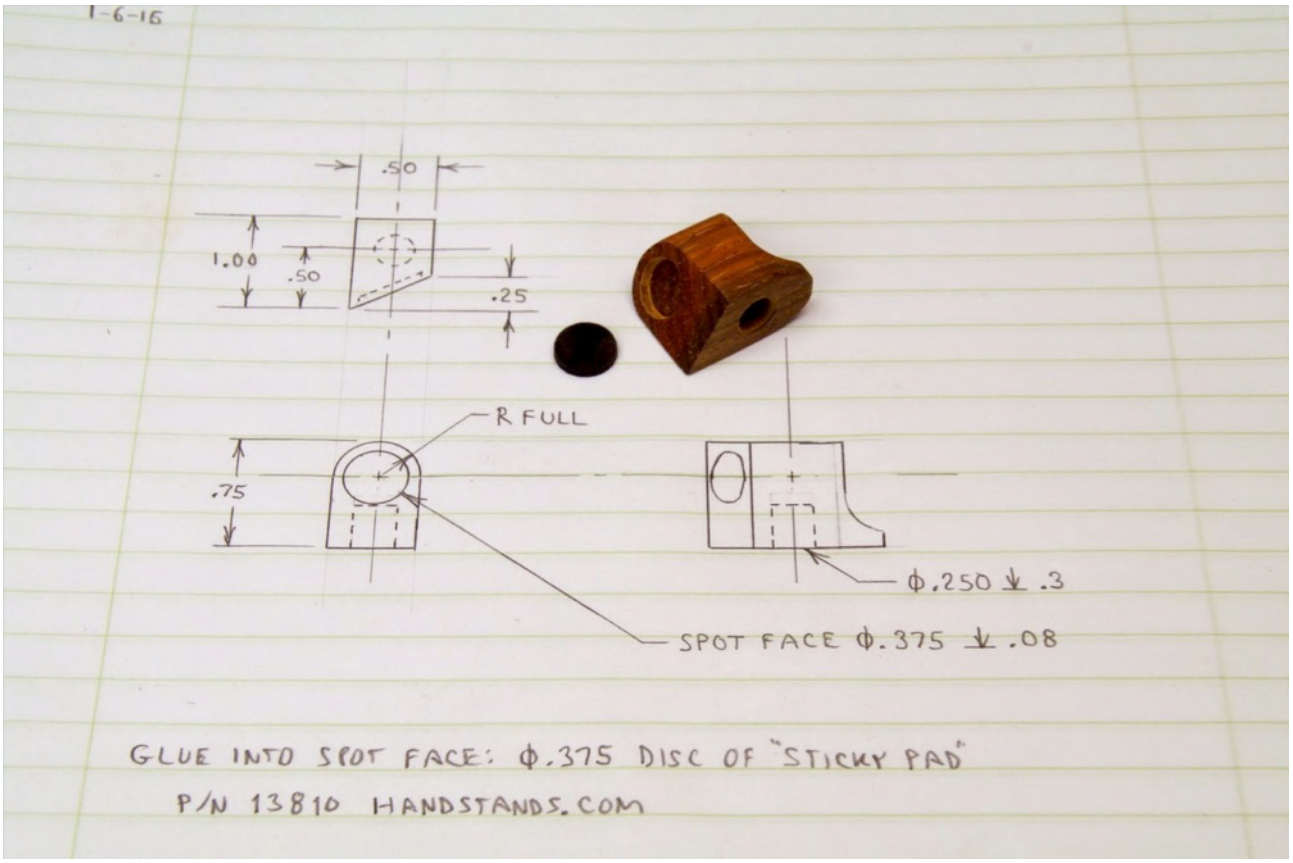
Machining one of the armature parts. Almost everything was done on the vertical mill.



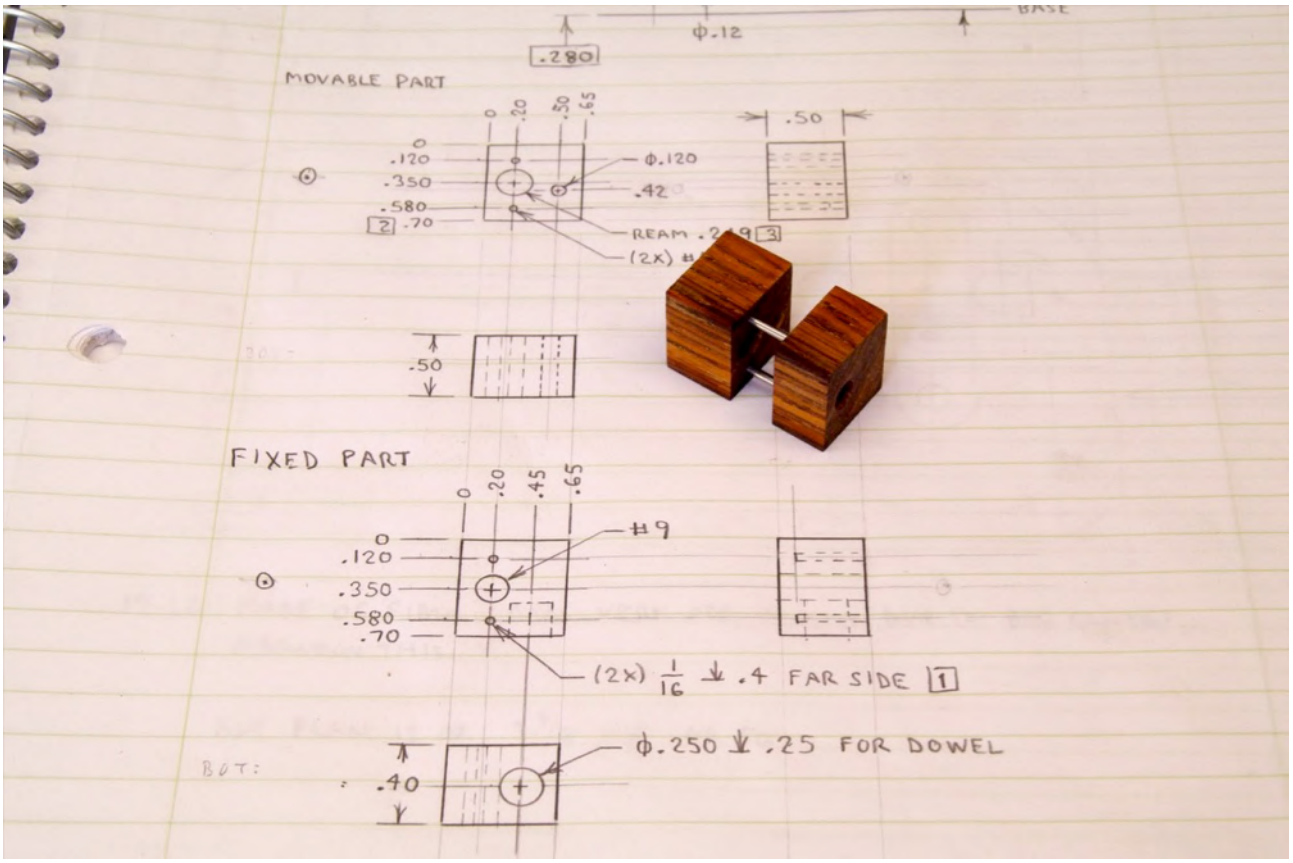
The main armature body. This is the most complex component. The drawing doesn't do justice to the final shaping, which is more like an hourglass.



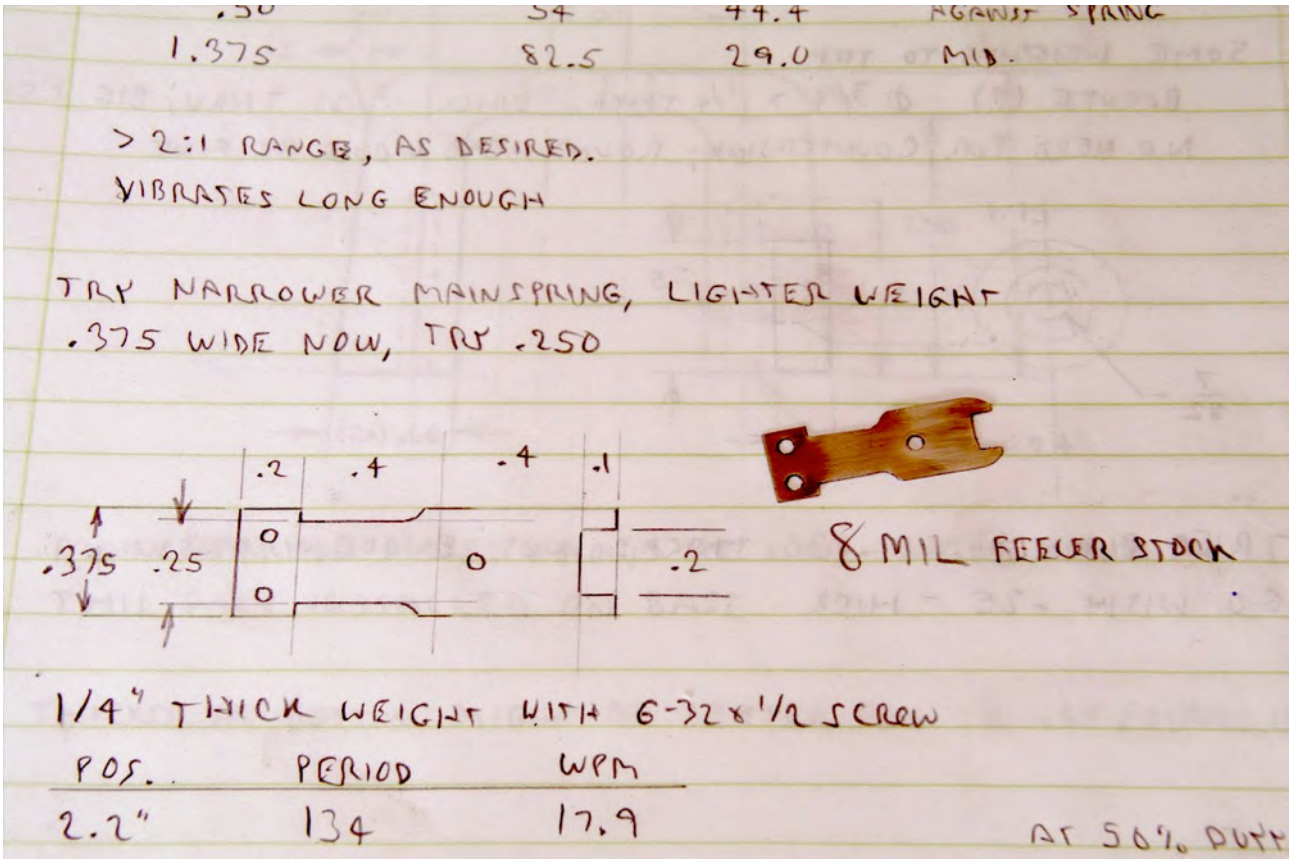
The dash armature. Like the main armature, it requires several machine setups. Most people have no idea how accurately you can machine hard woods like cocobolo. It’s more like aluminum than wood. Reaming holes to within a few ten-thousandths of an inch for a press fit works just as well as it does in metal.



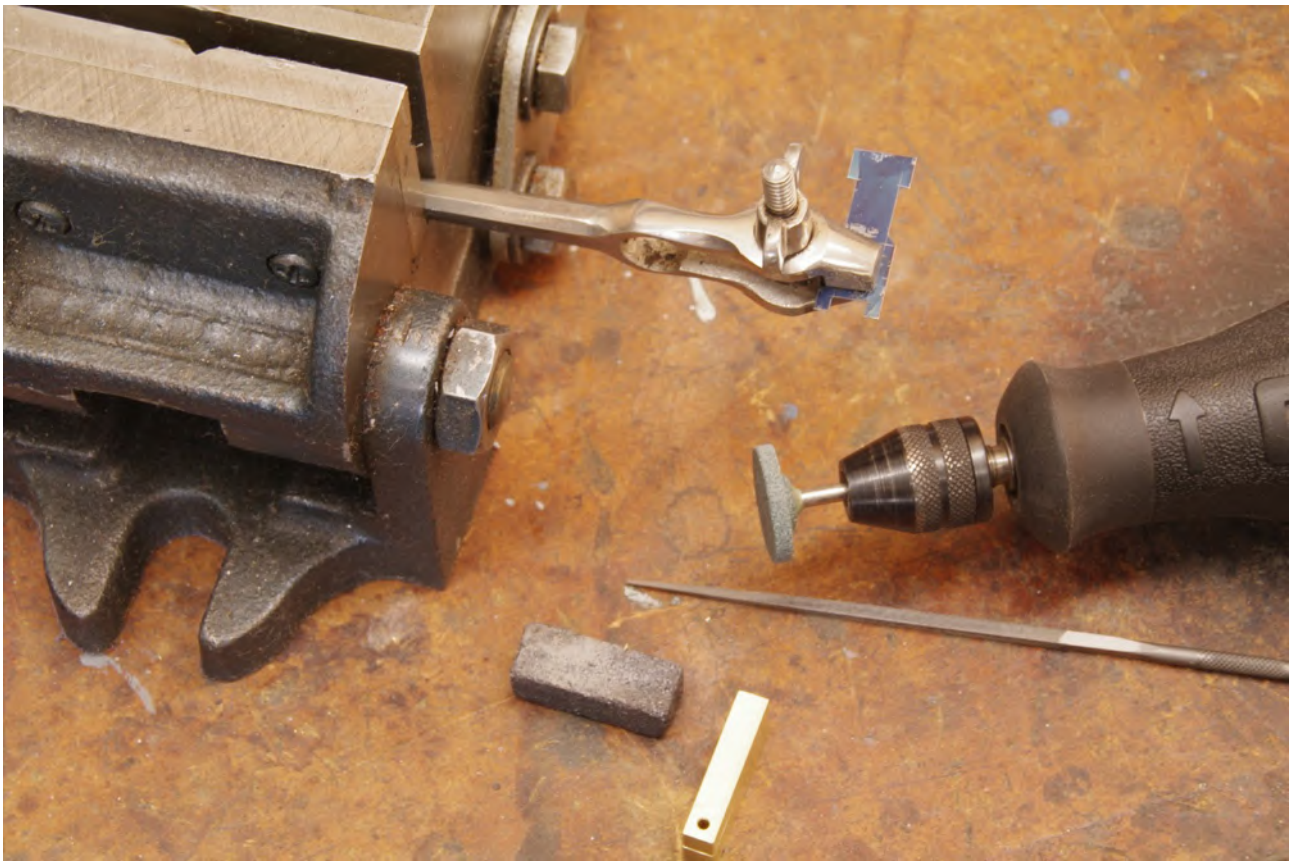
Damper. A little button of a soft polymer is glued in place. It's at a 45-degree angle so that the corner of the pendulum strikes the polymer, maximizing the local force. I tried many different polymers, too, and ended up with a sticky pad that is used for keeping your cell phone on the dashboard. It's the only workable damping solution that I could come up with.



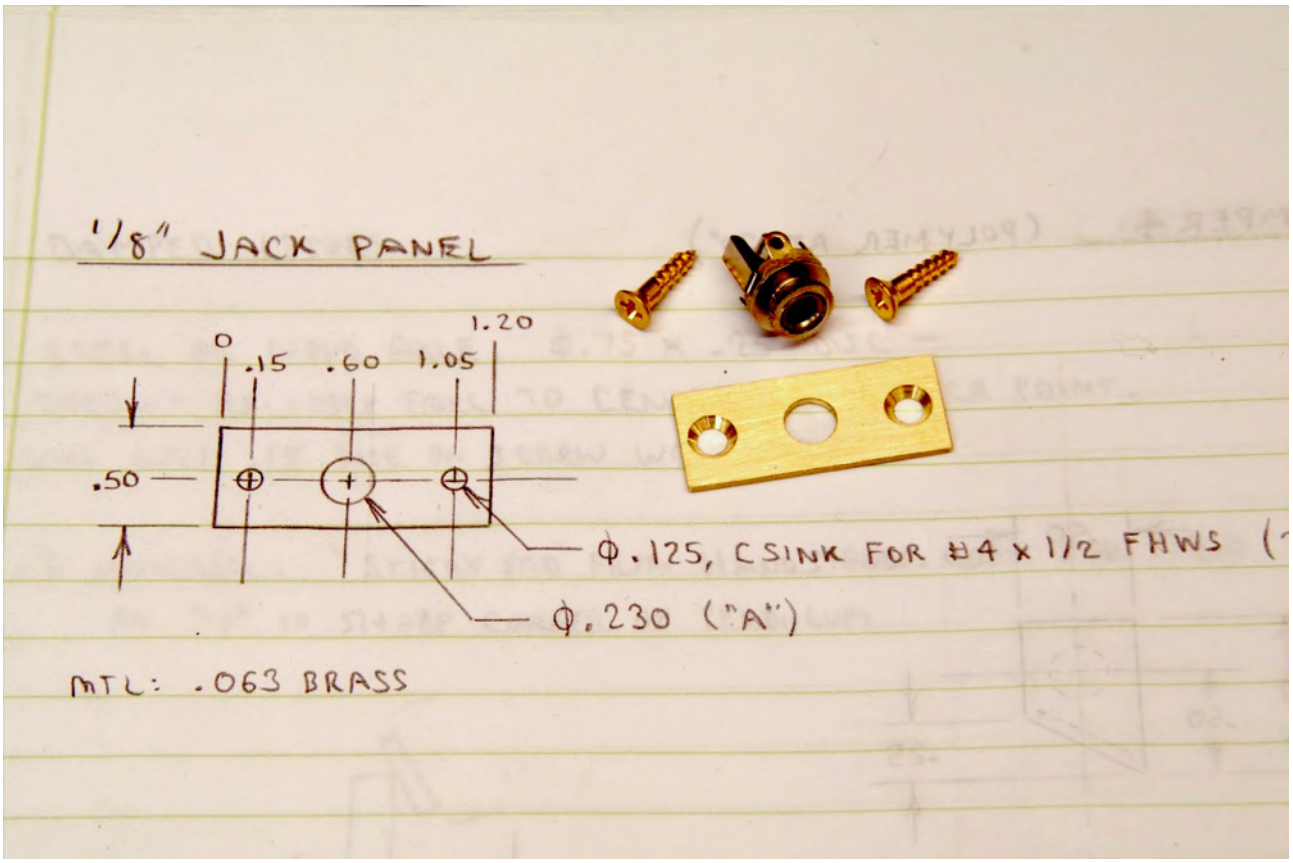
Main parts for the reed switch positioner.



Mainsprings are made from feeler gage stock, which is a fairly hard spring steel. Holes are punched with a hardened steel pin in a fixture. This is a very limber spring when compared with all commercial bugs. That’s required to match the low inertia of the rest of the pendulum.

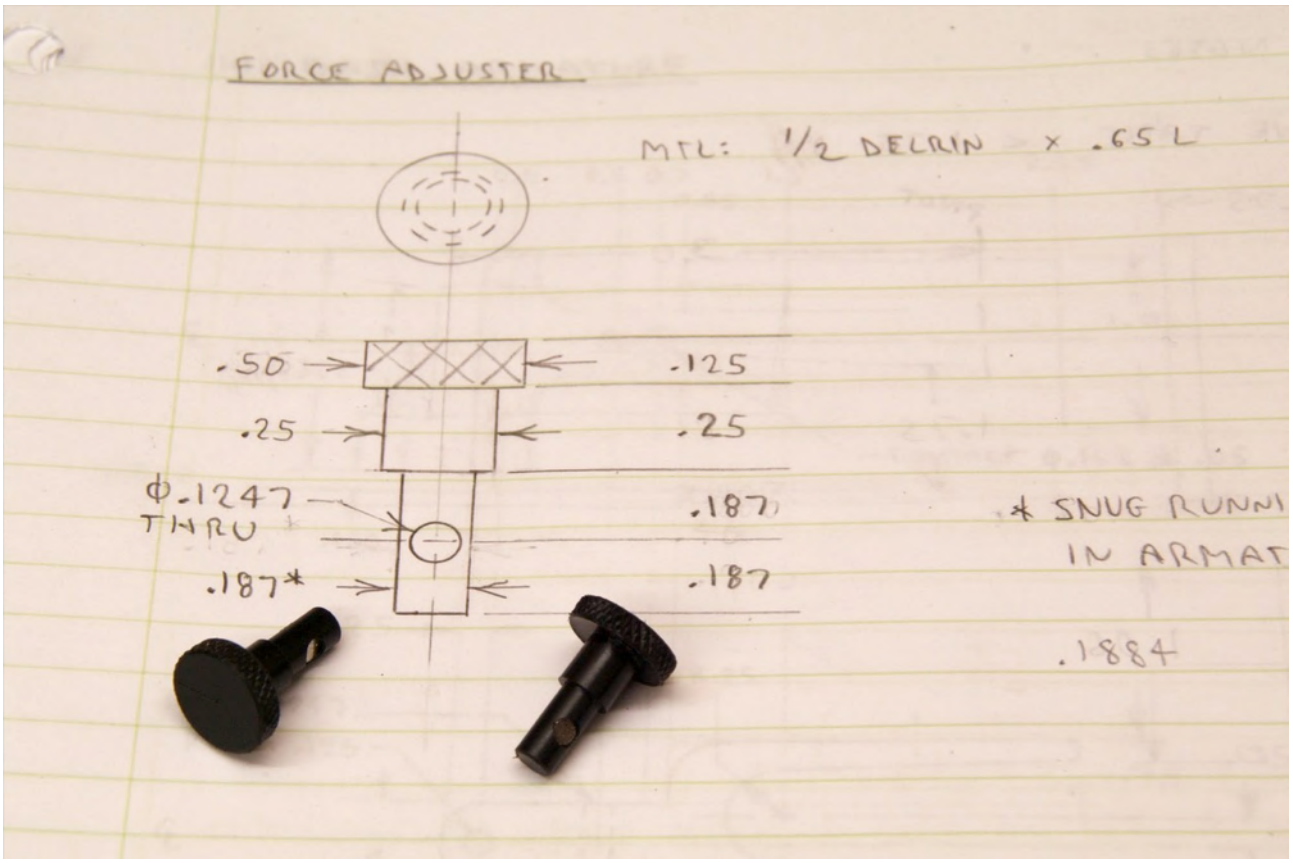


Mainsprings are contoured with a nibbling tool, files, and some fine grinding. Final detailing is done with jeweler’s files. The finish is bluing. I use Brownells Oxpho Blue. In the foreground is the hole punch fixture.

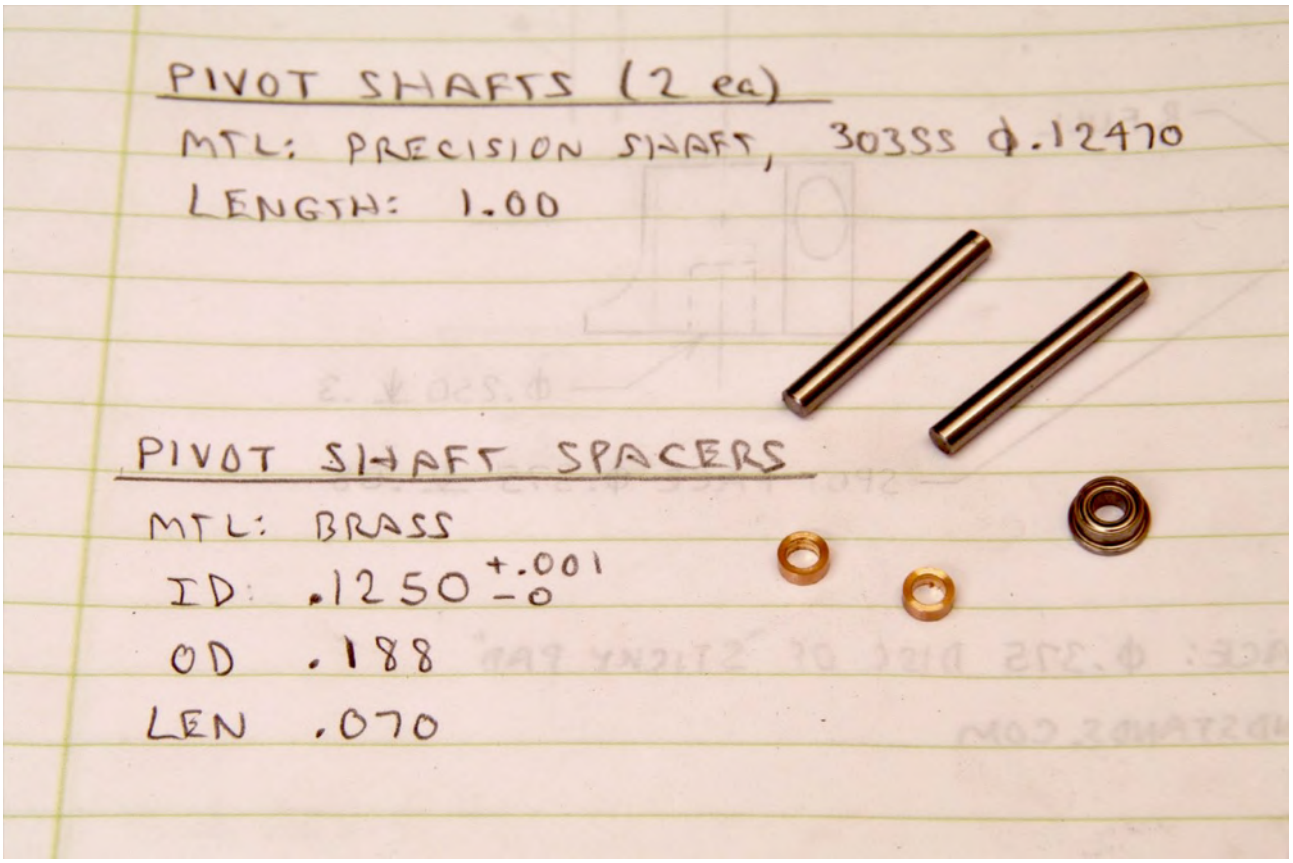


I've never been a fan of the traditional, gigantic terminal screws on bugs and they certainly wouldn't fit with the Woodbug design. So here's a little 3 mm jack instead. The brass panel gets nickel plated and looks like a mirror when it's done. It fits in a mortise in the back of the key.

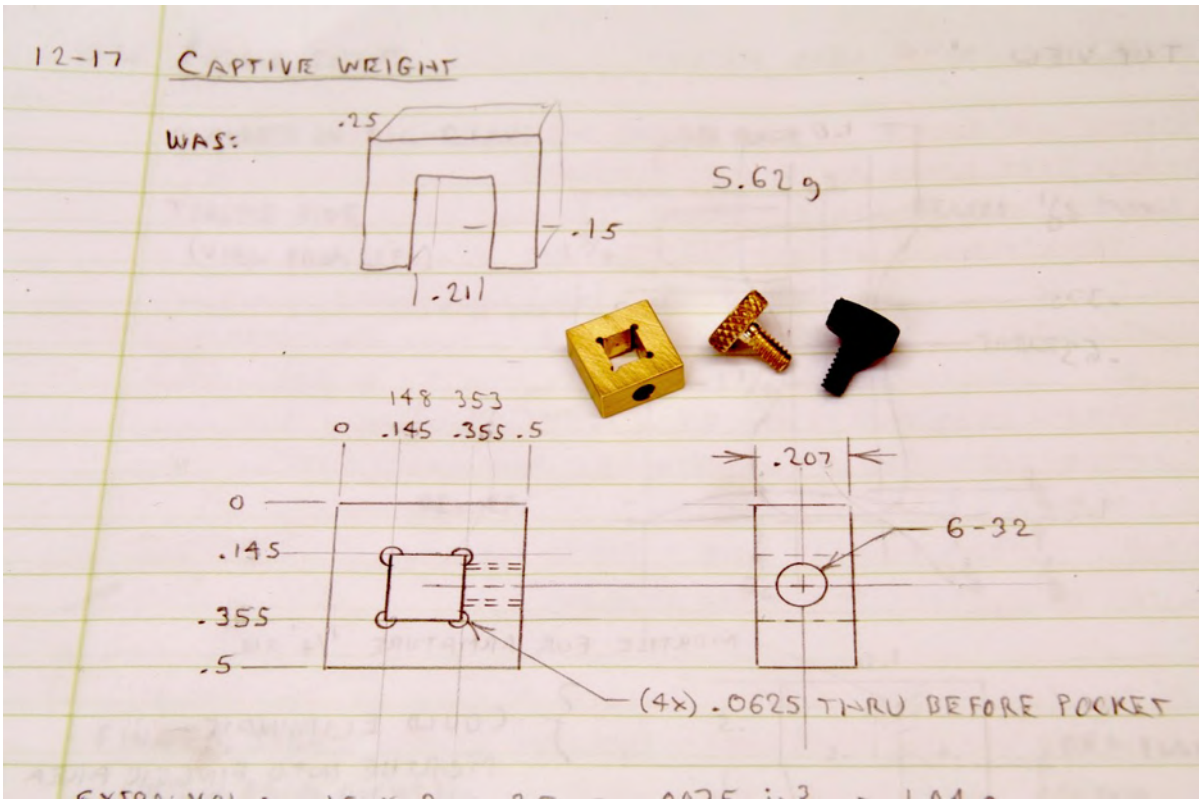
Reaming the hole in a rotary force adjuster to accept a tiny magnet. Neodymium magnets are amazingly strong. The tiny (1/8-inch diameter by 1/8 inch long) one that gets pressed into this acetal part supplies plenty for return force even for a heavy-handed bug user.



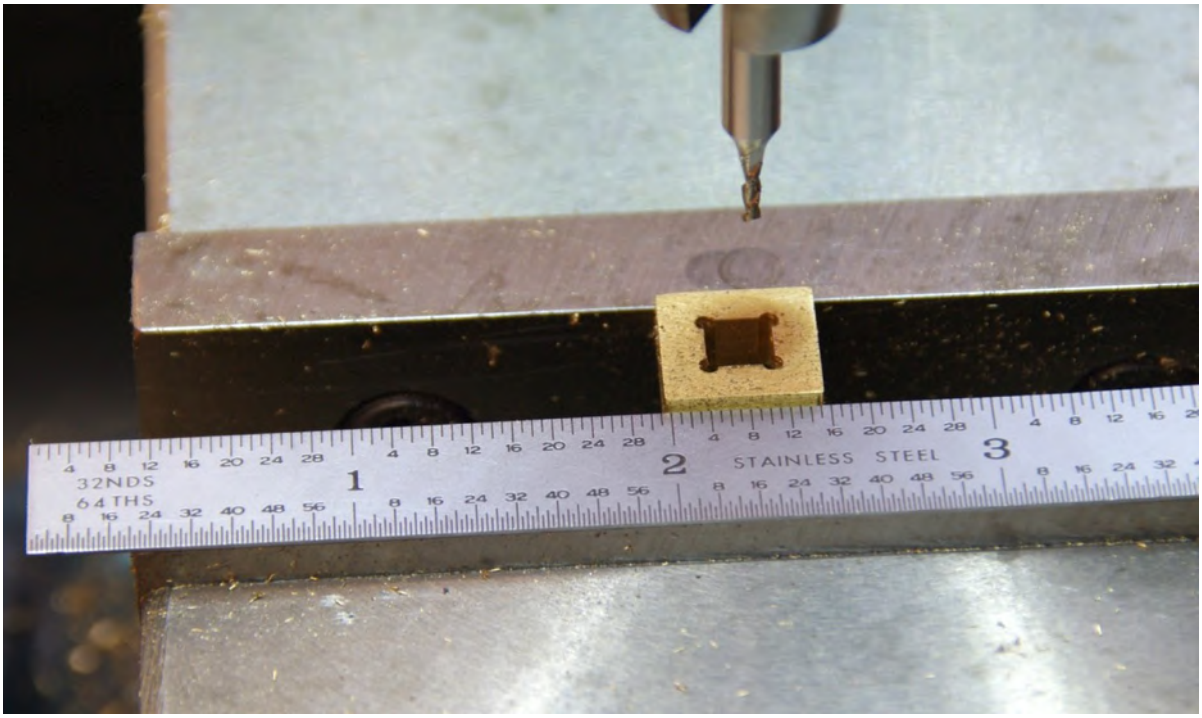
Here are a couple of the force adjusters assembled. They fit into precision-reamed holes in the armatures and rotate smoothly. This is probably my most clever contribution to bug design.



Precision shafts and bearings come from Stock Drive Products. The tiny spacers set the height of the armatures.



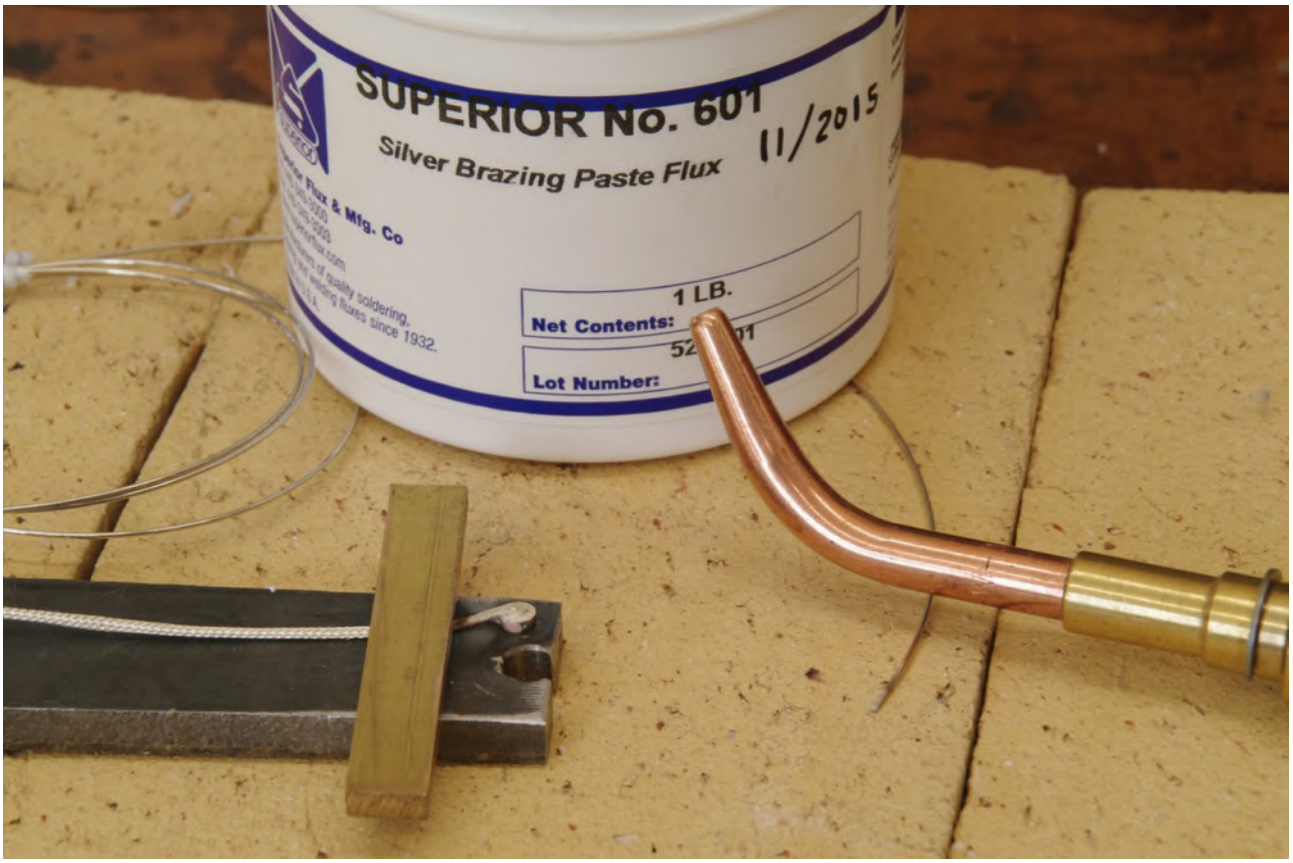
Every other bug uses round weights, so I used square ones. I almost made a broach to form a perfect square hole but instead just relieved the corners. The weight gets nickel plated. Two screws were tested, brass and plastic. I figured plastic was less likely to chew up the ebony arm, but in the end it really wasn't a problem. Model 2 Woodbugs have brass screws.



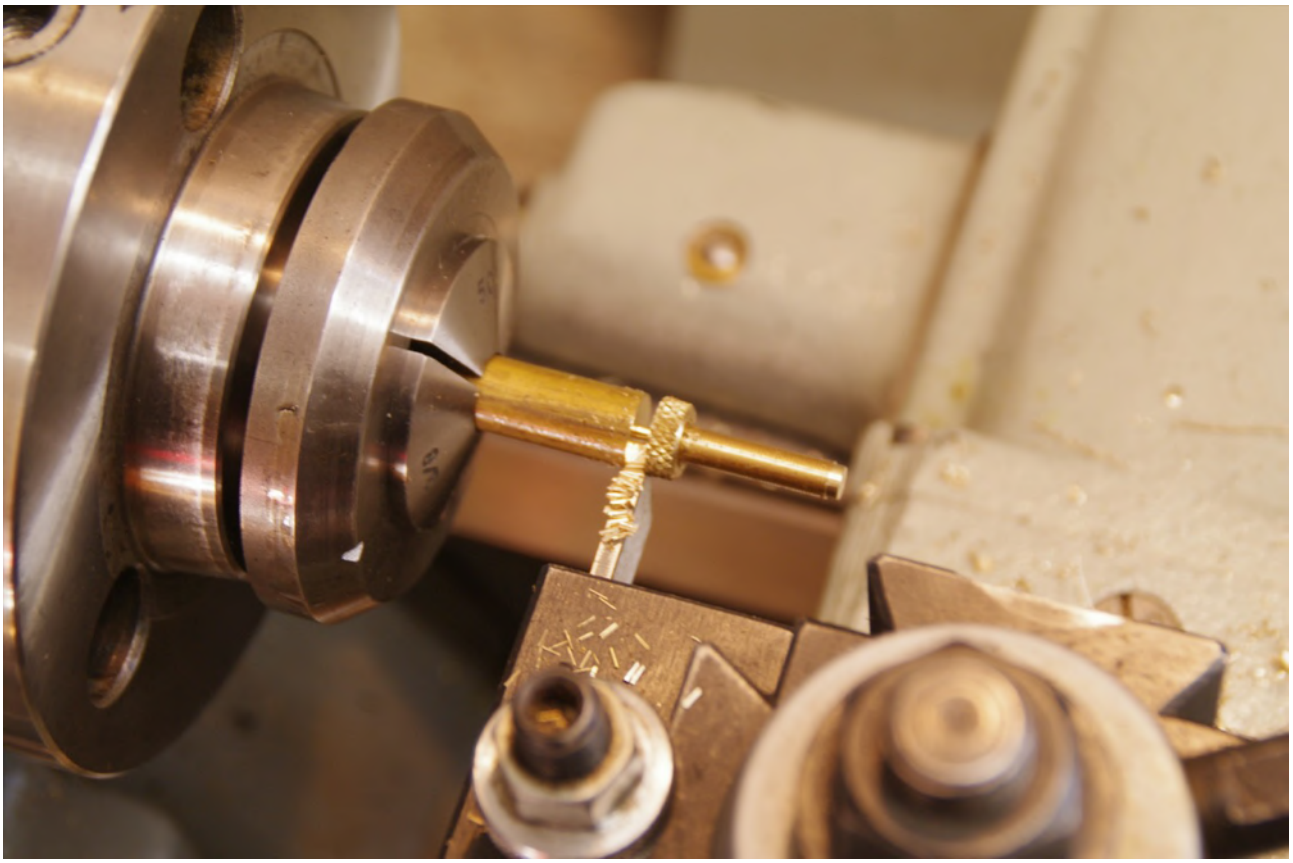
Since the Woodbug is so light, I poured lead weights that are glued into a cavity in the bottom. The mould is brazed up from steel. Casting lead is fun and also cheap if you get the material from Ebay. The casting furnace is usually used for making bullets and fishing weights. It's an interesting material to machine. I use a very slow speed with very fast feed and a light lubricant, otherwise it simply melts and smears. The weight gets a "safety coating" of heavy paint before installation.

I looked into Tungsten as an alternative for lead but it's incredibly expensive. Depleted uranium would also be a good choice but it's even more expensive; it would have cost around $10,000 for the required amount... [I used to work with D238 at LLNL.]

My nickel plating line. Successful plating is all about cleaning and surface activation. It took me a lot of study and testing to come up with a repeatable process that nearly always produces a mirror finish.

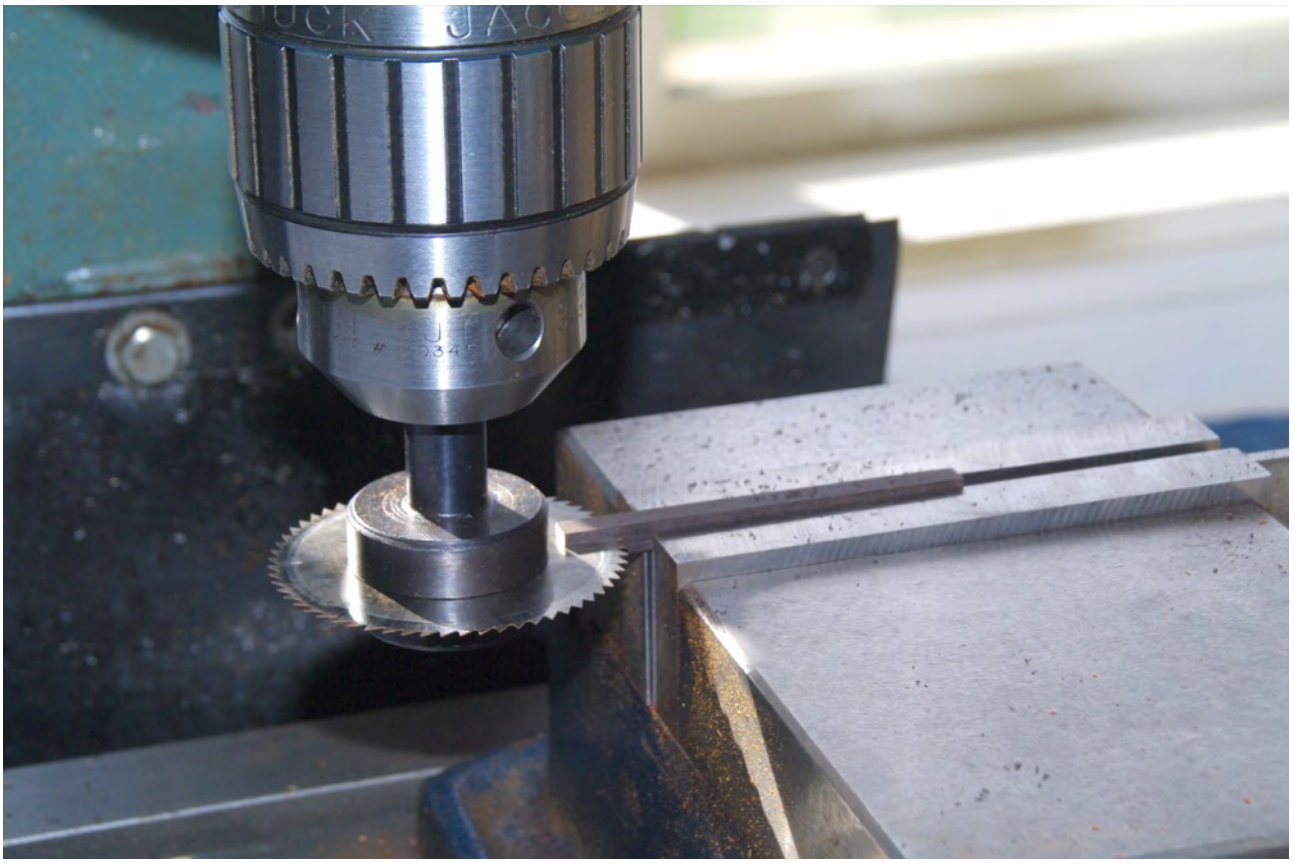


Silver soldering small braid to a dash contact. The parts sit in a fixture and the oxy-acetylene torch makes quick work of it. For the Model 2 Woodbug, I used the smallest size of solder wick for the braid.

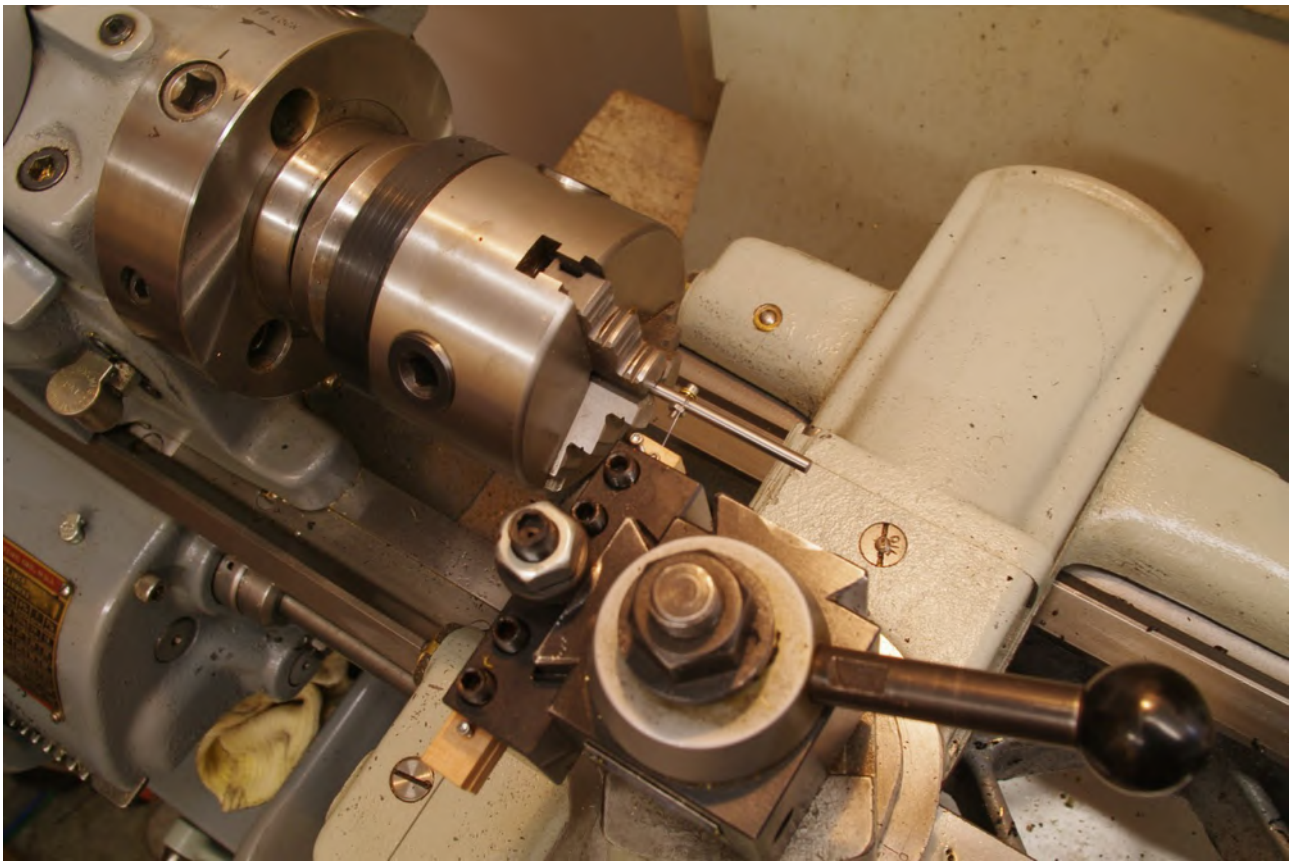


Parting-off a screw. Each bug requires three different styles for the various adjusters. I love working on my old South Bend lathe.

Cross-drilling a screw with a #80 drill. It’s a relief hole so that I can press in a silver contact. Here I’m using my Dumore sensitive drill press. It spins at 16,000 RPM and is perfect for this kind of job.

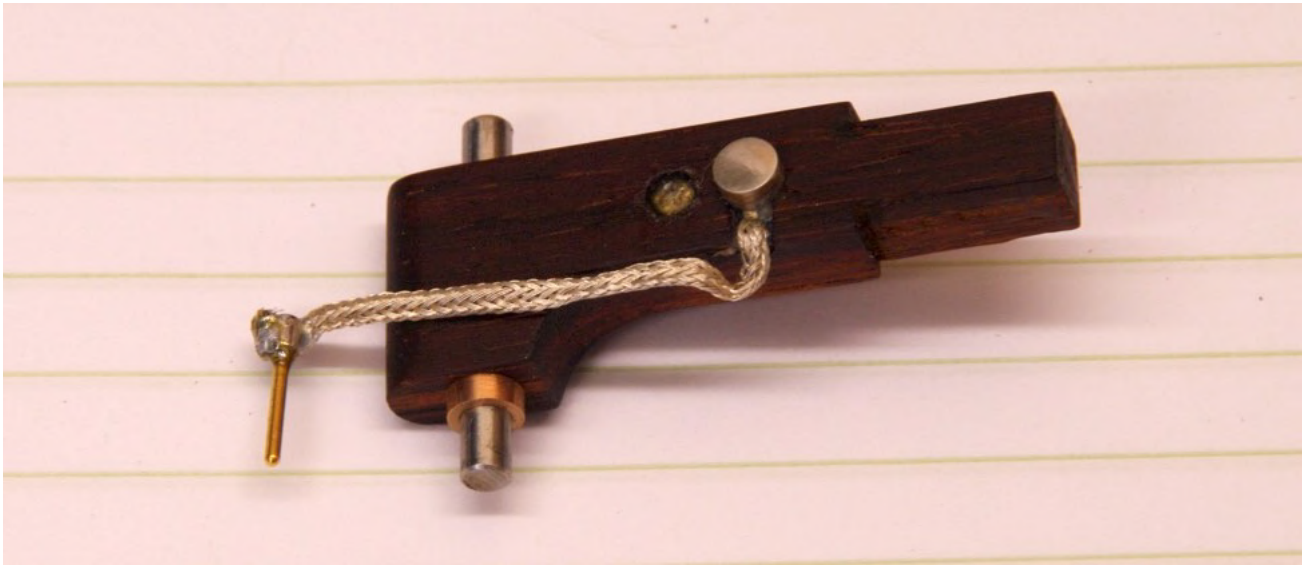


Making a 0.010 inch slit for the mainspring in the ebony weight arm.



Winding springs on the lathe. Piano wire is fed through a pair of wood blocks that guide it and also provide adjustable drag. The carriage travels along just like making threads and a perfect spring is quickly made.

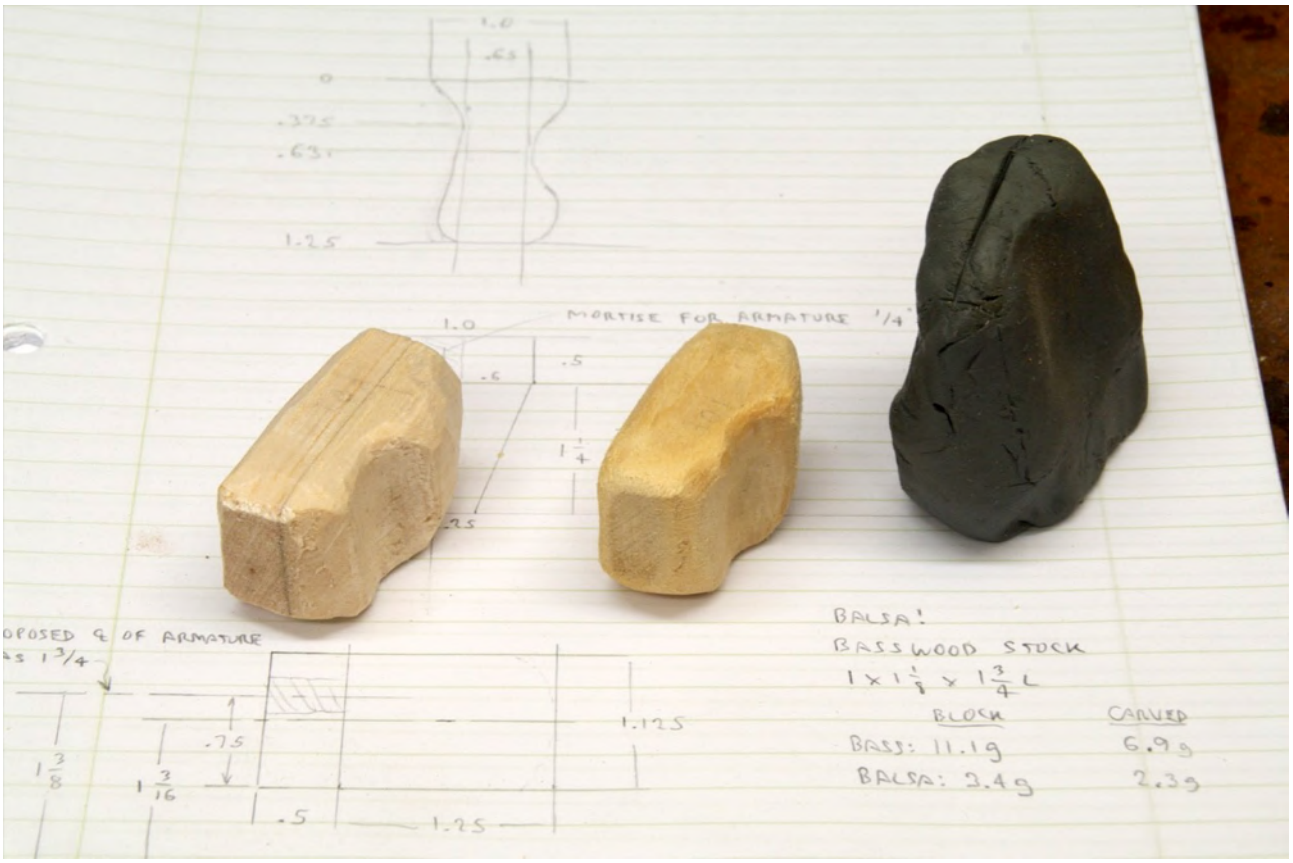
The completed pendulum assembly.



The completed dash armature assembly. The electrical pin is from a military connector.

Completed dash contact assembly. Each of these supports is mounted on a dowel that is pressed into the base. No glue was used. In the Model 2 Woodbugs, I slit the dowel and drove a screw in from underneath. That way, it will always stay tight and yet it can be easily removed.

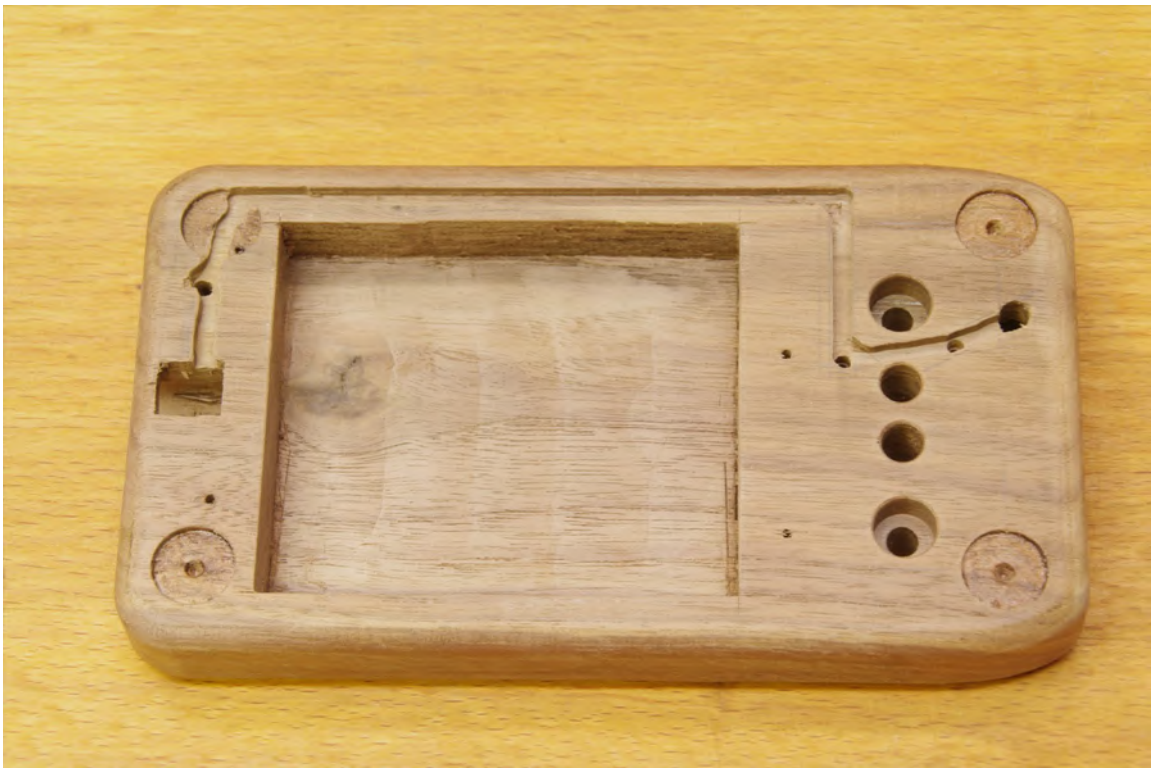
Dot reed switch embedded in the completed positioner. This is a linear actuator mechanism on a fairly small scale. With an adjusting screw and a spring between the two blocks, you can easily move the reed switch to vary the dot duty cycle.



Since this bug was made for me, I started with a lump of clay and made finger impressions right where I wanted the fingerpiece to be. Then it was a matter of transferring that shape to wood. I tried both balsa and basswood and ended up using the latter. The finish took a long time, starting with primer, spot filler, and then many coats of black lacquer. It looks like it's made of black plastic.

Making bases (here, for the Model 2). Blanks are drilled and milled in the vertical mill. Contouring is done on the bandsaw, followed by hand-shaping with rasps and files, scraping, and finally sanding.

A temporary base. Before potentially wasting expensive cocobolo, I made this. It was pretty close but a couple of holes needed to be moved.



All assembled on the test base. At this point, I knew it was all going to work.

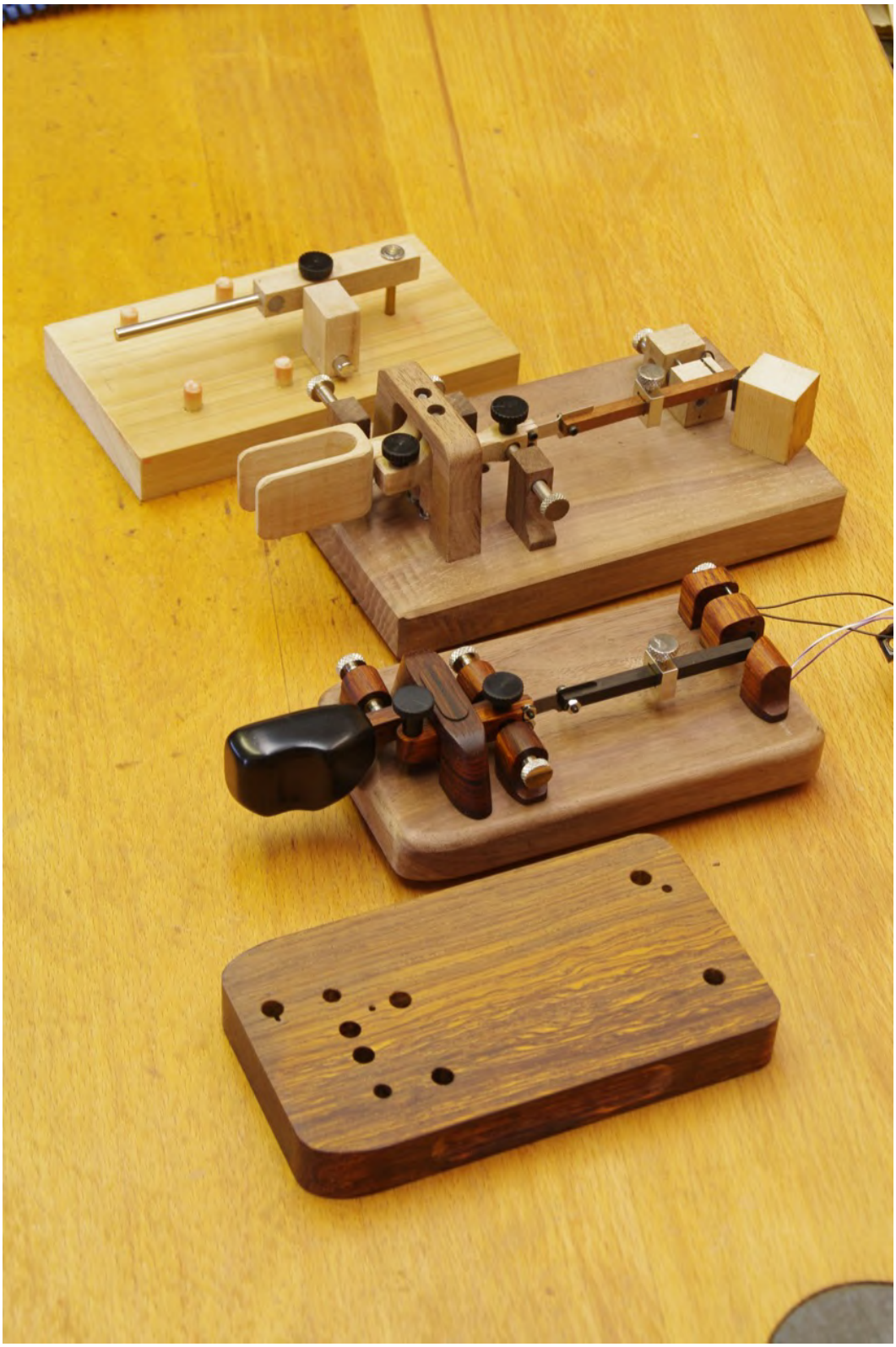
Finishing with Watco oil. Raw wood is sanded to 400 grit, and sanded under oil with 600. After curing for a week or more, I apply Renaissance Wax with steel wool.

Detailing parts. This goes on interminably. I built the head-mounted magnifier and light from a couple of commercial products. It’s almost as good as a real surgeon’s setup but much cheaper. And I can really SEE what I’m doing!

Cocobolo and ebony are both moderately toxic and irritating to the lungs, so some kind of respiratory protection is advised.

Uncle Gary at his 1957 South Bend lathe. I fully rebuilt it in 2011, right down to the last nut, bolt, and tapered pin. It even has an adjustable-speed DC drive and tachometer now.

My Chinese drill-mill. This sow’s ear has been turned into a silk purse by adding and adjustable-speed drive, digital readouts, spindle illumination, and a whole lot of careful adjustment.



Evolution. From component testbed, to preliminary bug, to an assembly on the temporary base, and finally the permanent base awaiting assembly.

The next stage of evolution: Temporary assembly of components for the Model 2, with the original next to it. I modified the geometry a bit and made sure it was robust enough for others to own and use.

Bottom view. Wires are glued into a groove. I experimented a lot with the feet and ended up using 1/4 inch butyl rubber sheet and a custom punch. They are reasonably sticky and stiff enough that the whole bug doesn’t jiggle.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