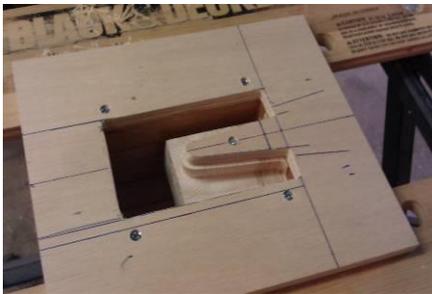
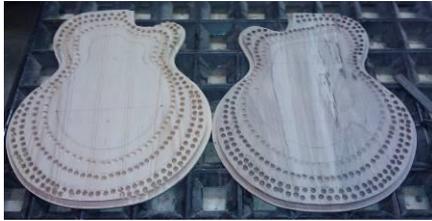


Archtop Build Journal



By Mike Conner
Fifth Edition © September 2016

Forward

I have played guitar for over 40 years now, worked as an engineer for 34 years, and a woodworker for at least 30 years. These combined to drive a strong interest in instrument construction, especially guitars, mandolins and upright basses. Having read, studied and thought about these instruments for many years, we now have been blessed with the opportunity to attempt to build some from scratch.

It would have been easier to build from a kit. Since I have done hundreds of guitar setups and built much of the furniture, cabinets and even our front door in our home, it seemed like a great challenge to build instruments starting from the milled lumber.

We humbly submit this journal detailing much of the process used to build a guitar and octave mandolin in the hope that it will help others understand how to build an instrument in a home shop primarily with normal woodworking tools.

This project would not have been possible without the many blessings God has granted us. With some modest abilities, reasonable resources, a shop full of tools, and the love and patience of a wonderful bride I was able to fulfill a life-long dream.

**Mike Conner
Seneca, South Carolina
September 2013**

Previous Editions:

**First Edition - September 2013
Second Edition – October 2014
Third Edition – June 2015
Fourth Edition – April 2016**

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Introduction

Background

Research and Design

Background:

I have been interested in archtop instruments (guitar, mandolin and upright bass) for several years now. Being reasonably handy with tools, having built quite a lot of furniture, and skilled with setup of instruments has motivated me to consider building archtop instruments.

I had acquired a used Samick Greg Bennett semi-hollow guitar some years ago, and enjoyed playing it at church, However, this configuration has a bit too much sustain for the worship band role, so in 2011 we added an Ibanez AF95, all laminated fully hollow body. I really like the Ibanez, and want to see how a carved solid wood instrument might work out.

Mandolins have always attracted me, but other than setups I have not developed more than a hack ability to play them. A Breedlove Quartz acquired about 10 years ago sounds great but mostly sits in the case.

In 2010 I got the inspiration to build an upright bass. We purchased plans, tools and the needed parts. Real life got in the way and the project stalled. Revisiting it this year, I am unsure about carving the huge plates and bending 8" wide sides! The archtop guitar project will come first and the experience should make the upright bass project easier to approach.

There are a lot of mandolin luthiers out there and a good many archtop guitar builders. Octave mandolin builders are more rare, and there is no entrenched design standard like there is for mandolins and jazz guitars. The plan is to build an archtop guitar and a guitar-shaped octave mandolin (GOM) side by side. The long term goal is really to develop the octave mandolin further, but building the guitar will give a reference I am more familiar with, and I can play it when I'm done!



Narrative Language and Measurement Units:

The reader will likely notice the mix of “I” and “we” identifiers frequently, perhaps even within the same paragraph. While most of the complex woodworking (lutherie) was done by my hands, often my loving and supportive bride Dianne would try her hand. These instruments would not have been possible without Dianne’s encouragement, patience and support. We have been very blessed in our lives and in our sharing of many home projects. So, the use of “we” honors my wife, my partner and my best friend.

We tried to take photos of nearly every step that is likely unique to lutherie. The included images are cell phone photos compressed to print resolutions, and we are not very good photographers. Our hands were often busy so there are very few “action” shots – probably a kindness to the reader since I am very non-photogenic.

The nomenclature for Lutherie can be a bit obscure or confusing at times. In researching construction of the carved violin or upright bass there are some very specific names used for various parts and dimensions. In that light, we will refer to the top of the instruments as the “front plate”, and the back is the “back plate”. This is potentially less confusing when referring to the tops of other features, and respects the traditional names for these components, even though most guitarists or mandolinists would call the front the top!

I mix fractional and decimal measurement units at will, depending on how I measure the feature (ruler vs. caliper) and in some cases due to common use of the measurements in describing the features of guitars. Sometimes the decimal versions are just more readable, and they certainly make the math easier (for example, scaling measurements from guitar to octave mandolin). I am comfortable measuring in metric (millimeters), but we are sticking with American standard units here (inches)!

[2nd], [3rd] or [4th] paragraph notations identify additional content from the Second and following Editions of this Journal.

Research and Design:

With the desire in place from playing the Ibanez archtop guitar, I began research on the web, looking at build postings, videos and looking into suppliers. Some years ago I had purchased a full-size D'Angelico archtop guitar plan, more out of curiosity than anything else (and it would look cool hanging on the wall). This is a classic large 18" wide guitar, way too big for a small guy like me. The 16" wide Ibanez is very comfortable for me.

The Benedetto archtop book ([Sources](#)) was a valuable investment, showing some details not found through the other internet sources.

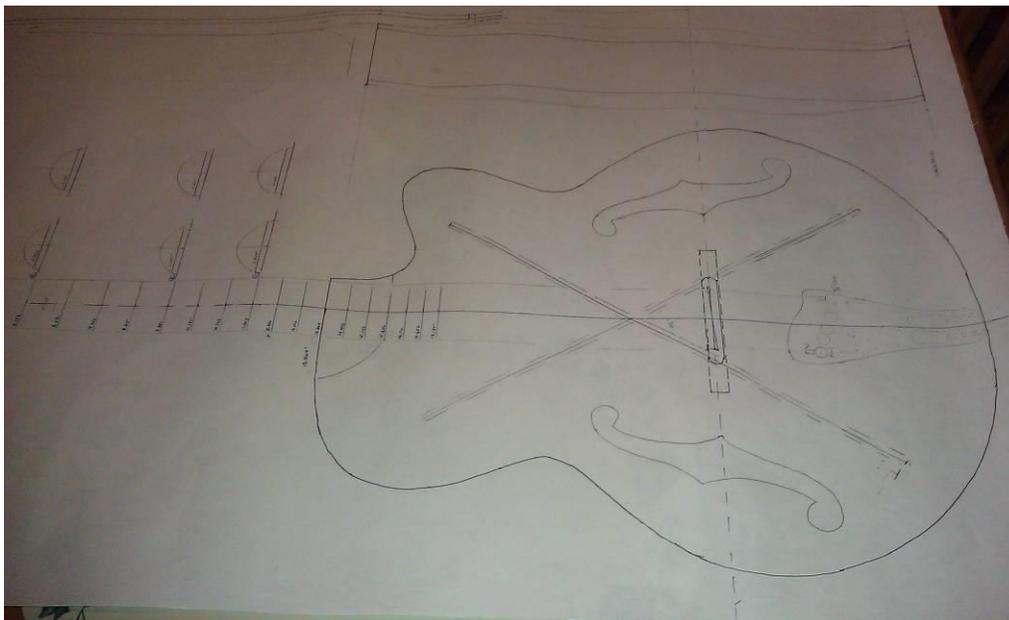
The basic specs I aimed for are:

	<u>Guitar</u>	<u>GOM</u>
Width at lower bout	15-7/8"	14-1/4"
Side depth	2.7"	2.5"
Total body depth (peak of back to top of bridge)	5.2"	5.0"
Scale length	25"	23.5"
Width at nut	1.7"	1.4"
String Width at bridge	2-3/16"	≈1-7/8"
Neck meets body at 14 th fret		
Both X-braced		

Tracing the Ibanez as a starting point, I drew a full size plan for the guitar, both front and side views. This was really important in terms of understanding how all the angles and features fit together, and allows measuring from the drawing as needed for specific details.

Key features I identified through this drawing exercise:

- Center line
- Bridge line (perpendicular to the center line). The location depends on scale length!
- Distance of inner point of f-hole to center line
- 3" spacing post-to-post for the guitar bridge
- Distance of intersection of X-braces from the bridge line



The penciled first outline was refined several times. For example, I wanted to refine the cutaway shape away from the "horn" appearance that comes from strictly mirror-imaging the bass side of the body. I drew and re-drew this many times before being satisfied. Same thing with the "f" holes, headstock shape, etc. This was time well spent!

Once satisfied with the guitar plan, I started scaling it down to a new drawing for the GOM. This took more creativity and careful study since there are no direct standards to lean on.

I decided on a 14.5" wide lower bout, 23.5" scale length and 20 fret neck joining the body at the 14th fret, and this determines the bridge line location. Working from the bridge line, it took several attempts before the body outline looked good to me (hopefully without sacrificing tone).

There are a wide range of scale lengths and body styles in the Octave Mandolin world. Longer scale lengths, even up to converting 25" guitars to 8 strings, can use lighter strings but the standard tuning in fifths for mandolin (GDAE) makes for long stretches using normal mandolin fingerings. Shorter scale lengths require heavier strings (at a lower tension). In the end, 23.5" seemed a good compromise.

Other design elements and material choices will be addressed as they are encountered...

[4th] After receiving a few requests for the plans, I have detailed a full scale drawing of the GOM using Number 5 as a reference. A CAD rendering of this drawing is available through the Musical Instrument Makers Forum. We encourage you to consider purchasing a copy of the drawing – the proceeds entirely go to the MIMF to help support the costs of operating the forum.

[MIMF Plans Page](#)

Preparation

Molds and Jigs

Milling Wood

Templates:

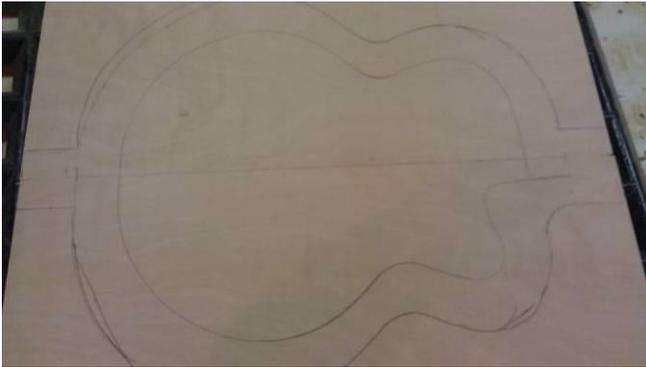
I played with the drawings for about 5 months intermittently, erasing and sketching, measuring and checking, tucking it away, then looking at it again a couple weeks later to see what might catch my eye as out of proportion, etc. Once we were ready to start building, the drawing needed to be transferred to a template.

The paper I am using is a heavier weight, 24" wide, smooth surfaced and made for inkjet plotters. It takes pencil and erases well, and also takes pen or Sharpie marker without bleeding. Fortunately, it is translucent enough that I can lay a fresh sheet on the drawings and trace the key features. We glued the 24" wide tracing to a 24" sheet of 1/4" birch plywood using 3M Super 77 spray adhesive – it adhered great without bubbling or distorting the paper.

The template tracing also included headstock shapes and neck profiles – more on this later. We carefully cut out the templates using a jigsaw (Bosch – great tool, very little vibration). Sanding to the profile lines using a sanding station now gives the completed template. Holding and playing with the templates gives a different perspective, so we further refined the body outlines with the sander until it looked good.

Molds:

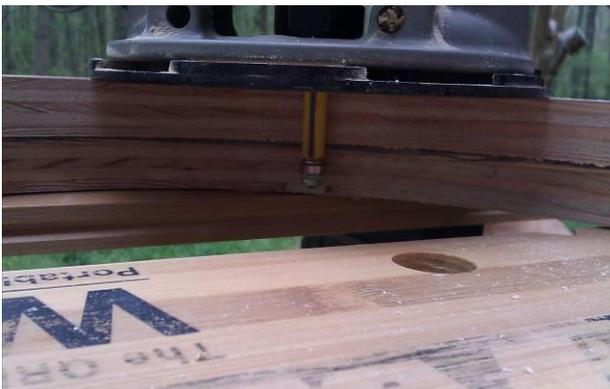
The template provides the layout tool for creating the outer body molds. The molds are assembled from 3 layers of 3/4" birch plywood – one 4' x 8' sheet ripped to 12" x 32" sections made both molds.



The mold really is defined by the first layer and provides the pattern for the other two layers. The template is traced onto two sections of 3/4" plywood butted against each other. This seam is on the center line of the body. Part of the layout includes deciding the wall thickness of the mold (2 to 2.5") and tab dimensions for connecting the two halves of the mold. We also planned for a slot at the neckblock area to allow the side to extend past the block during bending of the cutaway.

Both "pattern" halves were cut out and cleaned up to the lines with the sanding station. Standing the halves next to each other revealed some deviations from symmetry – we marked these and adjusted the curves further.

These patterns can now be used to shape the additional two layers. Trace the pattern to two additional plywood sections, then cut out about 1/8" outside the lines. Glue and screw together the rough cut layer to the pattern layer, aligning the flat center-line edges.



The flush cutting bit I used has a bottom bearing. The bearing rides on the first layer and the next layer ends up a nearly perfect copy. Glue and screw the next layer on and repeat with the flush cutting bit.

After the three layers are connected and routed, the sanding station makes quick work of cleaning up the mold halves. Curves can be further refined at this step too.



Note that the cutaway for the guitar mold was designed to match the diameter of the large end of the sander spindle. My bending iron is made from 2" pipe, so that also influenced the design.

The completed molds look like this – the GOM is on the left. (Note the holes in the templates at bridge line notch of the f-holes used to mark the location for corresponding holes through the front plate. The holes provide a bridge line reference during carving).

After this we hand sanded the mold surfaces, then sealed with about 6 coats of water based polyurethane.



The mold halves can be connected with bolts and washers through the tabs, but we just used 2" screws. We'll drill for bolts later if the molds start getting worn from the screws.



We also need some interior jacks for pushing the sides tight to the molds. We can use the birch plywood sections left over from cutting out the molds interior edges. These sections are near to the right shape, and with some shaping on the sanding station we can get a good fit to the mold.

The clamping is done with toggle bolts. Two pieces of the plywood were screwed together and shaped for each jack end. Then, the halves are taken apart and a pocket half the thickness of the toggle eye was cut using a 1.25" Forstner bit in the drill press. The re-assembled halves then trap the toggle end in the pocket.



Carving cradles were constructed from two pieces of $\frac{3}{4}$ " birch plywood, each consisting of a guitar perimeter cut $\frac{1}{2}$ " smaller than the mold shapes, screwed to a plywood base. The inner edge of the rim was rounded over to provide a smooth lip for the plate to touch. These cradles are needed to support the plate when scooping out the inner surfaces of the arches.

Some leftover packing foam was fit to the inside to cushion the arches when scooping out the inside surface. The foam was too thick for most of the plates though, and we used a folded section of an old towel as a support pad



Small clamping fingers were made out of maple to hold the plate in the cradle as well as many other clamping needs. The fingers rotate on the rounded section, with 1-5/8" drywall screws providing the clamping force.

Milling Wood – Red Maple:

We had a large Red Maple tree in our front yard, damaged by a storm in 2009. The tree leaned towards the house and we feared it was only a matter of time before we were crushed. We had the tree cut down in July 2011. We were pleasantly surprised that the tree was actually healthy inside.

The main trunk was over 20" in diameter.



The logs were painted on the ends with several coats of oil based paint to help seal it, but checking had already started in the few short hours before I could get home from work. The tree was leaning and likely under some stress, so I suppose some cracks were inevitable.

The logs were collected and sawn to 2.5" thick slabs by a local sawyer, Russell Whitworth. He has a bandsaw mill and it really cuts clean. I brought the slabs home to sticker and cover with a heavy tarp. We removed the bark and coated each slab with bug killer to discourage beetles and other wood boring pests. The outside of the stack was wrapped with landscape cloth to keep sun out and discourage insects, but ensure moisture can leave.

After sawing I estimate we have 400 board feet of maple to work with.

Here's the stack after 2 years drying. The top part of the stack came from the large tree branches, 10 – 12" diameter, and that's what we took to Russell to resaw into 7/8" boards. We'll use this potentially less premium wood first for these prototypes.



The sawn boards have the expected taper in the width, especially due to the fact that these were large branches. To turn into squared lumber, we snapped a chalk line one edge of each board to optimize the grain direction and width, and cut off this bark edge with a circular saw. We then ripped on the table saw with this edge against the fence, turned and ripped again with the table sawn edge against the fence. This yielded some reasonably straight and parallel edges.



Next we ran the boards through the planer. Russell does a really clean cut so it does not take very much to remove the saw marks. However, since these were branches, the wood grain affected the tracking of the saw blade so most boards ended up with a taper in thickness end to end. We were able to plane most to $\frac{3}{4}$ " thick, some could stay thicker.



The boards from these red maple branches really have some interesting figure, and even some signs of staining and spalting likely due to the storm damage the tree experienced a couple of years before we cut it down.



Milling Wood – Resawing Red Maple and Walnut:

We need maple thin enough for the sides and walnut for the neck laminations and trim. The milled thickness will be 1/8" in the rough, then thinned later as needed. This is too thin for our planer, but the 2.75" width needed can be handled by the table saw in two passes. Here's the setup using a fingerboard to keep it steady and safer:

Make a cut from one edge, and then set on the other edge to finish the cut. I clamped the source board to our bench by one end and cleaned up the cut surface with a hand plane. Then, back to the saw for another slice.



We ended up with enough maple side blanks for the two instruments, and plenty for practicing bending and future builds.



The walnut will be used first for the neck laminations, with the most figured sections saved for the headstock overlay, and later some strips for the binding.



The sides need to be less than 0.100" thick, and the rough sawing above leaves us at 0.130" to 0.150" thick. The typical way to thin the sides is with a drum sander – a tool we don't have. Sanding with a belt sander or RO sander didn't work because the maple is just too hard. Hand planing would be my preferred method, but the sides are close to flat sawn and I was getting too much tear out. What worked out finally was a ripping setup like we used for the rough sawing, just shaving off enough to get to 0.100". There were quite a few burn marks from this method, but they cleaned up well with a belt sander, then RO sander, and then scraping to give a nice smooth surface for bending.



We measured the thickness using a homemade caliper assembled from a couple of inexpensive aluminum levels as beams and wood holder for a depth gauge and screw tip as the bottom stop. The final side thicknesses ended up from 0.085" to 0.095", and I believe this variation is reasonable considering the hand work involved.

After thinning, the sides were ripped to final width; 2.70" for the guitar, 2.5" for the octave mandolin. I also ripped the neck and tail blocks with same setups so that their height will match the sides as close as possible. The stock we selected for these sides all came from the same board, and the re-sawing process above yields pieces with "book-matched" grain patterns. There are 3 pieces for each instrument – a spare in case we mess up bending.

In the future, we will try a different method for thinning the maple and walnut. The problem is that our planer really doesn't handle stock that thin. It is likely that using double-sticky tape to attach the stock to the surface of a 12" wide section of $\frac{3}{4}$ " of plywood might work pretty well. We'll test this when the next build comes around – maybe an upright bass?

[2nd] The resaw method above worked reasonably well, but did not seem safe enough. For the second build, I ripped a straight length of 2x lumber the 2.75" width of the sides, and a bit longer than the side lengths (the side stock is about 40", the beam is about 46"). I attached the 2.75" wide and 5/4 thick walnut stock to the beam with several pieces of double-sticky carpet tape along the length.

Using a new 24 tooth ripping blade we can rip the entire width in one pass, running the beam along the fence and letting the 1/8" thick section fall loose on the "out" side of the blade. The fence position was set for each pass by setting a square against the miter slot and sliding the beam-stock assembly to the extended square.

This worked great. It was very controllable and much safer. Each 5/4" thick board yielded 5 side strips. These side blanks were much smoother than we got using the original method.



Here we are ripping cherry sides for build Number 6 (guitar for Bridget Egan)

Surfacing the side slices was done using a section of $\frac{3}{4}$ " plywood with the slices tacked to it with carpet tape. We sent the entire assembly through the planer, taking light passes each time.

These walnut sides were surface to 0.077" thick.



[3rd] Using the planer method above worked really well for walnut, plain red maple and even the curly red maple for Number 4 (GOM for Josh Hicks). However, the figure in the cherry proved to be a disaster and the sides popped and shredded after only a few passes. We ended up sawing the side blanks initially to just under $\frac{1}{8}$ ", then using the sawing beam with carpet tape to shave them down to about $\frac{3}{32}$ " (0.090 or so). The final thicknessing was completed by attaching them at the ends to the plywood backer above, then using a belt sander and 5" ROS to work through the grits and dress them to the final thickness. Went better than expected, and a good lesson learned!

[4th] Alternatively, the sides can be thinned using the resaw beam and the sanding station. The sides are attached to the resaw beam with the reduced tack of previously used carpet tape, strong enough to hold the side firmly but still remove it without damage. The beam provides a good backing for the thin side material and standing the edge on the sanding station deck keeps the side blank parallel to the sanding belt. This is a decent alternative to using the belt and ROS sanders. The sanded surface has fewer scratches and cleans up pretty well with scrapers.

Body

Sides, Blocks and Linings

Tail Wedge

Front and Back Plates

Front Bracing and *f*-holes

Closing the Body

Edge Binding

Bending Sides:

Of all the new lutherie methods we needed to learn, bending the sides was the most intimidating. I read as many sources as possible from books and on the internet. Seemed like it should not be a big deal, but this something we really did not want to mess up.



I built our bender when I was pursuing the upright bass project from plans I found in the web. The pipe is a section of heavy 2" OD steel pipe mounted to a plywood base that can be clamped in a workmate.

The heating element is an electric fire starter sold at Lowes as a charcoal starter. I bent the heating element in a bench vise until it was narrow enough to fit inside the pipe. The element handle was disassembled to expose the wiring, and connected to a light dimmer to act as a temperature control.

To monitor the temperature I had purchased a magnetic temperature gage designed for barbeque grills, but this did not work.

What did work very well was a 12" temperature probe we also use for our turkey fryer, inserted into end of the pipe so that the probe was touching the top inner surface of the pipe, above the heating element. The bending temperature ended up being 350 degrees F on the temperature probe – probably a bit less on the pipe surface. Our goal was 300 degrees for maple bending based on what we researched.

We had previously used a cloth tape rule to measure and record the key bend locations on the templates. We marked these locations on the edge of the sides and also which surface was to be the "out" side.

We used a bucket of tap water and washcloth to wet the wood prior to bending – we did not soak in a tub. This worked very well. We wet the wood about 5 minutes before bending.



We don't have pictures of the actual bending since our hands were all busy and we were so focused on what we were doing!

The actual bending process was as easy as we had read about, and after bending the guitar sides our confidence improved.

Lay the wood on the pipe and rock back and forth to heat the wood. The water turns to steam pretty quickly, and while keeping gentle pressure you can feel the wood start to give and bend. No real force was needed. We kept the wood moving and re-wet the surface as the wood dried out. Much to our relief there was no scorching, burning or cracking. It seems red maple is a very bend friendly wood.

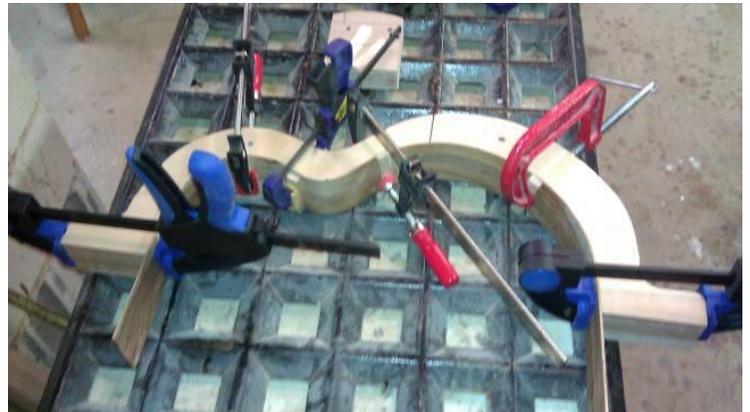


Following what we had read and videos on the web, we bent the waists first and clamped on the outside section on the molds.

We then bent the other direction for the upper and lower bouts. The cut-away sections were easier to bend than we thought. The only problem was that the wood remains somewhat flexible and tended to relax back and straighten out. It was a lot of wetting, bending, comparing to the mold, then repeating. When we got close we clamped the side to the mold, using small scrap sections and a wedge at the neck block area. We also used the blocks from the interior jacks as clamping cauls.

Like most woodworking projects, you can never have enough clamps!

Small scrap wood cauls are used to keep the wet sides tight against the mold walls and prevent cupping or warping as the sides dry out and the form sets.



Trimming Sides and Gluing to Blocks:

After drying overnight we were relieved to find that most of the sides retained their shape without any spring back. The guitar sides needed a second bending session to tighten up the cutaway bend.

The water raised the grain quite a bit, but sanding the interior surface to 220 grit was no problem.



I marked the sides for cutting and used a scrap block as a saw guide to trim both ends. Scoring several times with a knife and then finishing with a razor saw gave a nice neat cut.

Even with careful marking and cutting, it was tricky to get the joint at the tail block perfect. I think this is a common challenge for hand work, so a [tail wedge](#) will be fit in later.



The neck and tail blocks are red maple.
The neck block is the same width as the sides (2.75" or 2.5"), 3" long and 1.75" thick
The tail block is the same width as the sides (2.75" or 2.5"), 3" long and 7/8" thick



The interior edges of the blocks get a radius on the sanding station.

I predrilled a 1/2" hole 1.875" down from the front edge of the sides for the strap jack. This means that the strap jack will not be centered on the tail, but this way the tailpiece bracket will not need to be modified by drilling a large hole (more later).

This is where the interior jacks we made come into play, pushing the sides snug to the mold while we fit the blocks.

I touched up the fit of the neck and tail blocks at the sanding station and glued them in. Recall that there is a slot for the cutaway side to extend past the neck block, and this joint is not on the center line. We needed to carefully measure the bass side to ensure it met the cutaway extension.

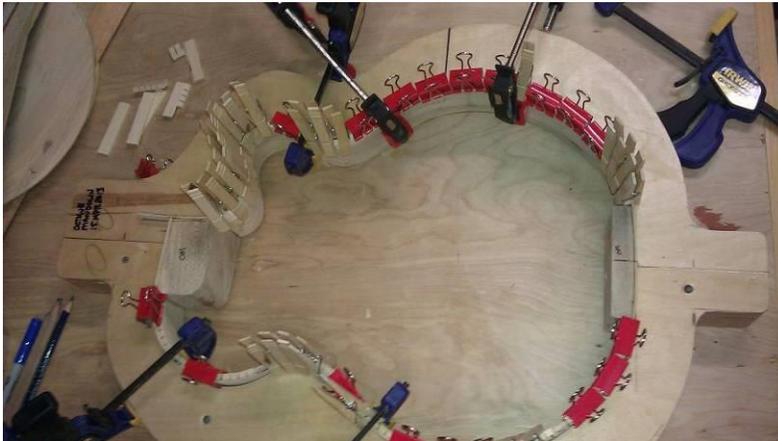


Wax paper ensured we did not glue everything to the mold. We used some tapered shims to push the cutaway side section tight to the neck block and to make sure the joint where the sides meet at the neck is very tight.

Side Braces and Linings:

The side braces are spruce 1/8" thick, 1/2" wide with the length equal the width of the sides. I glued in the braces first. Then we glued in the front lining. After letting the glue set an hour or so, we flipped over and glued on the back lining.

We chose reverse kerfed linings for the builds since they are supposed to yield a stiffer rim. I tried to notch the linings for the side braces, but in most attempts the thin part of the lining that should span the side brace broke out. I gave up and cut the linings to fit in between the side braces. I am not going to attempt the Benedetto style pieces glued to the side braces to match the width of the linings. Maybe in a future build we'll be more fastidious.



We really didn't have the right clamps to do the best job here (the GOM rim in picture). The clothes pins are not strong enough. The binder clips are good, but the width keeps them from following the tighter curved sections of the rims. We ordered the kerf clamps from StewMac. The GOM linings ended up with a less than perfect fit. But for our first time trying this it will have to do.

It took more kerfed lining pieces to do the GOM than expected - 6 and 1/2 pieces with loss due to breakage. We ordered more with the clamps.

The guitar turned out much better using the StewMac clamps and an assortment of spring clamps with the binder clamps at the flatter sections.

It helps to lightly wet the "web" that connects the individual kerf bits with some water a few minutes before bending to shape. This minimized the cracking or breaking.

In the end it took 12 reverse kerf lining pieces to complete both rims.

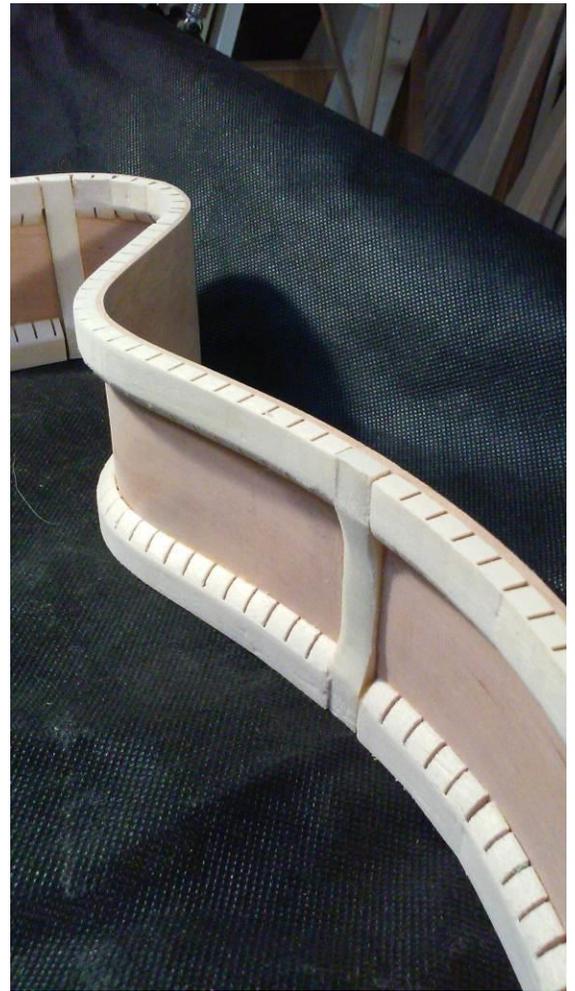


We constructed a simple sanding beam to level the rims and blocks. We glued a sheet of coarse sandpaper on a 30" long x 4" wide section of 2x lumber using Super 77 spray adhesive, and added a medium grit sheet on the reverse side. This worked great and the rims cleaned up rather quickly.

[3rd] For Numbers 4 forward we have modified the side braces.

Using Englemann bracing stock that is a little over 5/16" thick and about 1" tall, we rip it down on the bandsaw to strips equal in thickness to the reverse kerf. After gluing and leveling the linings, we carve the braces to reduce the thickness between the linings. This provides for more gluing surface for the plates, but lightens the braces down across the sides, (and it just looks cool too!).

Here is a photo from Number 6 – cherry sides.



[4th] The paddle works fine, but we have some large sheets of sandpaper left over from installing hardwood floors, and these are handy for leveling the rims. We clamp the rim assembly in the mold and rub on the bench top. Levels things out really well and a bit faster than using the sanding paddle.



Tail Wedge:

Since the joint at the tail block is a challenge to achieve, a tail wedge removes this concern and adds a decorative touch. We chose to use a 4.5 degree angle on both sides, bordered by 1/8" wide walnut.

We first layout the wedge on a piece of maple left over from the sides. This was cut out with the bandsaw and cleaned up by sanding on edge. We then clamped it to the rim at the tail block and marked the edges. Laying on the 1/8" walnut, we mark again. This defines the pocket that needs to be cut to accept the wedge and edging.



We clamped on a maple scrap to act as a guide and razor sawed the cuts, the pocket was cleared out with chisel and a four-in-hand rasp with smooth edges to prevent damage to the wedge cuts.

The wedge pushes the walnut banding tight to the pocket edges and creates a nice tight joint. Glued and clamped for a couple hours, we can then trim the ends and sand flush to the sides.

Here's the guitar tail wedge. The first attempt on the GOM did not look this good.



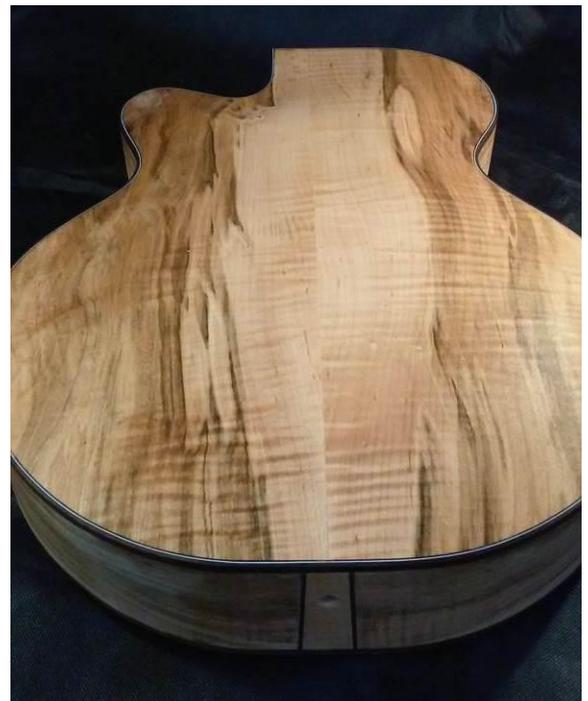
[3rd] In later builds we have refined the design a bit, and now use leftover lengths of binding on edge as a thinner decorative line.

Right: Walnut and curly maple tail wedge on Number 4.

Below: Cherry and Maple on Number 6.



Number 8: Curly Red Maple and Walnut



Front (Top) and Back Plates:

The waste section from cutting out the templates works great for visualization and layout of the front (top) and back plates from the maple and spruce stock.

It took quite a bit of moving the “frames” around to find the best grain direction and match for the maple backs. I managed to get the two pieces for each back from the same board, hoping for a decent match that way. The red maple has some funky defects and figure, and the final selected plates may very well look pretty cool when completed and finished.



The front plates are selected from “Depot Spruce”, a variety of spruce that is cut only during even numbered years in months ending in “Y” and only during a full moon.

OK, not really. I have a collection of 1x12 boards culled from the lumber racks of Home Depot. They have been stacked vertically and drying on our basement for at least 10 years. The sections used for the octave mandolin are definitely some sort of spruce. The guitar front may very well be ponderosa pine. The wood is less than ideally quarter sawn, but I think these will work out fine. The octave mandolin front has the tighter grain and is closer to quarter sawn than the guitar in the center, grading to rift sawn at the edges.



Quarter Sawn



Rift Sawn

The front and back sections were crosscut from the boards and ripped to reduce the width. Our table saw is a pretty rough looking Craftsman “Frankenstein” tool assembled out of parts from several sources, but we have it tuned up really well and it rips very clean and straight cuts that are usually ready for glue up.



However, we want the best joints possible since the plates will be carved thin, so jointing is preferred. We use hand planes in an “old school” jointing method.

The boards are ripped as clean as possible, then clamped together with the “front” sides out. I have a Stanley #6 plane that was my grandfathers and I have learned to sharpen and adjust it for a very fine cut. Planing both edges together, clamped as shown, removes the fine saw marks and leaves edges that really match well.



After jointing, we glue the two sections together in a homemade clamping fixture. The boards lay on a 2x4 frame that allows access for the clamps. 2x4 cauls with vertical clamps keep the boards flat while the horizontal clamps pull the joint tight. (Not too tight, we don't want to squeeze out all the glue). Wax paper ensures we don't end up gluing everything together.

After the glue has cured the plates are planed flat using hand planes. A belt sander would work for bringing them flat, but properly tuned hand planes work faster and yield a smoother surface. A random orbital sander finishes the surfacing.

[2nd] For the second build we used Englemann spruce from Rocky Mountain Tonewoods in Colorado. The spruce comes in split wedges, truly bookmatched!



The jointing method was the same as above. The resawn wedges were clamped together on the matching flat faces and the thicker edge joined with our hand plane.

The glue up uses the same frame shown above, just clamped a bit different so that the wedges do not kick up when clamped together.

The molds are laid on the plates and the inner surface traced. We don't want to count on the templates for this since the details were modified when sanding out the molds. We'll cut about 1/8" oversize to be sure the plates will fit the sides.



Plate Arching - Layout:

Using the Benedetto book as a guide, I could scale down the arching templates from the 17" lower bout guitar design in the book to the 16" we will be using and figure out the locations for drilling guide holes for carving. The guide holes are drilled down from the outside surface of the plate blank, progressively deeper from the center of the plate to the edge.

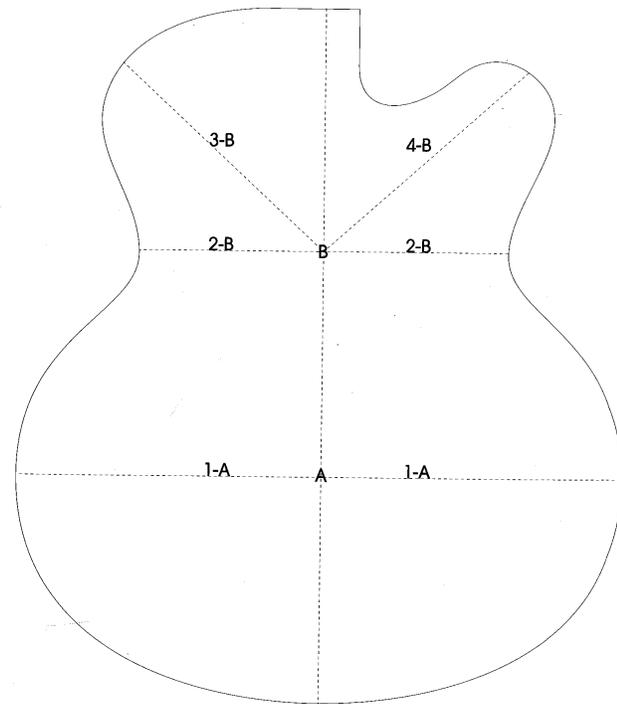
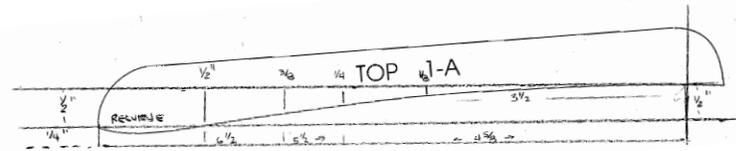
Two critical reference locations for the measurements:

"B" - the center point at the narrowest part of the **waist**

"A" - the center point at the widest part of the **lower bout**

The Benedetto book does not give the specific dimensions needed. So, I modified each template drawing to estimate the hole locations. The plate blanks are $\frac{3}{4}$ " thick, and the arch will sweep down from the center to the edge.

Here's what the marked up template drawing looks like. I found the locations that represent hole depths of $\frac{1}{8}$ ", $\frac{1}{4}$ ", $\frac{3}{8}$ " and $\frac{1}{2}$ ".



Working with each template I was able to find the guide hole locations relative to points A or B for both plates (tables below).

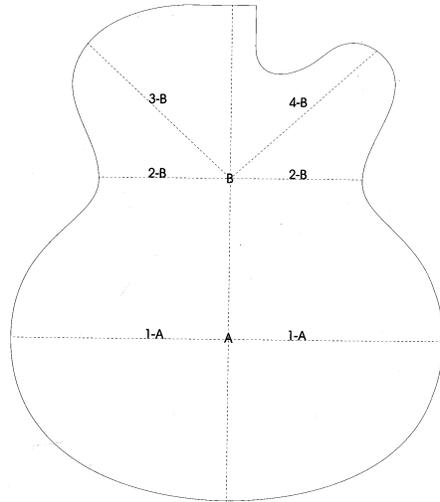
With the guitar guide hole locations established, I can estimate the locations for the GOM by using a ratio of the body size ($14.5" / 16" = 0.90$ or 90%). This will probably not look strictly correct when laid out and then carved into the plates, but it at least provides a starting point.



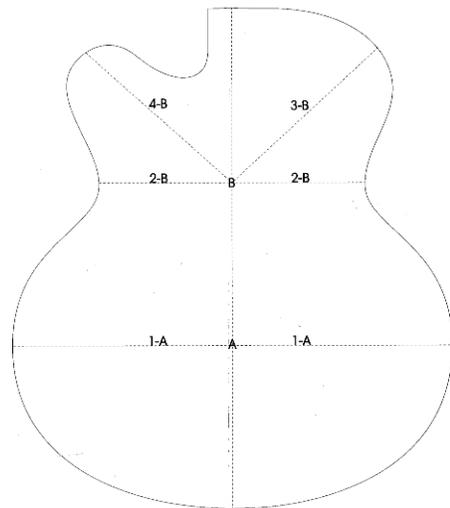
The holes are drilled with $\frac{1}{4}$ " bit in the drill press. Rather than using the hole depths, the setup is easier by viewing the arch as a height from the inside surface of the plate. The minimum height is $\frac{1}{4}$ ", and the peak of the arch is at $\frac{3}{4}$ " – the thickness of the plate blank. These heights are shown in the tables below.

Here's a gage for setting the drill height from the drill press table. Each step is $\frac{1}{8}$ " and this saves some setup time. We made this from a $\frac{1}{8}$ " thick strip of oak from our scrap bin, cut into descending lengths and then glued together in a stack as shown.

Front Plate



Back Plate



				Drilling Depth - Top of plate down			
				1/2"	3/8"	1/4"	1/8"
				Drilling Height - Drill Table to Drill Tip			
Desc	Line Label	Length	Recurve (from edge)	1/4"	3/8"	1/2"	5/8"
Widest lower bout	1-A	8	1.500	6.500	5.500	4.625	3.500
Waist	2-B	5.25	1.000	4.125	3.625	3.000	2.375
Waist to upper bout	3-B	7.125	1.000	7.000	5.375	4.500	3.000
Waist to Cutaway	4-B	6.875	1.250	5.250	3.875	2.750	1.250
Waist "B" center to neckblock	from B	6.125	1.500	4.750	3.875	2.750	1.500
Bout center point to tailblock	from A	7	1.250	5.750	4.500	3.500	2.125
				Drilling Depth - Top of plate down			
				1/2"	3/8"	1/4"	1/8"
				Drilling Height - Drill Table to Drill Tip			
Desc	Line Label	Length	Recurve (from edge)	1/4"	3/8"	1/2"	5/8"
Widest lower bout	1-A	8	1.250	6.625	6.000	5.125	4.000
Waist	2-B	5.25	0.750	7.250	3.750	3.500	3.000
Waist to upper bout	3-B	7.125	1.375	5.875	5.625	4.750	3.250
Waist to Cutaway	4-B	6.875	2.125	5.750	4.375	3.500	2.375
Waist "B" center to neckblock	from B	6.125	3.000	4.750	3.625	2.750	2.250
Bout center point to tailblock	from A	7	1.500	5.500	4.625	3.625	2.250

Plate Arching and Graduations – Design Elements:

[4th] Based on the most recent builds we can offer some design guidelines for the front plate arch and thickness graduations:

- The high point, or peak, of the arch corresponds to the point where the X-braces cross, 2.5" from the bridge line. Having the peak there instead of at the bridge line seems to better resist deflection under string load.
- The arch gently falls away from this peak point.
- At the neck block, be careful to have the arch flatten where the plate connects to the neck block, and keep the spruce thicker, following the neck angle. If successful, then fitting the neck extension will be much easier since this portion of the front plate can have material matching the neck angle. We have made a simple gage to help maintain this angle as shown here: [Neck Angle Carving Guide](#)
- Target 0.220" thick along the center line, in the 3" wide zone defined by the neck and tail blocks.
- Falling away from this center zone, taper to 0.175" around the f-hole zone.
- The outer 1" to 1.5" should stay at the 0.250" thickness. The recurve will scoop this area out later.
- We do not recurve above the tail block and keep the plate thickness at 0.220"
- Back plate: center zone and edge 0.185", flanking zones to 0.175"

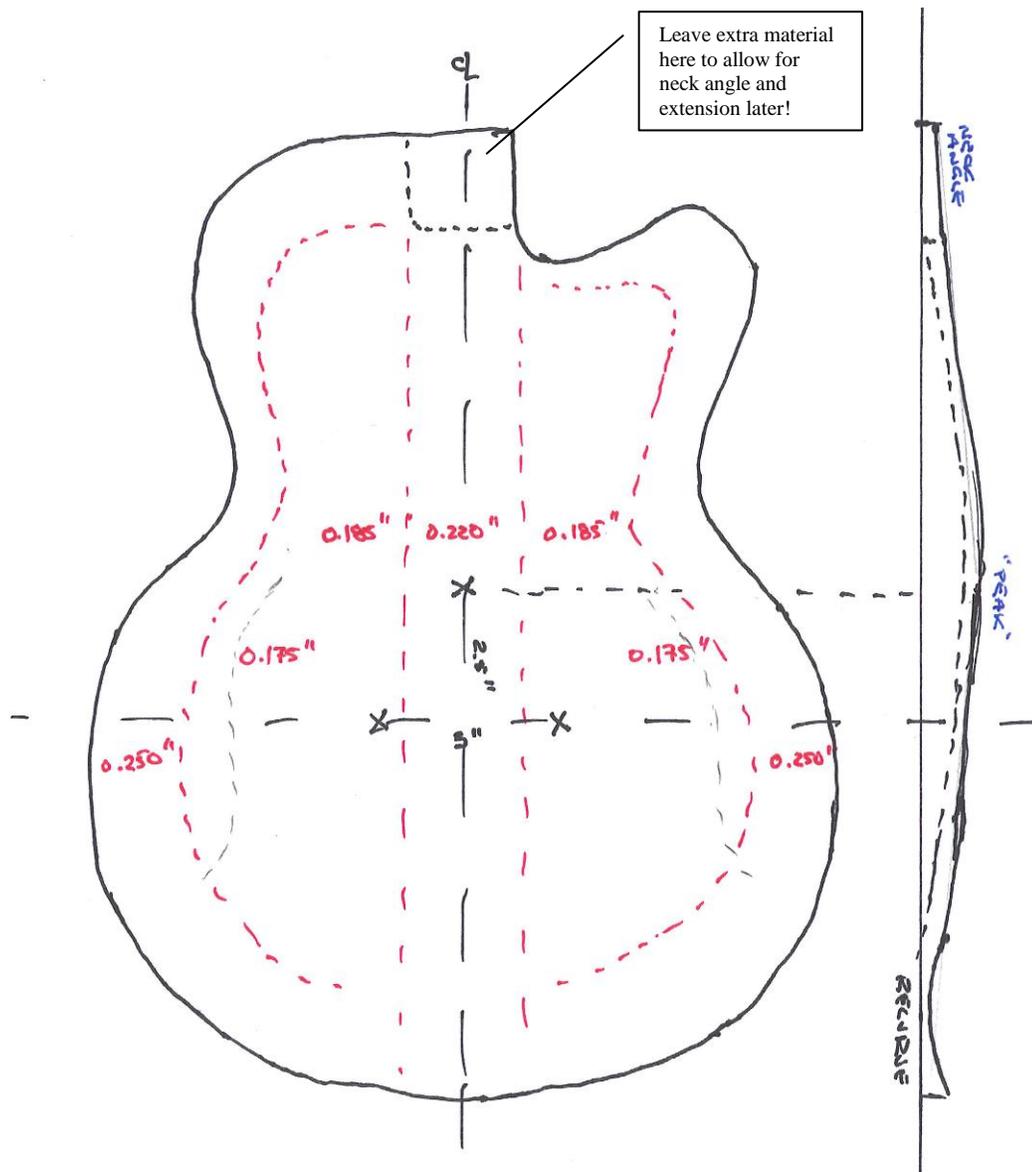


Plate Carving – Outside Arch:

We located points A and B on each plate. We marked the drill locations using the dimensions derived from the arch templates, then drew lines free hand connecting the locations for the $\frac{1}{4}$ ", $\frac{3}{8}$ ", $\frac{1}{2}$ " and $\frac{5}{8}$ " heights for the arching. Then we connected the marks using the templates to help with the curves. I made adjustments from there, erasing and redrawing until everything seemed to flow correctly. The result is a topographical style map that looks like this:

Next, a ledge was cut into the plate perimeters with a $\frac{1}{2}$ " rabbeting bit, leaving the $\frac{1}{4}$ " rough thickness as a guide for the carving to the edge. Then, the guide holes are drilled to the heights using the homemade gage to set the drill bit heights.



Here's where I learned a lesson! The octave mandolin front lower bout edge on the treble side broke away – tear out from the router bit. Fortunately, it was a small piece and I was able to glue it back on.

Lesson Learned: Make climb cuts to avoid the tear out.



Hundreds of plunges on the drill press and we have the guide holes.



Clamped to the bench, the plate carving commenced using a 3/4" chisel to rough things out, followed by FlexCut gouges to refine the form.

The chisel makes pretty quick work of removing most of the "overburden". I found it pretty easy to control. The FlexCut gouge set has 4 different "sweeps" or curves, and I started with a rounder sweep for roughing out, then the progressing to flattest one for finishing the surface.

Here's halfway in on the guitar front....

You have to feel the runout of the wood, and this was especially true with the octave mandolin plate. In one carving direction you get a nice slice, but the opposing direction may find the chisel or gouge digging in and trying to tear out chunks. So, the carving direction needs to change frequently, and most of the cutting is a slice at an angle across the grain.

Side lighting really helps in seeing the contours while carving.

After an hour or so, the front was rough carved, leaving dots from the last part of the guide holes to provide a reference during the final cleanup.



I did the same procedure on the backs, but the red maple is pretty hard! Each back took at least 2 hours to rough in, and it was brutal. I can see why some archtop builders use side grinders or other power toys to whittle on this stuff. (See below – now we use a side grinder with a Lancelot blade).



What finally worked out for me was to smack off most of the waste with the chisel and mallet. This was unpleasant but good anger management therapy.

Next I used an Ibez palm plane to remove the maple until the guide holes were gone. The FlexCut gouges and a curved scraper were needed to clean up tighter areas like the waist.

Final cleanup and shaping of the plates was done using our 5" random orbital sander. I used 60 grit hook and loop for the shaping, and this works really well even though everything on the plates is arched and curved. This especially went nice and quick on the spruce fronts – the maple was pretty slow going as expected.

I hand sanded to 150 grit, and this makes the plates smooth enough that any lumps or other problems are noticeable in reflected light. Back to 60 grit and more hand sanding until it looked right.

At this point, the front plates still have a center area that is quite flat. There should probably be a gentle arch at the bridge line, and the bridge posts will end up around 1.5" each side of the center line. Since we have holes in the front the bridge line is easy to locate. I used combo square with the slide at the mid-point to see the arch progress as I sanded the shape in.



[2nd] The first guitar build had front plate contours that used a flatter "table" area. With time this first guitar and the octave mandolin had a visible sag towards the middle of this table contour. The plates are very stable however.

The Englemann spruce wedges provided for more arch height, and the contours are more like the traditional "dome" arching. The past experience also helped in allowing for a 1/4" edge thickness and more thickness available for creating a recurve section.



[3rd] We now use a very dangerous tool for rough carving away most of the overburden – a Lancelot mini chainsaw blade in an inexpensive side grinder. Combined it cost about \$60. This saves many hours of mallet and chisel work. Using the Lancelot tool requires patience and focus to ensure neither the plate nor the operator are damaged. Chips fly everywhere so we are doing this outside.

Here is the roughed in cherry back plate for Number 6.



Plate Carving – Inside Arch:

With the outside arching well defined on each plate, the inside must be carved out. The side bending, trimming, head block, tail block and interior kerfed lining were previously completed. With each plate carefully aligned to the center line, the final interior perimeter can be traced onto each plate.

The first inside plate arch attempted was the GOM back. Given the experience with the outside arch, we needed a less violent way to remove all the inside material. We were very concerned that the hard smacking of the chisels to rough out the material would split the maple as it thins down.



I set up a router with a $\frac{1}{4}$ " carbide downcut mortising bit with a $\frac{1}{2}$ " cutting depth. I marked out the "table" area of the back plate where the arch is very slight and the deepest stock removal is needed. I used the carving cradle with some small hold downs made from scrap maple.

The router worked really well to cleanly get this bulk removed – only 10 minutes to clear out the GOM back.

Here it is about half way routed.

A drilling guide post was constructed using a chair leg pad as the tip to reduce the damage to the outside of the plates. A $\frac{1}{4}$ " gap is set between the post and the drill bit tip. Guide holes are then drilled throughout the plate interior surface.

This photo shows the setup with a $\frac{3}{8}$ " drill bit. I switched to a $\frac{1}{4}$ " bit because the larger bit caused some minor tear out and wanted to "walk" away from the hole. The smaller $\frac{1}{4}$ " bit means we have to drill a lot more holes, but they were cleaner and more controllable.



Next is a long session of drilling guide holes on the drill press using the fixture shown above. The bottom of these holes define a plate with a $\frac{1}{4}$ " thickness.

I drilled as many holes as possible. Easier to remove the hard maple by drilling than to chisel it out!



The waste is removed using a chisel and mallet, the Ibex plane and gouges. Dad and Dianne each got a chance to try out this anger management experience.



The plate is thinned in specific areas using scrapers and sandpaper. The Benedetto book does not have a detailed map, but the D'Angelico drawing does. From this information I made some assumptions on how to carve the graduations. In general, for the fronts we keep the centerline portion at $\frac{1}{4}$ " (0.250" to 0.270"), thinning between the center area and edge to $\frac{3}{16}$ " (0.190 to 0.200"), but trying to keep the last 1" or so near the edge at the full $\frac{1}{4}$ ". The back plates have an overall thickness goal of $\frac{3}{16}$ " (I settled at 0.200").

I kept thumping on the plates, pressing on them and twisting them to get a feel for how the carving changes the response. With no experience in "tap tuning", I have no real goal in mind, but the process may give me some insight for following builds.

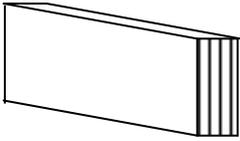


Compared to the red maple, carving the inside surface of the front plates was like cutting butter! It's surprising to hear the musical tap tones and feel how light the plates are after carving and graduating.

[3rd] We now use the Lancelot carver for the inside waste removal.

Plate Bracing:

I decided to carve and glue in the “X” braces before cutting the “f” holes.

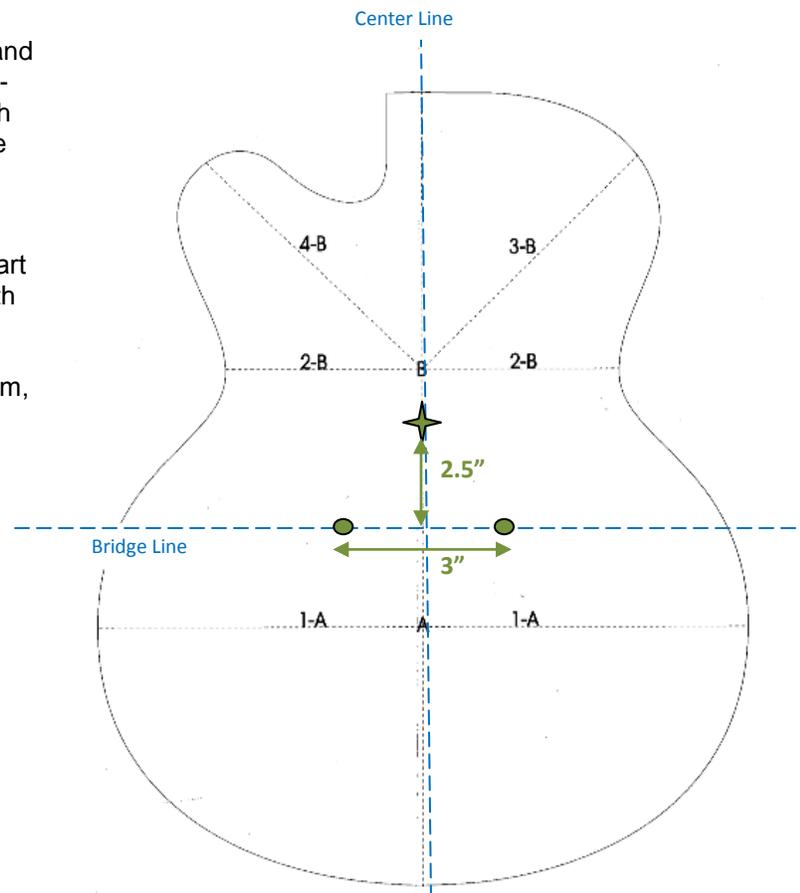


The front plate brace blanks were ripped from sections of spruce 1”x8” lumber selected to have vertical grain, 5/16” thick and 3/4” tall. I hand-planed all the edges to clean up saw marks and square them up.

[2nd] We now use Englemann spruce bracing stock provided with the front plate wedges from Rocky Mountain Tonewoods.

The first step was to mark the brace locations and lengths in the interior of the front plate. The pre-drilled holes give the location of the inside notch of the f-holes, and from these we can locate the bridge line.

The bridge posts are to rest on the top immediately above the x-braces, and are 3” apart (1.5” each side of center line). After working with the drawings, I decided that the braces would cross 2.5” above the bridge line (towards the neck). The braces end 2” from the lower bout rim, and 1.75” from the upper bout rims.



After cutting to length, I attempted to fit the first brace by carving with chisel, scraper and sandpaper. This really failed miserably. I would just chase the gap up and down the brace with each cut or scrape.

This jig solved the problem. I milled a 5/16” slot, 1/4” deep in a piece of pine that was 32” long and 7/8” thick. I trimmed 10” of each end to provide clearance at the rim of the plate. Two small screws lock the brace in position in the arm – the screw holes are in a section that will be removed with later carving.

The rough brace contour was marked with a compass set to the largest gap between the brace blank and the front plate (about 1/2”). A chisel was used to remove the bulk of the waste.





Scrap blocks screwed to the carving cradle hold the jig arm in position.

Sandpaper drawn between the brace and front plate shaped the brace edge to an excellent fit with the inside arching.

We started with 100 grit, then 150 and finally 220 grit.

The weight of a large C-clamp hanging on the jig arm provided the ideal amount of pressure for sanding.

Some closer views of the brace jig in action...

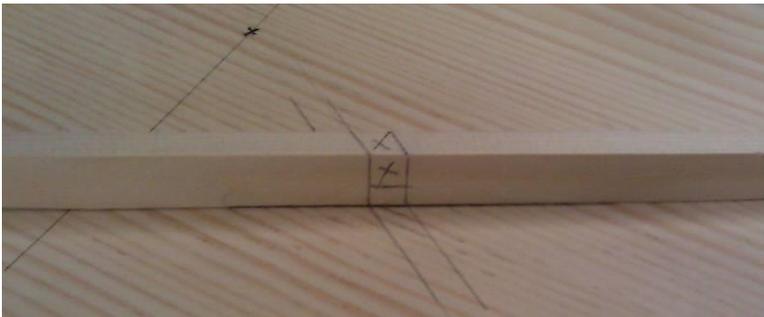
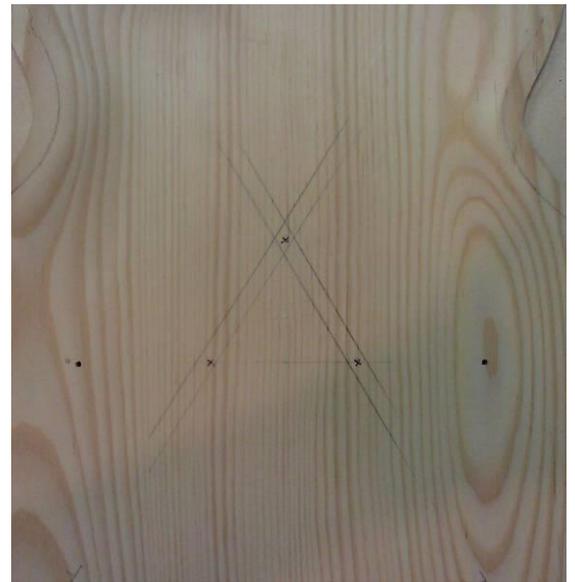


Each of the braces was fit individually. Laying out the half-lap (or box joint) for the intersection of the braces was not too difficult.



Lay each brace in position and trace the edges to the plate surface with a sharp pencil.

Then, mark these intersection points on each brace and transfer across the width using a square.



Using a razor saw and very sharp chisel, the bass brace is notched leaving $\frac{1}{4}$ " of material at the plate surface. The treble brace gets a $\frac{1}{4}$ " notch to complete the joint. This was not too fussy to get a good fit.

Completed GOM box joint...





With the box joint completed, we can use the brace fitting jig upside down as a clamping caul, dropped in the same alignment blocks screwed to the carving cradle. The jig arm clamps on one brace, and a second notched arm bridges the jig and presses on the other brace.

The clamping pressure was just enough to get some glue squeeze out, and too much enthusiasm causes the plate to distort. An 8 pound weight ensures we have some pressure on the very center of the joint.

After curing overnight, I could start carving the braces down. The original brace stock is $\frac{3}{4}$ " tall, and the thickest part of the braces will be at the box joint, about $\frac{1}{2}$ " tall. The braces are tapered to about $\frac{1}{8}$ " at the ends. I carved with a very sharp chisel, tapped and carved some more to get a feel for how much the tone changed as the material was removed. Final shaping was with sandpaper, finishing with 220 grit.



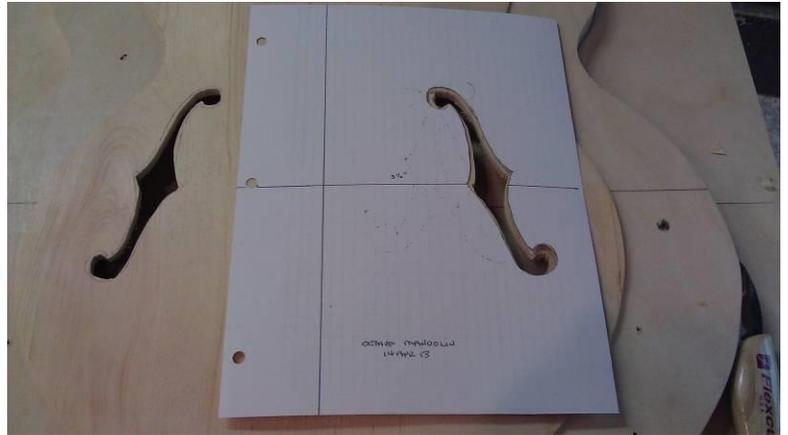
Here are the completed braces for the GOM. The braces are 0.520" tall at the box joint, and 0.350" tall at the bridge line. Below the GOM is on the left, and guitar on the right.



F-holes:

The f-hole design for the guitar is a compromise between the Ibanez AF95 and the shape from the Benedetto book. We created a template traced on graph paper from our drawing, then photocopied on to card stock. The template has center line and bridge line references for alignment on the plates

The GOM f-holes took a bit more work to design. Scaling at 90% of the guitar f-holes did not look correct, so several iterations were needed to refine the shape.



We have an inexpensive scroll saw that worked out well cutting out the f-holes. I drilled holes at the f-hole tips, then passed through the scroll saw blade and slowly cut out most of the waste – well inside the f-hole lines.

A very sharp FlexCut carving knife trimmed the remaining waste close to the layout lines.

The shape was refined with 100 grit sandpaper wrapped around the shaft of a screwdriver, followed by 150, completed with 220 grit.



Closing the Body:

The molds, frame from the carving cradle and the maple clamping fingers are used to close the body. The clamping fingers use 1-5/8" drywall screws driven into the mold faces.



First we screw the carving cradle frame to the mold.

Flipped over, we can then use the clamping fingers to glue the back plate to the sides.



Then we can turn the mold over to clean up any squeeze out with a damp rag.

[2nd] We apply waterborne polyurethane to the interior surfaces of the rims and back plate. The first coat raises the grain significantly and that is easily knocked back with 220 grit sandpaper. After wiping and vacuuming clean, a second coat of poly is applied. After waiting a few short minutes for the finish to get tacky, we can lay the labels on the finish.

After a few hours to cure, we can move the carving cradle frame to the other mold face and glue on the front.

The GOM front glue up worked well, except that we had too much squeeze out and some runs at the blocks. No way to wipe up through the f-holes. The guitar went smoother with no obvious runs from the front glue up.

[4th] Glue the pickup sensors at the **pickup sensors locations** before attaching the front plate.



The overhang of the plates was trimmed down on the sanding station. This takes significant intestinal fortitude since I was holding the body firmly while sanding down the overhang, and trying very hard to not touch the sides and cause a flat spot or scar. This went easier than expected, in spite of visions of the body getting caught by the belt and launched across the shop.

The photo above was from Number 8.

With the plates nearly trimmed to the sides, I followed with the 5" random orbital sander – 80 then 120 grits. Hand sanding with worn 120 discs in the grain direction yielded a really nice surface.

Here's the Guitar on left, Guitar Octave Mandolin on right...

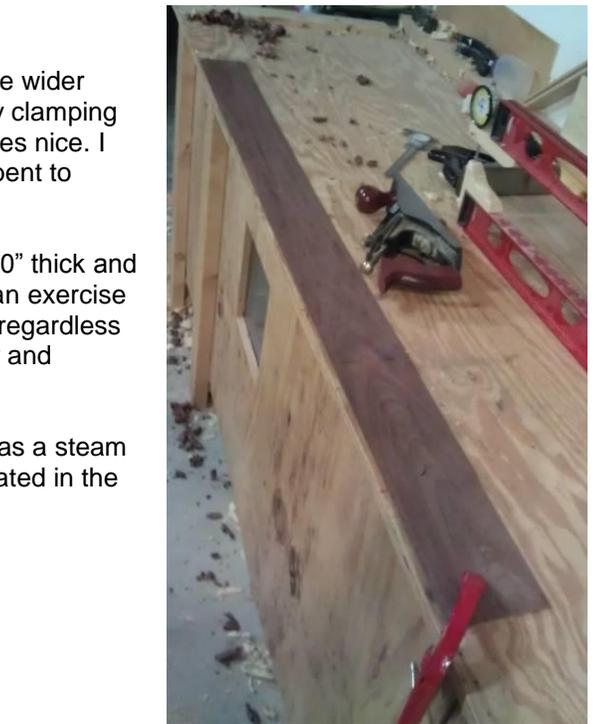


Binding – Milling and Pre-bending:

We will use ¼" wide solid walnut for the binding. Thinning the wider binding stock down from about 1/8" thick was easily done by clamping to the bench and using a hand plane. The walnut really planes nice. I need 8 pieces about 40" long to complete both bodies, pre-bent to conform to the rims.

The original attempt was to use binding strips 0.090" to 0.100" thick and bend on the hot pipe like we did the maple sides. This was an exercise in frustration. Each strip broke at some point in the bending regardless of how much heat was used, how much water or how slowly and carefully we moved.

So, we built a steamer using PVC pipe with our turkey fryer as a steam source. A section of scrap wood kept the binding strips elevated in the pipe.



Great idea. Should have worked. Steamed the binding strips for about an hour or even longer. Only one strip bent without breaking. Our second failure!

Using the walnut for binding was starting to feel hopeless. We started looking at plastic binding alternatives, but we really want the solid walnut for contrast, and to match the walnut already used in the neck and tail wedge, and later for the headstock overlay.

Most commercial bindings are typically closer to 0.060" thick. We made some more binding stock, thinning using hand planes to 0.060" to 0.070" thick.

Bending on the hot pipe went much better, and we only lost a few more due to breakage. The bent binding strips were clamped to the inside of the molds overnight to set the form.

Lessons Learned Regarding Solid Wood Binding:

- Thicker pieces break. Keep it to 0.060" or so.
- Make many more pieces of stock as you may need – some will break no matter what.
- If using purchased wood bindings, you better buy a lot more than you think you need.





[2nd] A simple jig for the bandsaw has made it much easier to rip down the 0.077" thick blanks into 1/4" wide strips. Ganged together, the edges can be scraped and sanded smooth, and then each binding strip is thinned between 0.060" to around 0.070" - the goal is 0.060 to match the outer binding channel.



Binding Channel:

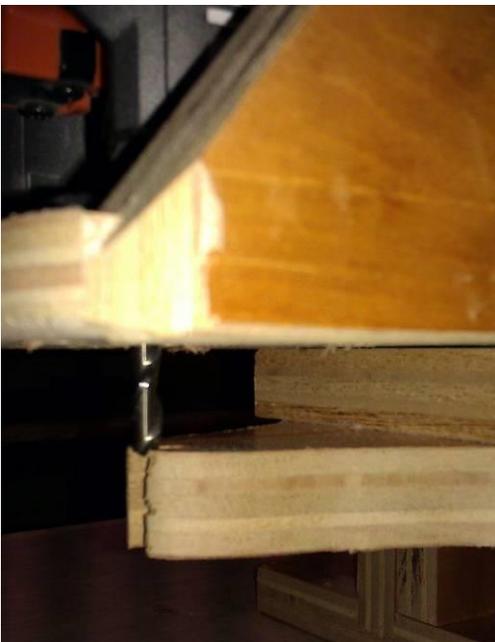
Another lesson learned: The thickness of the carved plates where they meet the sides varies from about 1/8" to 1/4". A typical tool or jig for cutting the binding channels would index from the plate surface, and the result would create a wandering appearance of the binding viewed from the sides. (Look for Dudenbostel mandolin binding jig web pages or YouTube for examples).

I first attempted to build a version of the StewMac jig that suspends the body in a cradle and uses an overhead mounted trim router for cutting. My cradle concept was good, but the execution was too sloppy, and it appeared that the body leveling and support would not be reliable. No photos here – trust me, it was not worth showing, and I did not try to use this first cradle jig attempt.



I realized that the carving cradle frames could be re-purposed again. They support the body from the plates very well, and the height of the upper edge of the sides was really pretty uniform. I recycled some clamping blocks from my first jig attempt – these have imbedded 1/4" x 20 threaded inserts and 1" 1/4" x 20 bolts with felt chair leg tips as padding. The body is held securely at five points.

I constructed a column and arm from scrap plywood to mount the trim router. The Ridgid trim router has a clear square base and LED light. Using the square base as a template, it was no trouble drilling for mounting the router to the supporting arm.



The cutter is a 1/4" carbide upcut mortising bit. A plywood edge guide with a round tip sets the depth of cut as it rubs along the sides. The depth of cut is set by covering most of the bit with the edge guide and securing with a bolt into a threaded insert.



I cut the guide length carefully so that the depth of cut can be measured at the back end of the support column. The width of the binding channel is set by adjusting the trim router.



To help with the setup for each channel I made some test blocks from sections of 2x4 lumber cut to the height from the plate surface down to the bench top.



Cutting the binding channels with this setup worked really well. The nominal channel dimensions are $\frac{1}{4}$ " wide and 0.050" deep. The channel width we used removed about $\frac{1}{8}$ " from the rims, and the portion trimmed from the front or back plate varied as the plate thickness varied at the edge.

After cutting the binding channel for both front and back edges, we changed the setup to cut a 0.080" wide by 0.035" deep channel matching the purfling dimensions on the front plate only. The purfling is black-white-black fiber from LMI.

Some refining was needed in the waist curves using knives and chisel.



[2nd] We purchased the StewMac binding cutter set and install in the trim router. The setup is easier, and the guide arm in the original version of the fixture tended to leave rub marks on the sides.

The binding was glued in with Titebond. We started with the front since it was harder to wrestle both the purfling and binding strips together. This was definitely a four-hand job. Dianne prepared strips of 3/4" wide 3M medium tack blue masking tape about 3" long and handed them over as we progressed.

The carving cradle with the clamping blocks, clamped to the bench, worked well to hold the body securely while we installed the binding.

The non-cutaway walnut strip was taped in place at the waist and held tightly in the channel down to the tailblock. A few strokes with a knife at the center line cut the strip to length. The purfling strip is long enough to do the whole body and we marked the mid-point with a pencil.

We cut down a flux brush to create a tip close to the channel dimensions and used it to brush glue into about 3" of the channel at the tailblock, and a little on the purfling and binding. We slipped them into the matching channels and taped. This takes some finesse to guide the purfling without twisting and to push the binding tightly into the channel to minimize gaps.

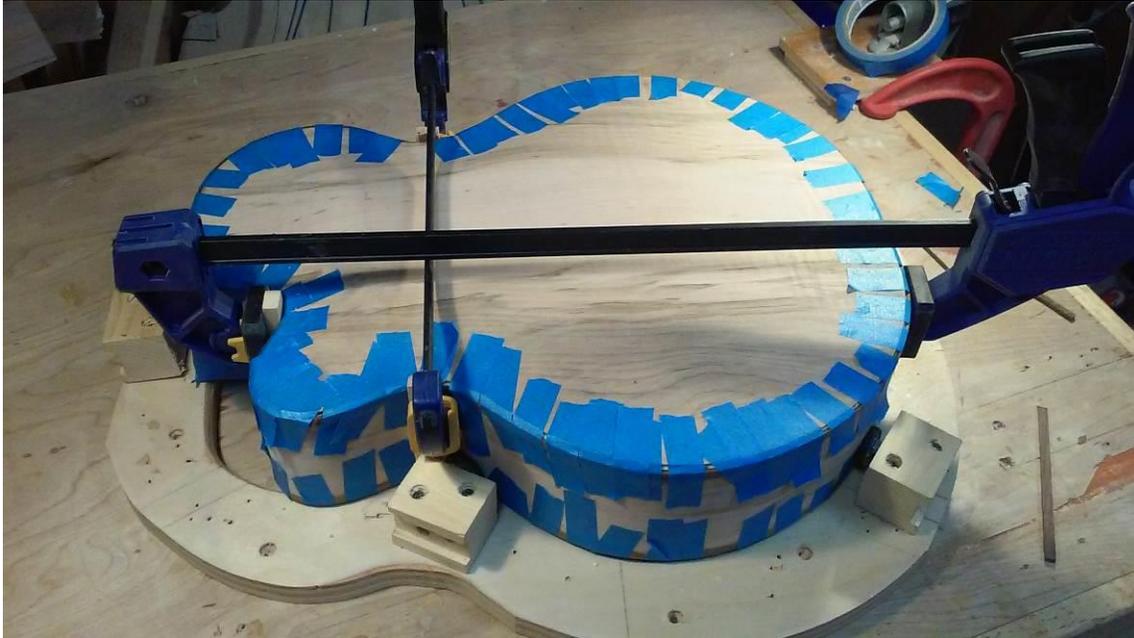
Working about 3" at a time we glued and taped the strips in until we reached the neck block, and then trimmed with a knife again. Then we installed the cutaway side binding.

After completing the front binding we flipped the body over and bound the back edges. This was a lot easier after wrestling the two strips on the front edge.

After an hour or so, I removed the tape using a hair dryer to warm it first. This was to loosen the tape glue and minimize any tear out from the spruce front plate.



[4th] We have had problems with keeping the binding and purfling tight in the inside curves at the waist and cutaway. Some clamps and cauls provide some pressure to keep the binding tight.



We allowed the binding to cure overnight. I scraped and then sanded the plate surfaces flush to the binding (or the binding to the plate depending on how it overlaps) using a random orbital sander with 80 then 220 grit. The sides were sanded the same way. This was quite a bit of work since there was lots of glue squeezed out and smeared on the sides.

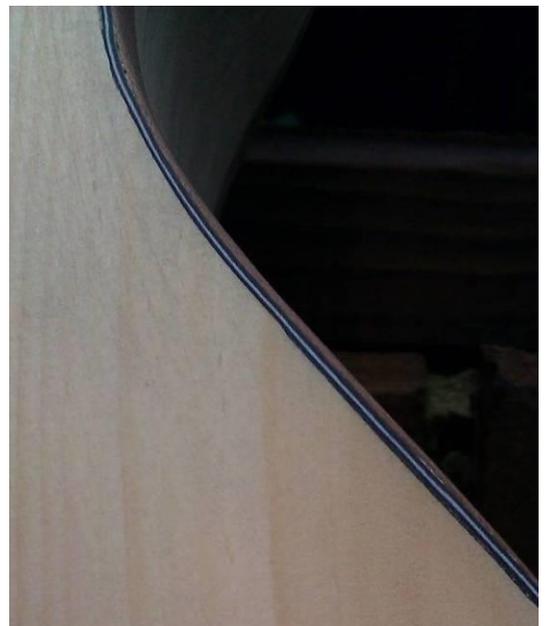
I hand sanded all the surfaces with the wood grain to 220 grit. This left a nice smooth surface.



It is tricky to keep the walnut binding the same thickness as viewed from the plate edges, and some areas ended up far thinner than we wanted. But hey, we're learning!



The bodies are basically done!



Neck

Neck Blank

Headstock and Heel Block

Dovetail Joint

Fingerboard Extension

Headstock Plate

Fingerboard and Frets

Neck Shaping

Final Fitting

Neck Billet and Blank:

I expect that a laminated neck is more likely to stay straight and resist string pull better, especially using red maple rather than hard maple. Since we are building two guitars, I am trying a "billet" lamination – I have not seen this way of doing it online, but really hope this works out! ([5th] It does, really well!)

The billet is laminated from five pieces 3-1/2" wide and 36" long:

3/4" Maple
1/8" Walnut
1/2" Maple
1/8" Walnut
3/4" Maple

The billet stacks to 2-1/4" thick. Here's the glue up, using our homemade miter saw aluminum extension fence as a clamping caul.

[4th] We now use thinner walnut sections, basically the same thickness as the rims:

	<u>Guitar</u>	<u>GOM</u>
Maple	0.750"	0.750"
Walnut	0.075"	0.075"
Maple	0.620"	0.500"
Walnut	0.075"	0.075"
Maple	0.750"	0.750"



Ripping it down yields two 7/8" thick boards for the main neck length, 1/2" thick boards for the headstock and neck extension and two 3" blocks for the neck heel.

Assembling the pieces required a cutting sled for the 14 degree headstock angle since this cut cannot be made safely on our miter saw. We a nice straight section of 2x lumber ripped to ensure the edge was square ,fastened to an old varnished kitchen cabinet door. The sled has a strip on the bottom that glides snugly in the miter slot of the table saw.

The 7/8" neck shaft section was cut first at 14 degrees, then the 1/2" headstock was cut in the same way except the "down" edge was reversed. Cut to 8" length yields the headstock section, which is then flipped around and over for gluing so that the wood grain matches.

We used the sled as a support for gluing the headstock and heel block to the neck section.

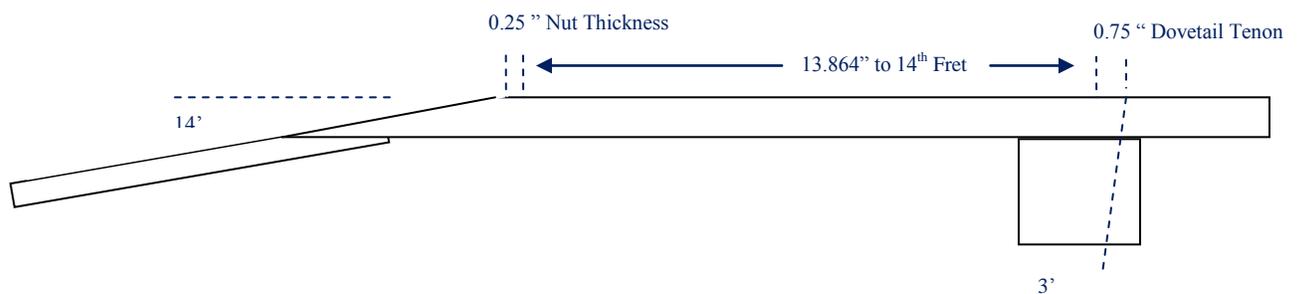




The location for the heel block was found by using:

$\frac{1}{4}$ " Nut blank thickness + 14th fret distance from nut + $\frac{3}{4}$ " dovetail tenon thickness

The fret distances for the 25" guitar and 23.5" octave mandolin scale lengths are in Appendix A.



The neck dovetail angle will be 3 degrees, which should give a 1" string height above the peak of the front arch at the bridge line. (See alignment tests below).

[5th] The neck angle needed can vary depending on the carved front plate arch, leaving room for a neck humbucker pickup, etc. The goal is to have a 1 inch bridge height in most cases.



We selected a truss rod from LMI for the neck. These are dual action and can adjust to keep the neck straight against string tension, or even correct a back bow. The truss rods install in a $\frac{1}{4}$ " wide by $\frac{3}{8}$ " deep slot cut in the center of the neck. I used a dado blade on the table saw to mill the slot.

The instructions on the LMI web site and YouTube video are very clear. As expected, the welding burrs at the ends needed filing to fit the slot



I also did the basic layout for the $\frac{1}{2}$ " thick neck extension stock. The neck extension will glue into a $\frac{3}{4}$ " wide x $\frac{1}{2}$ " deep rabbet cut after the dovetail is cut and fitted. I rough cut the stock at 4.25" and will trim them later. I am pre-cutting a truss rod slot in the extension since the truss rod will extend into the extension. Then I will fill the slot with a $\frac{1}{4}$ " thick spacer to provide a positive stop for the truss rod.



Neck Alignment:

We need a jig to cut the neck dovetail tenon. The neck joint geometry is critical to the correct setup later. Since the joinery needs to be precise, and this is our first build, we made some dummy necks out of shop scraps to practice and setup the cuts.



The neck angle to the body should result in a bridge height of around 1". Our design used a neck angle of 4.5 degrees. We cut our dummy necks using a 10" chop saw and set up some blocks and clamps to test the alignment.

With the 4.5 degree angle the bridge height is 1-3/8". Far too high, so the neck angle needs to be reduced.



A neck angle of 3 degrees works well. The bridge height is close to 1". There should be enough room for the neck mounted pickup on the guitar.

The center line of the neck must align with the centerline of the body.

The guitar neck aligns really well to the body centerline (right).

The GOM neck did not line up, so that means that the neck block did not end up perpendicular to the body centerline. We checked for this alignment when we glued on the plates, but obviously we missed something. We will fix this while fitting neck dovetail.

[5th] One critical factor is to ensure that the body mold area where the neck block rests is square to the center line. We reworked our molds by carefully cutting the neck and tail section square on the table saw, and then blending the cuts into the curve of the upper and lower bouts. This took care of the mis-alignment we found on the prototype GOM and haven't had a problem since, though we still watch this carefully.



[3rd] For building Number 4 (Englemann – Walnut – Curly Red Maple Guitar) and Number 5 (Englemann – Curly Red Maple GOM) I assembled a simple neck angle gage to have more precise control over the final bridge height.



The gage is constructed from 1.5" thick walnut. The two arms are connected by a simple lap joint and a screw.

Two wood screws set the height for the overstand (thickness of the neck extension) and the height of the bridge relative to the plane of the neck without the fretboard.

Lines on the gage arm show the expected height of the strings, including the fretboard, frets and height of the strings above the frets. Here the bridge screw is in the

location for the guitar. It extends $\frac{1}{2}$ inch below the gage arm and the lines on the gage arm end up at 1" for the bridge height.

The goal is to have a 1" total bridge height. With the screws set for the $\frac{1}{2}$ " overstand and $\frac{1}{2}$ " for the bridge base, the arm can be adjusted so that the screws are flush with the top, and the side section flush with the neck block portion of the sides. Tightening the screw at the lap joint locks the angle well enough to use the gage to set the neck angle on the miter saw.

With the Englemann spruce tops, the neck angles turn out to be 3.5 degrees for the GOM and 3.0 degrees for the guitar for a total bridge height of 1".

This gage worked especially well at eliminating the trial-and-error neck angles using dummy necks.

[5] A set of angle gages made from shop scraps has made it easier to monitor the area of the front plate above the neck block and guide the shaping of the plate to match the intended neck angle. The top arm is 0.5" thick – the same as our neck extension, and marked where the neck block will end. This one is for 4.5 degrees for Number 7 – the higher neck angle needed to provide clearance for a surface mounted full humbucker.





The neck angle gage has been modified to allow for the humbucker pickup.

The humbucker is a Golden Age neck pickup from Stew-Mac. The pickup comes with standard base tabs and the polepiece screws are extra long. This makes the pickup too tall for mounting on the front plate at the end of the neck (without cutting a big hole). The pickup was modified using a metal cutting disc in a Dremel – the base plate legs and extra polepiece screw lengths were chopped off. (We filed the nubs cleaner after this photo).



A hole through the front plate allows for the pickup cable to pass into the body.

Note I messed up the location and had to fill a hole with a piece of spruce! Measure twice!

The balance of the humbucker installation is shown here: [Humbucker](#).

Neck Dovetail Tenon Jig:

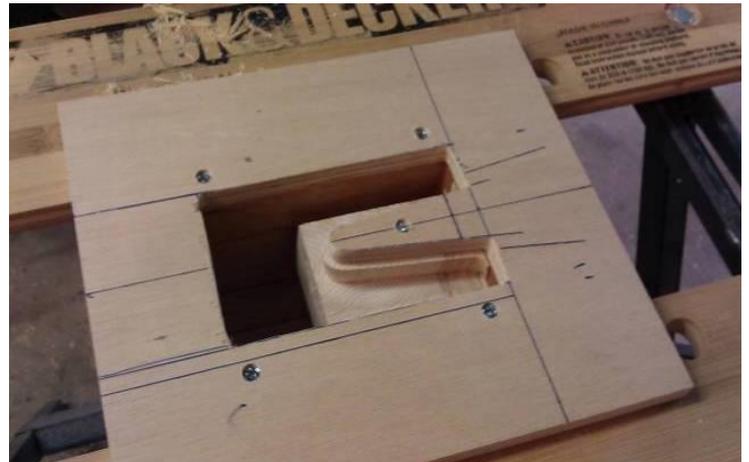
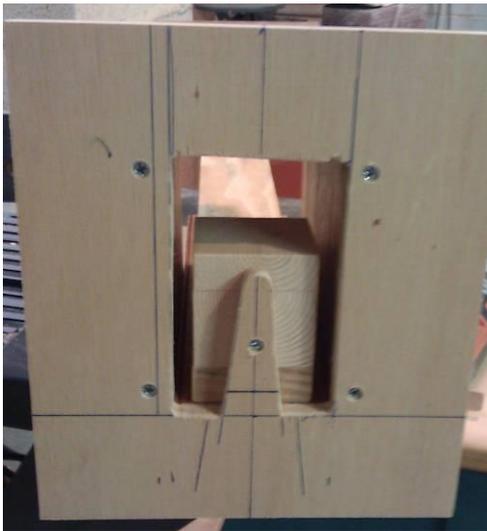
The neck is milled with a dovetail tenon, and a matching dovetail mortise is cut into the body neck block. The neck tenon router template was created first, then the mortise template was cut to match it.



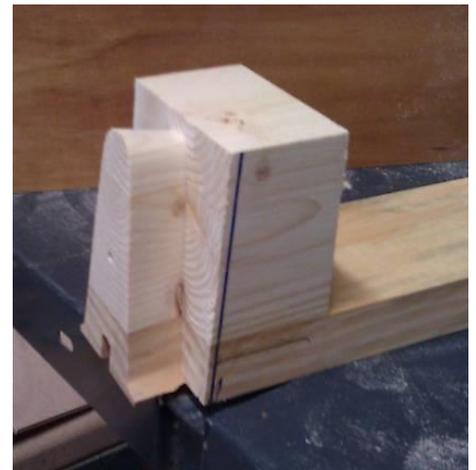
The neck dovetail jig is basically a box. One side is mounted at the 3 degree angle and has a 1/4" dado to hold alignment tabs. The alignment tabs fit into the truss rod groove and ensure that the tenon is milled on the neck centerline.

The dovetail dimensions were selected to fit within the width of the GOM neck at the body joint . The dovetail is about 1" at the widest.

We made a 1/2" plywood template for a 3/4" dovetail bit and a 1/2" guide installed in the router. A small screw locks the neck heel tight to the template.



[5th] Tapered shims are used to make sure the heel section is tight against the template when the neck angle is more than 3 degrees.



Body Dovetail Mortise Jig:

The matching mortise was developed by first tracing the neck tenon template to a section of $\frac{1}{2}$ " plywood. I drew guide lines wider than the tenon template tracing to account for the width of the router guide. I made test cuts in a section of lumber, tested the fit using the dummy neck, and used a rasp to enlarge the template slot.



It is tricky to estimate how much to modify the slot when testing with the dummy neck because you cannot see the interior surfaces. I mounted a section of $\frac{3}{4}$ " plywood in the neck tenon jig and milled with the router to create a section representing the dovetail tenon only. This makes it much easier to see how the tenon and mortise fit together and where to enlarge the slot for proper fit to the tenon.

The goal is to have a mortise slightly undersized so that the neck tenon does not fully drop into the mortise. This allows for final fitting into the guitar body by shaving the tenon and adjusting the neck alignment to the body. It took a couple of tries to get the optimal match to the tenon.

With the template ready, we need a fixture to hold the body firmly aligned with plane of the front plate and centerline of the body. We used padded carriage bolts to fix the body position and clamps to ensure it doesn't slip during routing.



After cutting the dovetail tenon and mortise, we need to make a 1.5" long by 1/2" deep rabbet to form the pocket for the neck extension. I used the table saw and a dado blade with pretty good results

Here's the guitar neck in the body. The tenon is sitting proud of the top plate about 1/8", and you can see the rabbet for the extension.



Headstock Templates:

The headstock templates were cut from 1/4" plywood and the shape and tuner locations refined. The headstocks are the same size – just the width at the nut is different. This headstock design is intended to be the smallest practical size and to achieve a straighter string path from the nut to tuners than the typical jazz guitar headstock provides.

The Gotoh guitar tuners need 10 mm holes, and our 3/8" drill bit is close. The tuners fit in the holes with just a little bit of tweaking with a round rasp. Our 5/16" drill bit has enough run out that the mandolin tuner bushings fit well without tweaking. The post to post spacing for the plate mounted mandolin tuners is 0.92" (23 mm), so the holes must be carefully placed in order for the posts to not bind after installation. The tuning machines are inserted into each template to ensure there are not any problems with the tuner to tuner clearances and to the headstock edge.

With the headstock templates completed we could trim the neck blank headstock to length.

Overall, the octave mandolin template shape looks better so we'll use that for the final shaping of the headstocks.



Neck Rough Cut Out:



I drew some layout marks on the necks to establish the width and overall thickness:

	Width		Thickness	
	<u>at nut</u>	<u>at 11th fret</u>	<u>at 1st fret</u>	<u>at 11th fret</u>
Guitar	1.70"	2.00"	0.50"	0.75"
GOM	1.40"	1.70"	0.50"	0.75"

I used a dovetail saw and the bandsaw to trim down the width of the necks and the extension sections. Our bandsaw is an inexpensive Ryobi. It did fine for the 7/8" thick portion of the neck shaft, but wandered too much when cutting the heel section. I cut well outside the line, and another method is needed to cut this part cleanly.

I reused the sled for the headstock angle, using the existing guide that rides on the saw slot and attaching some blocks to hold some of the fingers from the body assembly. With the neck firmly fastened on the sled I could use the table saw to clean up most of the heel sides. I finished the cut by hand with a dovetail saw.



Fitting Neck to Body:

With the rough width at the heel established, we can trim the neck dovetail tenon so that the neck fits correctly.

The above sentence was easy to write. Actually fitting the neck to the body was not! The neck needs to stay on centerline to the body, we want the fingerboard to end up in the same plane as the front plate, and we need a nice snug fit tight to the body for maximum strength. Trimming the tenon is like backing up a trailer with a truck – you cut the opposite way than your instincts tell you!



I also had to trim where the heel meets the body on the octave mandolin since the neck block ended up off-square to the centerline. Working slowly, this turned out mostly good, except the fingerboard is tilted toward the bass side slightly. I could not get the fit tight and keep the fingerboard surface parallel to the front plate. Probably ended up close enough – we'll find out later when we string it in the white. (Yep, worked out fine!)



[4th] Note that we do not use glue for the final attachment of the neck. The dovetail joint is pretty secure and holds the neck pretty well for handling in the white. We use a 8 x 2.5" screw through a strap pin to lock the joint in place, and this allow for disassembly for finishing and for the eventual service in the future. Some details here [Neck Dovetail Screw](#)

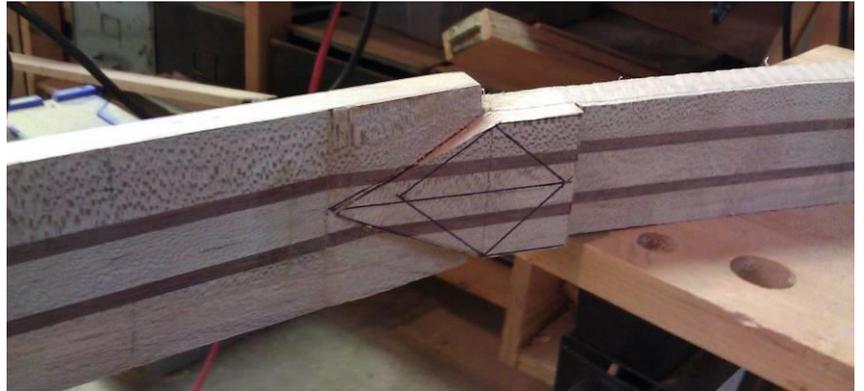
Roughing in Neck Volute:

We are incorporating a volute where the headstock meets the neck with the idea that the extra material will help strengthen this weakest section of the neck.

After laying out with markers, we can rough out the volute by hand with a dovetail saw.

We started on the headstock section. The first cut follows the volute lines.

Then we cut the waste away following the thickness of the headstock.



Next we do similar cuts to remove the neck section waste.

Here's how it turned out. This will be shaped, carved and blended into the neck later.

[2nd] We have given up on volutes! The execution is a challenge and we have not been able to achieve a pleasing look. Also, we like using a Paige style capo that can park above the nut when not in use, and the volute gets in the way.

Headstock Ears:

We need some small ears added to the headstock to provide the width needed for our design. We saved the off-cuts from trimming the headstock to length, so we trimmed off the maple edge bits. These should be a really good match for the main headstock.



A simple clamp arrangement and some wax paper worked well.

Fitting the Neck Extension:

The underside of the neck extensions need to be carved to match the arching of the front plate. We clamped the extension into the neck rabbet, then inserted the neck into the body mortise until the extension touched the front plate. Setting a compass to the widest gap, we can scribe both sides of the extension to guide the carving. (No pictures here).

Clamped upside down on the bench, we carved the waste away using chisel and gouges until the neck fit fully into the body mortise. You carve away the areas that touch the front plate, and the neck drops further into the mortise until the next area touches. This takes some time – carve a little, test fit, carve some more.



Once we had a decent fit, we glued the extension to the neck. We used a section of $\frac{1}{4}$ " thick maple wrapped with wax paper in the truss rod slot(s) to keep the extension in line with the rest of the neck.

[5th] We now leave extra material on the front plate to carve and match the neck angle, so the bottom of the extension needs very little carving to get a good fit to the front plate

Headstock Veneer (Headplate):

The headstock veneer, or headplate, provides a decorative feature while also adding strength to the headstock joint.

We used 1/8" thick walnut sections set aside when we were cutting for the neck billet. These have an attractive "cathedral" grain pattern. A simple paper template with a cutout for the headstock shape helps line up the walnut grain patterns. We included a 1/4" wide by 1.75" long slot for the truss rod access. We will make a matching truss rod cover later.

I used an off-cut from the neck headstock angle to trim the nut end of the headplate so that it will join correctly with the nut. I removed most of the waste with a chisel, then fine tuned it with 100 grit sandpaper as shown

We glued the headplates to the necks, careful to watch the centerline, and lining up on what will become the nut slot.

After the glue cures overnight we can trace the headstock template and cut out using a hand jigsaw.



[3rd] For building Number 4 forward, I gave in to pressure from friends and came up with a logo inlay for the headplates.

This is created by tracing the design onto the headplate, then routing out a pocket with a Dremel and a 1/16" downcut inlay bit, following the letter design.

Small bits of 0.060" thick ivoroid binding are cut and shaped with a chisel, then superglued into the pocket. Walnut filler closes the gaps.

After sanding the inlay flush, we used ebony grain filler to provide an nice flat surface for finishing.

[5th] Note that we have modified the headplate to have just a rectangular hole for truss rod access. This allows us to use two small brass screws to attach the truss rod cover.

Fingerboard (Fretboard):

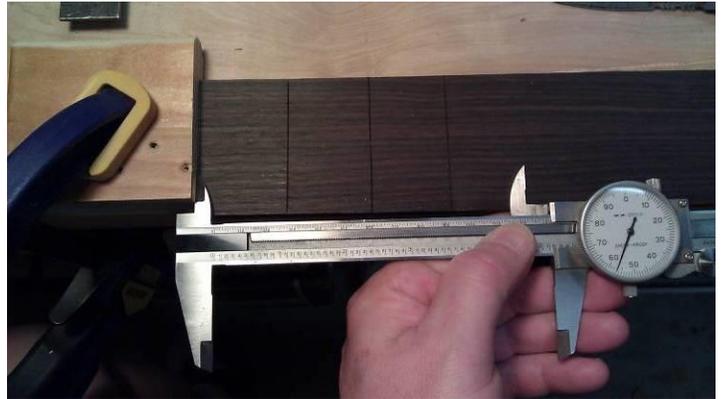
The fingerboards will be Macassar Ebony from LMI. These are “standard first grade” with a nice dark chocolate color and some interesting stripe figure. The blanks are about 5/16” thick and about 2-3/4” wide.

I ripped them on the table saw to clean up the edges and remove extra material – 2.250” for the guitar, and 2.125” for the octave mandolin. The nut end was cut square on our chop saw.

We need to lay out the fret slots. The fret slot measurements were determined using an online calculator from StewMac and are in Appendix A. It is important to measure these very carefully! We will measure from the nut end each time to reduce the chance of measurement errors stacking up as we progress down the neck.

There are several ways to lay out these measurements. We did not want to purchase the StewMac templates since the 23.5” scale of the octave mandolin means we have to measure anyway. Here’s how we did it:

We clamped a scrap block at the nut end. We have a 6” caliper gage that reads in 0.001”, so we can measure the first few slots from this nut block.



We used an “old school” method for marking and striking the fret slots.

Make a mark with a sharp knife at the measured location.



Set the knife in the mark and slide a square tight to the knife. Hold the square tight and strike across the fretboard to mark the width. These knife marks can provide a place for the fret saw to catch and help with accuracy when sawing.



Our caliper is only 6", and we need to keep measuring from the nut. We are past the 6" distance after the 4th fret on the guitar, and the 5th fret on the octave mandolin.

We clamped a precision 6" rule tight against the nut block, and measured from there.



When we got past 12", replace the 6" rule with a 12" rule.

With the layout completed, we need a jig to guide the saw. The LMI fret saw has two holes in it. I cut a 1/2" thick piece of plywood 0.560" wide. This will fit tight against the spine of the saw and function as a depth stop for sawing the slots.

We constructed a frame from scrap plywood to hold the fingerboards and guide the saw. A clamp at the end was enough to keep the fingerboard in position during sawing. A section of plywood above the fingerboard keeps it snug to the jig base and provides a guide to keep the saw square while sawing.



The fingerboards need a 12" radius. We used a block purchased from LMI with a 12" radius on one side (and a 10" on the other). We glued on a ¼ sheets of 100 grit sandpaper using a couple of shots of 3M Super77 adhesive.

Two scrap strips were screwed to the bench to guide the block. We clamped the fingerboard on the centerline and slid the block back and forth to sand in the radius. This was a lot of work, and I wore a dust mask to avoid breathing the ebony dust. I went through at least 3 full sheets of 100 grit to complete the full boards. Pencil marks on the fingerboard surface help to show when the entire surface was sanded to the radius. 150 and 220 grit sandpaper completed the surface.



Sanding the radius generated a good pile of ebony dust. I collected it into a cup for later use as filler.

After cleaning the sawdust out of the slots with a knife, we can use the saw and attached depth guide to re-cut the fret slots following the radius.

The centerline and width dimensions for each fingerboard can now be marked, and then trimmed oversize using the other edge of the headstock angle sled as a guide.



Installing Inlays:

For these prototypes we are following the modern jazz archtop tradition and not using any inlays in the fingerboard.

[3rd] For Number 4 (walnut guitar), Number 5 (GOM) and Number 6 (cherry guitar) the clients preferred to have some inlaid fretboard markers. We are using small 4 mm pearloid dots superglued into shallow holes, then sanded flush to the fretboard before gluing the fretboard to the neck.



Neck Assembly:

With the headplate and neck extension installed, we can sand the surface flat and prepare to glue on the fingerboard.

After verifying that the truss rod is adjusted straight by laying on our flat tablesaw top, the truss rod is inserted without glue.



[2nd] We now use a small amount of clear silicone caulk at the ends of the truss to minimize the risk of rattling.



Note the maple filler strip glued in to function as a stop for the truss rod

The glue will let the fingerboard slide around when clamped. Prior to gluing, small 1/16" holes are drilled through the fret slots at the 1st and 14th frets for small brads. These will lock the fingerboard in place during clamping.



Titebond glue is brushed on the neck surface, being careful to not get any on the truss rod.

Both the neck blanks and fingerboards are pretty straight, so we did not use a clamping caul to force things. The brads kept the fingerboard neatly in place and aligned during clamping.

After curing overnight we can pull out the brads and clean up the sides of the neck and the headstock profile on the sanding station. We are leaving the back of the neck flat to help keep it stable during fretting.

The fingerboard blanks were 5/16" thick and they are thicker than the usual 1/4" thick fingerboard after sanding the 12" radius. We have unbleached bone nut blanks from LMI and they are not quite tall enough to provide the proper string height above the fingerboard after fretting. We glued a leftover piece of walnut binding as a shim at the bottom of the 1/4" wide nut slot (the gap between the headplate and fingerboard end). I think this also dresses up the appearance of the truss rod pocket.

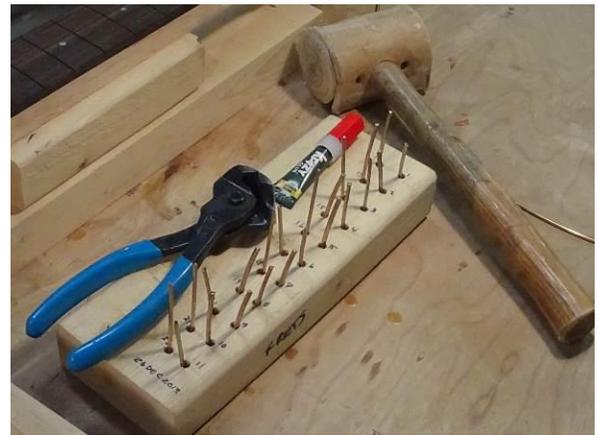
I also glued pieces of leftover walnut on the end of the heel to dress it up, and cut couple of 2" long by 5/8" wide walnut strips to make the truss rod covers.



Installing Frets:



To prepare for fret installation, I first lightly chamfered the fret slots with a needle file to ensure that they guided in straight.



We purchased the fret nippers from LMI. These are basically heavy wire cutters with the faces ground flat. These worked great for cutting the fret wire.

A simple block with holes for 22 frets is a handy way to organize the rough cut fret chunks, each cut just a bit wider than the fretboard width.



The fret wire came in a loose coil and did not need any fancy bending to conform to the 12" fingerboard radius.

After a bit of thin super glue is swiped into the slot, I pressed the frets in by hand to start, then used a leather mallet to drive them tight to the board. The neck is supported by a couple pieces of framing lumber, and since the back of the neck is still flat it was very stable when tapping in the frets. Overall, this was far easier and faster than I expected.

After all the frets were in place the ends were clipped tight to the fingerboard with the nippers. Then a large fine mill file knocked the sharp points flush to the fingerboard edges.



Installing Side Dots:

Ebony dust mixed with Titebond filled the small gaps at the bottom of the fret slots.



We are not using any inlay on the fingerboards for the prototypes, but we do need fret markers on the bass side of the neck. We purchased 1/16" diameter white plastic rod from StewMac.

Installation is simple – drill a small hole, insert with superglue and trim with the fret nippers. These side dots are common to almost all guitars and mandolin family instruments. The conventional positions are frets 3, 5, 7, 9, double dots at 12, 15, 17 and 19.

The octave mandolin will follow the mandolin convention of having the dot at the 10th fret instead of the 9th.

Here's how things look now:



Shaping the Neck:

With the frets installed, we can turn our attention to the back of the neck. When developing the drawings I used a pattern gage to copy the profiles of the neck on my Taylor 810 and the Ibanez AF95. The Taylor is a dreadnought from 1990, and this is a slim profile neck about 1-11/16" wide at the nut. This is my ideal neck shape! The Ibanez is a little chunkier than the Taylor. (Photo of template on next page).

The LMI truss rod sits in a 3/8" deep groove, so the target thickness for the maple part of the neck at the nut is 1/2". Any thinner and we risk exposing the truss rod from the back. The neck thickens to about 3/4" at the 11th fret. The necks have already been rough cut and flattened at the back to these dimensions and it seemed to make the carving easier to visualize.



We built a simple support from framing lumber to hold the neck for carving - just a 2x8 with a dado cut on one edge to keep the neck from rocking and clamped in a Workmate. I used a wedge leftover from cutting the dummy headstock joints as a support for the headstock during sanding. Blue painters tape on the fingerboard protects the frets while carving the back of the neck.

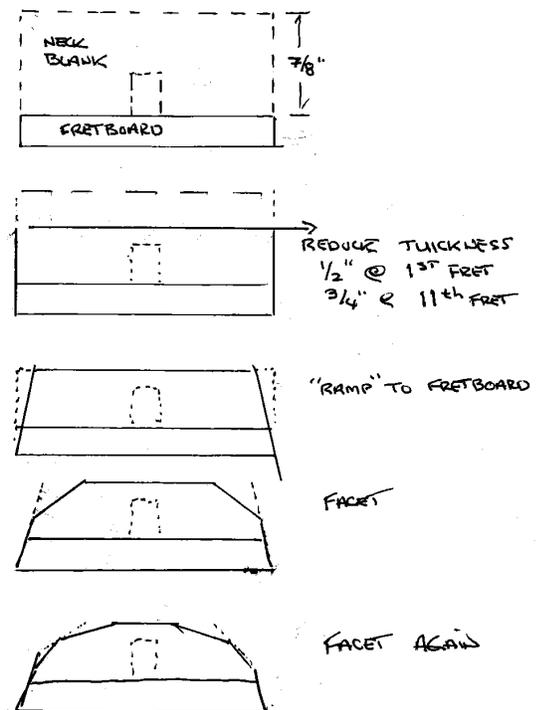
Our build sequence so far has the neck flattened on the back and sanded to width. This helps when installing the frets because the flat surface provides for a solid support when hammering. (Many builders will bind and install the frets into the fretboard before gluing to the neck, but this sequence is easier and demands less precision in fabricating the fretboard).

I used a Surform rasp to remove the bulk of the material on the neck shaft. This was faster than I imagined. The rasp was easy to control and predictable and it was not hard to see the neck shape.

The basic idea is to establish the neck thickness along the length, followed by carving a series of facets until the desired profile is roughly defined.

With the faceted profile close to finished shape, we switched to 60 grit on a 5" random orbit sander and refined the neck curves, removing from the clamps frequently to check the feel.

The heel area was trickier to get at with the rasp or sander, and a regular "four-in-hand" rasp worked better there.



[5th] Here are some photos of the neck carve for Number 7:



A small combo square set to $\frac{1}{2}$ " can ride on the flat neck spine surface and guide carving the thickness to $\frac{1}{2}$ " at the 1st fret and $\frac{3}{4}$ " at about the 11th fret.

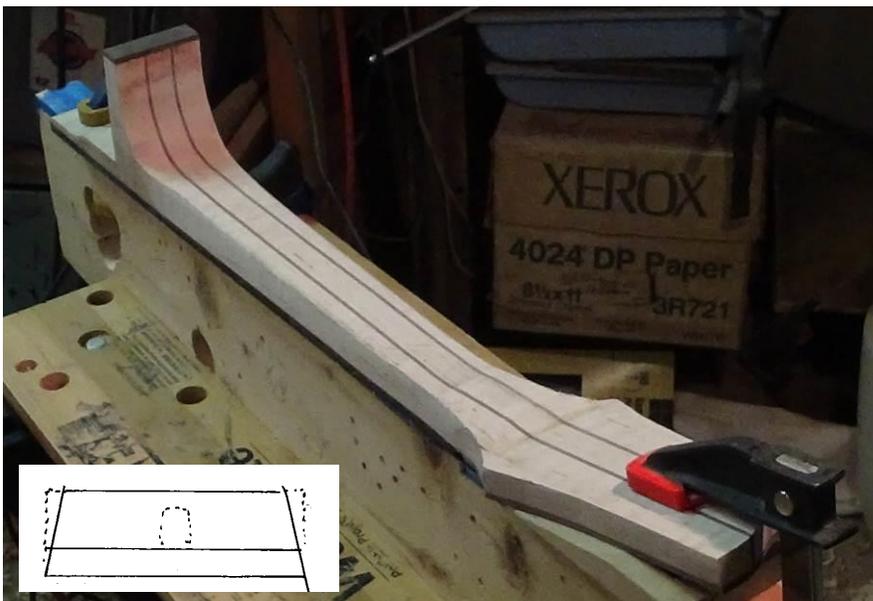
It's very important that we do not make the neck shaft less than $\frac{1}{2}$ " thick to avoid exposing the truss rod slot!



A Surform rasp makes pretty quick work of bringing the thickness down.



Knock the corners down using the rasp to leave less material for the next step...



60 grit in the 5" ROS sander to "ramp" the neck flanks from the fretboard edge to the still flat spine.



Facet the profile again with the Surform rasp.



A regular half round wood rasp is good for blending the facets and completing the rough shaping.



Ready for the ROS. A 4-in-hand rasp is good for shaping the heel profile.

We will worry over the neck to headstock transition (the volute area) later.



Use the neck cross-section template to check the shape as the sanding progresses.

The template made to match the Taylor neck has profiles for the 1st, 4th, 8th and 11th fret locations. The fret 11 profile is not really usable due to the difference in the heel profile.

Ready for hardware!



Bridge and Tailpiece

Tailpiece Block

Bridge Fabrication

Fitting Bridge

Milling Ebony:

The raw material for the tailpiece and bridge was a block of West African ebony from LMI, second grade, approximately 8" long, 3.5" wide and 1.5" thick. It is close to quarter-sawn on the thickness, and the long edges were very rough sawn. Cleaned up the edges on the table saw, then ripped a 0.580 thick strip for the bridge base, and a 0.375" strip for the tailpiece and bridge saddle.



A plywood fixture was constructed for milling these small ebony parts using the trim router. Two rails guide the square base of the router.

A removable plywood "deck" provides a way to securely fasten the small parts and align them with the router bit path. The entire fixture is clamped to the workmate to keep it steady.

The trim router accepts 1/4" shaft bits, so we can use different profiles for the various cuts to shape the ebony parts.

Each milling step had a setup using scrap blocks and small screws to align and lock the piece in. Here we are milling a recess at the back of the tailpiece string anchor to hide the ball ends of the strings.



Tailpiece Modifications:

The basic tailpieces were purchased from WDMusic, with a shorter version selected for the GOM. These come with brass bars for the string anchors, and we want to replace the bars with ebony to better match the other hardware, and provide for 8 strings on the GOM.



Here is the shorter tailpiece disassembled. The brass string anchor bar will be set aside.

The anchor bars are secured with threaded caps, so it is simple to remove and replace them with a 1/2" thick section of ebony. 9/64" through holes accept the anchor rod(s), and 3/32" holes allow the ball end strings to pass through and guide the strings to the bridge.

A groove was cut at the tail block end of the anchor bar to recess the ball ends. The GOM will use ball end strings purchased as bulk packs and not the traditional loop end strings.

Bridge:

We are using the same bridge design for both instruments. These are floating bridges, not glued to the top, and held in place by string pressure. The bridge parts are milled out of the same ebony block as the tailpiece.

The bridge base is 5" long, 0.580" wide and 0.400" tall. The saddle support posts are 3.0" apart to match the spread of the x-braces.

The holes for the support posts holes are 9/64" diameter through-holes, then threaded with a 4 x 0.7 mm tap. We purchased a very inexpensive metric tap set from Harbor Freight just to get the tap and handle.



Next, we used the trim router fixture to mill a 1/4" notch, 2" long, creating the bridge feet.

A bevel was cut on both long edges with a bevel bit in the trim router.

The saddle is 3.750" long, 0.440" thick and 0.500" tall and has 5/32" blind holes to accept the support posts. Using a router bit and the router fixture, a 1/8" slanted slot is milled in the top of the saddle to hold a bone insert. This slant should help with intonation later, and the bone saddle should have a brighter tone and make it easier to swap out to adjust action and string spacing.

The saddle needs a notch at the ends for the thumbscrews. Turns out the depth of cut using the fret saw was just right, so I made several cuts and then removed the waste with a chisel.

I also carved away some material following the lines of the slot to dress up the look and reduce some mass. A light cut with a razor saw to define the end and then a chisel to carve the rest. It came as a surprise that the hard ebony carved so well with the chisel.



The sanding station and hand sanding worked well to finish the shaping. I sanded a radius on to the top of the tailpiece to soften the hard lines.

Here are the bridge components before and after fitting and carving.



Fitting the Bridge:

There are several sources on the web showing how to fit a mandolin bridge, with the best probably being from Frank Ford at frets.com. We mostly follow his methods. We want to complete most of the fitting now since we don't have to worry about scratching up the finish, and we want to test the instruments in the white. We will make any refinements needed after finishing.

The carving of the front plates is fairly flat, so we do not have too much work to conform to the arch.

Pencil rubbed on the feet will provide witness marks to track our progress towards a good fit.

Using 100 grit sandpaper taped to the front plate and covering the bridge location, we can rub the base back and forth along the centerline direction to shape the base to fit the front.



A slight hollow scraped with a pocket knife helps ensure a good fit without rocking. We can switch to finer grit sandpaper to refine the fit further.

Assembly in White

Fitting and Alignment

Cutting and Slotting Nut

Stringing Up

Install Tuning Machines:

The guitar tuning machines are high quality Gotoh 510 with black plastic buttons. These are expensive but worth it. I marked the tuner hole locations on the headstock using the template created previously. The tuner shafts need 10 mm holes, but our 3/8" brad point bit is pretty close. I used a pine backer board and the drill press to minimize tear out. A few strokes with a round rasp and the tuners slide in snugly. The Gotoh use threaded bushings installed from the front, and a small screw on the back to lock them in place.



The octave mandolin tuners are also good quality Gotoh, plate mounted with black buttons. I would have preferred mini guitar tuners but they may add more weight on the headstock and affect the balance of the instrument. Also, we likely do not have enough room for eight guitar tuners on our headstock design, and the Gotoh are not sold as sets of 8 (4 left and 4 right).

I used the headstock template to lay out the mandolin tuner holes. The Gotoh tuners install in 5/16" holes and our brad point bit makes a perfect fit. The bushings are press fit from the front, and there are small screws to attached the plate on the rear.

Neck Attachment:

We are using a screw to lock the necks in the dovetail. Glue would be preferred structurally, but we want to be able to assemble in the white to test these prototype instruments, and then disassemble to finish the body and neck separately.

Also, it is likely that we will make a new, wider neck for the guitar, so not using glue will make this much easier. (Yep, we made a new neck – much better!)

I drilled out the holes in strap pins to 11/64" on the drill press. Then 11/64" holes were drilled with a hand-held drill through the heel and tenon, keeping the alignment as centered and square as possible. (Could have done better here, but we're learning).



Clamping the neck in the body, we can feed through the hole in the heel to drill a 1/8" hole into the neck block, and then remove the neck to finish drilling through.

The neck is attached with an 8 x 2-1/2" brass screw through the strap button and neck heel, anchored into the neck block. The GOM neck feels very secure this way, but the guitar seems to have a very slight play to it. The guitar neck was the first dovetail I attempted to fit, so it does not surprise us that this is not as precise as the GOM. We'll see how things look during playing tests.

Bridge Height:

The unbleached bone saddle was cut to length with a razor saw and the ends radiused with sandpaper. It fits right into the 1/8" slot in the saddle without too much fuss. The top edge of the bone insert was sanded to the 12" radius using the same block we used to radius the fingerboard.

We can use a piece of scrap 1 x 3 to check the bridge height. The bridge is about 1/8" too high on the GOM, so we trimmed the top of the saddle down and also trimmed the bottom of the bone insert to keep the height above the saddle the same. The guitar was nearly identical.



Carving the String Nut:

There are several good sources online on how to cut and fit the nut. See the [Setup](#) section in the Finishing chapter for the details of our methods.

Most of the nut making process is not too difficult for me, but I have made quite a few guitar and mandolin nuts before so this was not as intimidating as it would be for some.

One neat trick is to use a sanded off pencil to mark the fret heights on to the face of the nut. This makes it easier to see how deep to cut the string slots.

Having some decent nut files is really important to get a good result!

The string spacing for the octave mandolin was mostly a guess as to what would work.

Bridge and Tuning Up (GOM):

With the bridge fitted and nut roughed in, we can assemble the tailpiece and install the 1st and 8th strings to check the bridge string spacing and alignment. We were pleased that the neck alignment was decent on the octave mandolin and doesn't look too far off the centerline! With the alignment confirmed using the outside strings, we can drill 3/32" holes and secure the tailpiece at the tail block.

Working from the outside strings, we can install each additional string and eyeball the spacing at the bridge between the string pairs and from pair to pair. Shallow notches are cut in the bone saddle insert for each string to set them.

From here, we can tune to pitch. The paired strings gages are 0.044, 0.032, 0.022 and 0.012 and are phosphor bronze ball with ball ends. The pitches are GDAE, same as a mandolin just one octave lower – the high E pitch is the same as the first string on guitar.

With the instrument to pitch we can check the action (playing height, neck relief) and intonation (how in tune up and down the neck). The pitches were sharp at the 12th fret, so we needed to loosen the strings and move the bridge toward the tailpiece.

The bridge ended up further towards the tailpiece than we expected, but it sounds good and plays in tune so we'll take it! The truss rod worked as expected and we able to adjust a small amount of relief in to help with buzzing.

Some observations...

Octave Mandolin in the White:

- The neck alignment turned out better than hoped, so things do not look too far off of centerline.
- The neck was left a bit thick for this first playing test, and it is remarkably stable in terms of neck relief and tuning. With the truss rod loose we actually have the proper amount of relief (slight curve over the length of the fingerboard to reduce strings buzzing against the frets). Unfortunately, this also means the loose truss rod can buzz sympathetically with the strings. We can reduce the neck thickness considerably and expect it to be stable.
- Based on the above, the neck thickness was reduced further, especially in the range of frets 5 to 12. There was no change in relief nor truss rod adjustment needed, which should mean removing a substantial amount of material did not affect the neck strength at all. Whew!



- The pair-to-pair string spacing at the nut and bridge feels about right. We guessed well!
- The between-pairs spacing could adjust some – the G and E strings could be slightly further apart. Probably will leave it alone for now, and it's easy to replace the bone insert at the saddle.
- The tuners are pretty stiff and need some lubrication and adjustment when we re-assemble after finishing.
- Intonation was sharp with the bridge at the expected position relative to the f-holes. We moved the bridge back towards the tailpiece and this is better. We might trim the nut end slightly (about 0.013", the kerf of our razor saw), and this will improve intonation especially for the G strings at the lower frets. I have used this same modification on guitars with good results.
- The bridge design is working very well, and the combination of thumbscrew adjustment of the saddle and the replaceable bone insert allows for plenty of adjustment. The bridge height finished just under 1" – right on target.
- The volume is surprisingly loud! String to string volume and response is very even.
- The tone is surprisingly good, and the sustain of the plucked strings is far more than we would have expected for an archtop instrument. Parallel braced (tone bar) construction typical of mandolins and

guitars tends to yield a punchier, louder tone that emphasizes the mid-range with a quick decay in the volume. Our x-braced construction was expected to be warmer sounding, but we ended up much more like a flat top instrument than anticipated.

- Based on this testing, it does not seem like we need to carve in a re-curve at the front plate edges. We have plenty of bass volume, and I am concerned that a re-curve carve could unbalance the tone.
- After finishing we will test an alternative “bouzouki” tuning where one of the G strings is replaced with 0.022” gage tuned an octave higher, and a D string at 0.016” also tuned up an octave. This is preferred by players using the octave mandolin more for chord accompaniment versus single note melody playing.
- Based on where the bridge ended up, we could definitely go for a 15th fret neck-body joint instead of the standard 14th fret joint. This would move the bridge away from the tailpiece and line up better with the f-holes. Maybe for the next build.



Guitar in the White:

- The neck alignment turned out near to the centerline, so the tailpiece is installed on center.
- The neck joint seems solid under string tension.
- The neck was thick for this test, but as with the GOM we can greatly reduce the thickness and get a nice low profile carve.
- The string spacing is way too narrow at the bridge - about 1.8" versus just over 2" as designed. This is because the neck width at the upper frets is too narrow, and that is due to the band saw blade wandering when attempting to trim the width of the heel. By the time this damage was cleaned up on the sanding station, the width at the 14th fret neck-body joint is far less than the 2" we planned. The neck width at the nut is near the target at 1.68" (1-11/16").
- With the intonation set, the bridge is landing very near the original bridge line for the top plate (aligned with the inner notches of the f-holes).
- When first set up, the guitar sounded a bit "choked off" and disappointing. The next morning, it had really livened up and sounded pretty good and the volume had increased. Overall, not as good sounding as the GOM, and that may be related to the pine front plate versus the more spruce-like front of the GOM.
- The guitar top seems a bit denser, so we tried a curved scraper to create a recurve just in from the edge of the front plate. We can do this while tuned to pitch and test the affect as we progress. Benedetto states you gradually carve the recurve and stop when the tone does not change further. The scraper caused too much tear out, so I switched to the ROS and hand sanding.
- The guitar is more balanced on the leg than the GOM – the GOM is slightly neck heavy but not uncomfortably so.

Finishing

Enduro-Var Urethane Finish

Rubout and Polish

Final Assembly and Setup

Pickup Installations

Summing Up

Improved Finish – Enduro-Var Catalyzed Urethane Varnish:

[4th] We have significantly revised this finishing section to emphasize our improved understanding of the process to achieve more professional results!

Introduction to Finishing:

We are committed to using waterborne finishes to avoid the flammable and toxic solvents used in traditional guitar finishes like nitro-cellulose lacquer. This is especially important because our shop is in our walk-out basement and we do not want to invest in explosion proof ventilation, etc.

We have an excellent Turbonaire HVLP that we use with waterborne polyurethane for furniture finishing. However, we have not attempted to develop the spray techniques for the guitars. Using disposable foam brushes, a coat of finish can be applied to the neck and body in less than 15 minutes – setting up and cleaning the spray system would take at least that long for each coat. Also, even with the HVLP there is overspray that wastes the finish.

We have not invested in professional polishing arbors, and instead have focused our efforts on how to achieve near-professional level results using more commonly available sandpapers and polishing compounds.

For the prototypes Number 1 and 2, and the walnut guitar Number 3, we used the finish we have a lot of experience with – Parks water-based gloss polyurethane. I am certain many instrument purists are cringing. We are very comfortable with using the water-based poly. For many years now we have been adding a few drops of Transtint Honey Amber dye to the finish. The water-based poly can look very slightly grey or green, but I believe that is because our eyes are accustomed to seeing the amber leaning color of traditional varnish or oil-based finishes. The Transtint warms up the look, and we could even go further and get an “aging toner” affect. 6 drops of Transtint in a quart of finish is just about right.

For building Number 4 forward, we changed to General Finishes Enduro-Var catalyzed urethane varnish. This finish is used by several guitar and mandolin craftsman. The finish dries to a clearer, more “crystal” looking gloss. It is much harder than the poly and is a lot more work to rubout and polish.

The Enduro-Var is waterborne. It seems to have higher solids content than the Parks or other waterborne poly I have used on furniture. The liquid finish is thicker and somewhat cloudy in the can, but dries to a really nice gloss. It has a slight amber tone so adding honey amber toner to the finish was not necessary. We have been applying the honey amber toner to the bare wood much lighter, and letting the amber tone of the finish add to the final “natural” appearance.

The finish has an odor, not unpleasant but different than the ammonia type odor of the waterborne polys.

We use a foam brush to apply the finish to the main surfaces, and a flux brush trimmed to a point for the edges of the f-holes, etc. We have also learned that in order to prevent sanding or buffing through the finish we need to have more on the guitar to start with! 8 very thin coats seems about right.

The foam brush and flux brush can be stored in a zip-loc bag between coats. We usually use a fresh brush at the start of each day.



Preparation for Finishing:

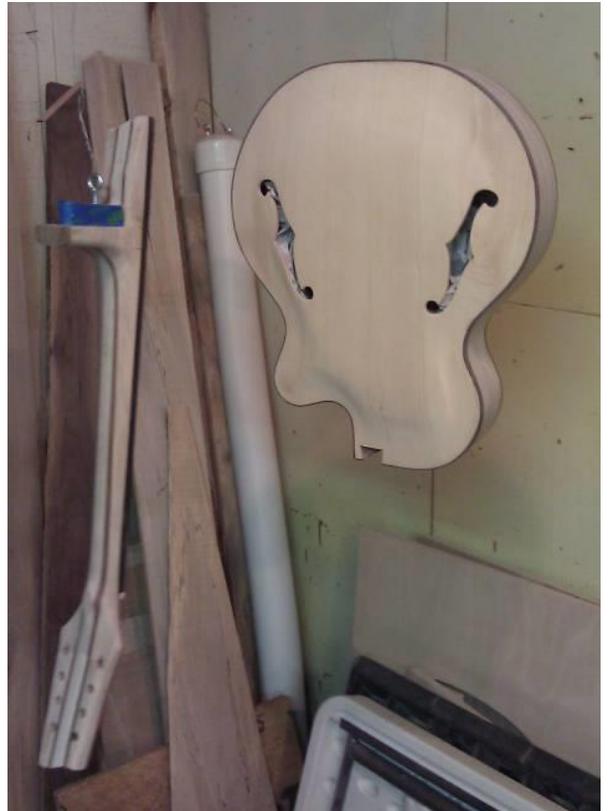
Our dovetail joint design allows us to disassemble the guitars. We take some time to do some refining of the neck carve, and filled binding gaps on the body with walnut filler or superglue where needed.



The necks have a screw hole in the dovetail tenon left from the router fixture. We drill it slightly bigger and inserted a screw eye. The neck will hang from a wire attached to the eye.

We take some time to tape off everything that doesn't get finish with blue painters tape.

The $\frac{1}{2}$ " hole in the tailblock drilled during the rim assembly is filed out. We feed a wire with a wood block on the end through the f-hole and out the tailblock hole. We will hang the body from the wire for drying. Paper stuffed through the f-holes should catch any finish we slop inside.



Sanding – The least satisfying yet most important process:

Some good information from the Mandolin Café forum in this thread: [Finish questions](#)

The advice from John Hamlett in the thread is worth quoting here, and is pretty close to where our preparation method has evolved:

220 grit is fine enough for sanding wood in preparation for finish, but sanding must be thorough for best results. That means, the first sanding should remove all tool marks, scratches, dings, any defects in the surface, including the wood just beneath the surface that may have been compressed or damaged by machining, banging against things, whatever. After that, each successive grit should remove all scratches left behind by the previous grit, including subsurface damage from the larger, previous grit. If that is done all the way to 220 grit paper, there should be no visible scratches under the finish. It is surprisingly difficult to sand completely thoroughly and not miss any defects all over an entire instrument, so raising the grain, side-lighting, magnification, and anything else you can think of to determine the thoroughness of your sanding can help. I usually raise the grain (get the surface wet, let it dry) at least twice, starting after about 120 grit. If... well not if but when I find scratches and defects in the raised grain, I sand them out and repeat the grain raising process until they are all gone.

The main point to take away from this discussion is the importance of thorough sanding with each finer grit to ensure we have removed the damage from the preceding grits, and this is true for both preparation and final finishing stages.

Some sources state that for stain or dye applications the wood should not be sanded finer than 220 grit to prevent burnishing the wood surface and affecting the ability to absorb the color evenly.

One challenge is to detect and remove any glue smear residue from installing the binding. This can be easy to miss - as we did on Number 5! The method that has worked for us is to wipe the body with distilled water and look carefully for the darker or off-color glue areas. While wet, sand these areas with 220 grit garnet paper until the spots are gone.

After drying overnight, sand again with 220 grit, and then lightly wet the surfaces to raise the grain. After drying for a few hours, all surfaces are lightly sanded to 220 grit to remove the grain fuzz – we don't need to go finer.

For curly maple especially, the neck and body are dyed with Transtint Honey Amber mixed in alcohol. A scrap of cotton t-shirt wrapped around a cotton ball is the applicator.

(Our tobacco sunburst attempt on Number 7 can be found here: [Sunburst](#))



After a little time to dry the dyed surface is sanded back with 220. This leaves some of the amber tone behind, and helps to enhance the curl without the overall color looking muddy. Without the dye, curly red maple can have a “salmon” color under the Enduro-Var.



Enduro-Var Finish Schedule:

Our basement shop is not heated or air-conditioned. An exhaust fan in the door pulls some conditioned air from the house. Winter temperature in the shop can be in the low to mid 60's F, and that seems to be warm enough for Enduro-Var to cure correctly. In the summer, the high humidity may actually allow the finish to cure a little slower and perhaps "flow out" a little better.

Enduro-Var dries tacky pretty quickly, so there is not much time to go back over and brush out drips or runs without causing brush marks. It is best to keep each coat quite thin – just enough to wet the surface. It doesn't take long to get a feel for how much to load the brush and get decent results.

1. Three very thin coats, drying 1 hour between. The goal is to allow the finish to catalyze and cure enough to re-coat, but not enough to more fully set. If the coat is too thick, sags or runs are more of a risk. Drips may not fully cure.

The water based Enduro-Var will raise the grain slightly, so the surface will feel a little fuzzy or rough. This will cause some drag on the foam brush, so watch for that. The three coats are needed to have enough finish build to sand the raised grain smooth.

2. After the third coat, dry for at least 2 hours (or even overnight).
3. Sand with 400 grit to level out and take down the fuzzy raised grain. We use a section of a spent 220 grit foam sanding block as a supporting block. This keeps the sandpaper supported enough to keep the surface flat and level but still conform to the curves of the arches. Be careful at the binding edges to avoid sanding through.

The Enduro-Var sands to a very fine powder and does not "pill" up on the sandpaper like the poly will. Most available instructions state to not wet sand to avoid witness marks between coats, but we have not seen these at all. We dry sanded and use a shop vacuum to clear off the dust. Wiping with a damp towel cleans it enough for the next coats

4. Three more coats.
5. Dry overnight.
6. Sand 400 grit.
7. 2 coats.
8. Hang to dry 5 days. In the winter we move the neck and body to a warmer room in the house (the shower rod in a spare bathroom).

Rubout and Polish:

After 5 days of curing...

9. Level sand 400. The goal is to remove any brush marks or sags. We have learned that the finish is so hard that normal rubbing out will not remove these defects!
10. Wet sand 600 grit using a drop of dish soap in water, just enough to lubricate the surface. Rinse the dust off the sandpaper frequently, and wipe the sanded surface to inspect. Sand the entire surface to ensure removal of the previous grit scratches!
11. Wet sand 1200, 1500 and 2000 grit. It will not seem like there is much removed with each grit, but we can see the fine white slurry with each step. Take care to sand all surfaces to remove the previous grit scratches. After the 2000 grit the finish will have a dull satin luster.
12. Rub out all surfaces using rubbing compound.

Buffing by hand with Enduro-Var is a really hard work out. We purchased a 6" Ryobi buffer (\$25) and some automotive liquid rubbing and polishing compounds. We purchased some extra pads so that we can dedicate one to each of the compounds. The buffer works better and is not so exhausting.

After the 5 days of curing the finish is cured enough to rub out without superhuman effort.



13. Buff with Swirl remover. The finish will have a nice luster, perhaps slightly dull at this point.
14. Wait 5 to 7 more days.
15. Buff with Swirl remover again. The gloss will start to show!
16. Buff with Polishing compound. Now the finish is hard enough to take a nice gloss.

Alternative Methods:

On the Musical Instrument Makers Forum (MIMF), a thread discussed experiences with using General Finishes water based finishes, the version available from Stewart-McDonald (probably relabeled Enduro-Var). The thread can be found here: <http://www.mimf.com/phpbb/viewtopic.php?f=13&t=4092>

Chuck Tweedy has compiled his comments from the above thread into a Google document. His method uses a sprayer, MicroMesh sandpaper and professional buffers. Well worth reading:

https://docs.google.com/document/d/1K6_LrNH3ILXhHZyaXpZyaOX8DAgVOMNN4XiAS1TJOMg/edit

Sunburst Finish – First Attempt:

For Number 7 we have attempted our first sunburst finish. As a goal, we like the Violin Burst of the Ibanez AF95 (on right in photo). A web site photo of an Ibanez mandolin shows a similar example.

We prefer very little red tone to the sunburst.

Here are some examples of what we are aiming for...

Ibanez mandolin:



An Ibanez example again, a tobacco burst:



Girouard one piece mandolin back:



What we got was a tobacco burst much darker than intended.

To prepare we sanded as usual to 220 grit, wetting, drying and inspecting for any gaps, glue smudges or scratches.

We taped off the rims next to the walnut bindings, and applied Dark Vintage Maple dye to tone the walnut browner (it can look grayish at times). The bindings were sealed with two coats of Enduro-Var. Q-Tips were the applicators in this step.

The walnut headplate and heel cap were treated the same way. The tape was removed and the finish cured for two days.



The maple back, rims and neck were dyed with Dark Vintage Maple and dried overnight.

The curly grain has soaked up the dye and the idea is to highlight this with the darker dye first. The dye was sanded back using 150 and 220 grit to remove most of the color.



The tail wedge was taped off.

The spruce front and all the maple surfaces were dyed with Honey Amber. This will be the background for the burst.

Dark Vintage Maple was applied to the edges of the plates, the valleys of the rims, and the heel and volute sections of the neck.



Medium Brown dye was applied near the edges of the plates and the deepest part of the valleys.



Clean pads dipped in alcohol were used to blend from the center to the edges, trying to get a good color transition and minimize blotching.

We tried to get a good match in color tones comparing the back plate, rims and front plate. The spruce front is a challenge and tended to look blotchy.



The neck gets the same treatment. The end grain of the neck heel soaked up more dye and got especially dark – in the future we should experiment with ways to seal this area before applying the darker dyes.

A coat of Enduro-Var applied with a foam brush was allowed to dry overnight to seal in the dye. The foam brush likes to pick up some of the color and any sags or runs tended to be highlighted.

The rest of the finish schedule was basically the same as in the previous sections.

Here is the back plate after 8 coats of Enduro-Var. The final look is much darker than we were trying for, and there are some darker areas due to endgrain affects or variations in the absorption of the dye.



The front plate has an antique look, definitely a tobacco burst.

These photos were taken about two hours after the final varnish coat. There are still some obvious brush marks, but these should shrink back some. We will hang the guitar for five days in the shop, then level sand and rub out.

This photo of the rims shows the darker shade in the valley of the waist and the fade to lighter tones at the widest part of the bouts.



Final Assembly:

Final assembly was very straightforward since the guitars were already tested in the white, Everything just goes back where it came from!

Dressing Frets:

Fret dressing ensures that the tops of all the frets are at the same height – a high fret can cause buzzing. Fret dressing is a normal part of guitar maintenance, especially as the frets get worn by the strings over the years of playing.

I decided not to dress the frets at this time, and instead to play the instruments for a while. I can dress the frets later if needed. Testing in the white did not reveal any obvious high frets or problems.

The dressing process is not too complicated. The strings are removed (of course!) and the wood fingerboard taped off, just exposing the frets. The neck is adjusted straight using the truss rod. Each of the fret tops are marked with a sharpie marker – I use blue since it shows up well. A very fine mill file is then stroked up and down the neck until all of the fret tops have been touched. The frets that start out higher will naturally be filed down more, and it is easy to see where we have removed material because the marker will be removed. (We could use our 12" radius block and sand the frets as an alternative).

After all the frets are at the same height, the fret crown is reestablished using a special crowning file. The fret ends are beveling and rounded to remove any sharp edges. The tape is removed, and the fingerboard and frets polished with synthetic steel wool.

Setup:

The goal of the final setup is to optimize the intonation (how in tune the notes are from fret to fret along the fingerboard) and playing action (buzz free playing with minimal finger pressure). The setup process for most acoustic guitars and mandolins is essentially the same, with some extra steps needed to address the floating bridge. The most effective sequence is bridge fitting, nut slotting, relief, string height then intonation:

- 1) **Fit the Bridge:** Sand the bridge base to fit the arch of the top with no gaps under the bridge feet. The basic procedure is shown in the Assembly in White section above. We completed this when we made the bridges. The same fitting process is needed when installing any new bridge, and often on new factory made instruments where the time was not taken to get a perfect fit. Rubbing the bridge base on sandpaper taped to the front plate can create a very good fit in a reasonably short time. We'll take care of the bridge height later.



- 2) **Optimize the string height at the nut:** When making a new nut, the blank must be sanded to fit the slot in the headstock, cut to length with a razor saw, and profiled to a gentle ramp or crown on the tuning machine side. The thickness of the nut at the surface where the string slots are cut should be minimized to reduce string friction while tuning but leaving enough material to securely hold the strings. The nut is only held with a dot of superglue at the end of the fingerboard so that it can easily be removed in the future.

The string spacing should be arranged so that there is equal space between the strings – the gap from string to string – and not from the string center to center. I set the 1st and 6th strings in 3/32" from the fingerboard edges, then even up the string to string gap from there. On guitar, a spacing of about 1/4" works really well for standard neck widths of 1.680" (1-11/16") and we used the same 1/4" spacing between the string pairs on the octave mandolin. We mark the string spacing with a pencil, and make a cut at each line with a razor saw to help start the nut files.



A half-pencil marks the height of the frets on the face of the nut and helps provide a reference for how deep the string slots should be. The string slots are cut with round edged files gaged to about the thickness of the strings (they can be rocked in the cut a bit if slightly undersized).

If the nut slots are not cut to the optimal height, the intonation from the 1st to 3rd fret will definitely suffer, and the extra finger pressure needed to play in these positions will make the instrument feel stiff.

The slots are slowly cut, one string at a time, and canted back towards the tuning machines. Press the string gently down on the 3rd fret, and look for a very slight gap between the top of the first fret and the bottom of the string. If there is large gap, detune the string, remove from the slot, file a bit down, then replace the string and retune. When you get close to the line, the optimal height can be found by taping on the string over the first fret while holding down at the 3rd. If the string is very close to the first fret height you will hear the string click on the first fret with very little downward movement.



After all of the string slots are cut to height, they usually end up as deep grooves. Sand down the top of the nut so that about 1/2 the string diameter is setting in the slot for the wound strings, and just barely below the top for the unwound strings.

- 3) **Adjust the Relief:** A slight curve along the length of the fingerboard is needed to keep the strings from buzzing on the next higher frets during playing. The amount of relief needed depends on the player – harder strumming usually needs higher relief.



The 6th string on a guitar (or the lowest pair on the mandolin) makes a great straight line to view the relief. Press the string at the 1st and 15th frets, and look for the gap between the string and the top of the 5th or 7th frets. If there is no gap, the neck is too straight and more relief is needed (loosen the truss rod – turn counterclockwise). Feeler gages can be used to measure the gap, but I usually just eyeball it and make adjustments now and later while playing. If the gap is too large tighten the truss rod by turning clockwise. (The LMII truss rod takes a 9/64” hex wrench).

- 4) **Adjust the String Height at the bridge:** Most floating archtop guitar and mandolin bridges have thumbwheels for adjusting the height. Loosen the strings, adjust, and tune back to pitch. (We want to get close to the optimal string height before checking intonation). In cases where the bridge is already at the minimum height, the saddle height may need to be reduced by removing some wood and re-cutting the string notches.

Our bridge height was pretty close from setting up in the white, and it needed about 1/8” trimmed from the top of the saddle to optimize the adjustment range. Our bridge design uses a bone insert in the saddle, so we have an extra way to adjust the height or even the string to string spacing. The bone insert should have a nice slip fit without forcing it, and not so loose that it can rock in the slot.

Our bone insert was sanded to match the 12” radius of the fingerboard. (A conventional ebony bridge saddle should also be sanded to match the fingerboard radius). The notches that guide the strings should be very shallow – to the same criteria we used for the nut slots. If they are too deep the bone insert should be sanded down to correct it.

The string height, or “action”, can be measured as the height above the 12th fret to the bottom of each string. On guitar, a low action would be 5/64” for the 6th string, and 3/64” for the 1st string. The GOM is similar, and mandolins could be a little lower. This is easy to measure using a 6” rule marked in 64ths, and it doesn’t take long before you can eyeball this too.



- 5) **Adjust Intonation:** With the string height optimal, the intonation can be checked using an electronic tuner. The place to start is always at the 12th fret, and this note should ideally be exactly one octave higher in pitch than the open string. Check all the strings, and if all the 12th fret notes are sharp, move the bridge toward the tailpiece (detune, move, retune). If they are all flat, move the bridge towards the neck. When the notes are close, check some other fret positions, especially the 3rd, 5th and 7th. It’s not unusual to find perfect octaves at the 12th fret but be slightly sharp at the 3rd or 5th fret. Move the bridge to get a good compromise. (Realistically, how often do you play at the 12th fret?).

Achieving this compromise intonation usually involves several repetitions of adjusting bridge height, checking string height and neck relief, and adjusting again. Strings usually break from the repeated detuning and tuning (or just because they can!).



With the compromise action and intonation achieved, we can fine tune the intonation by adjusting the locations of the individual string notches on the saddle. If an individual string is sharp, carve the saddle point back towards the tailpiece, and it needs to be closer to the neck if the note is flat. This may mean sanding off some of the saddle top, shaping the saddle points with needle files, and recutting the string notches with the nut files.

Polish. The bone saddle insert and the nut can be polished to a satin sheen. I use fingernail dressing boards from Walmart – each stick has all the grits needed to clean up and polish the surfaces.

Clean and polish the fingerboard using synthetic steel wool in fine and superfine grades, and this will polish the frets too. A very light application of some lemon oil (Formby’s Furniture Reconditioner – No Silicon!) will condition the fingerboard and enhance the appearance.



- 6) **Fresh Strings!** Normally, by the time all of the setup is accomplished the strings are shot. A fresh set of strings is needed to ensure that the action and intonation is where we intended it to be. If all the strings need to come off for further polishing, use some blue painters tape to hold the bridge in position. It is always preferred to change strings one at a time when working with floating bridges.

Pickup Installations:

We are using a piezo soundboard transducer from Shatten Design with their included endpin jack. A ½" hole for the endpin jack was prepared in the tailblock earlier. I installed the pickup in the GOM first.

The endpin wiring instructions from Shatten are very clear. I tinned and soldered the hot lead and shield (ground) to the jack tabs. The tailblock was milled 7/8" thick so it was easy to pre-adjust the locking nuts close to the right thickness before inserting into the body.

The transducer disc is very delicate, and I was not certain where the best location for attaching the disc to the inside of the front plate would be for good tone and volume.



The pickup ships with an adhesive putty. I used superglue to attach the transducer to a 1" diameter by 0.100" thick disc of spruce. A small amount of putty was applied to the other side of the spruce disc.



I fed a 0.016" diameter guitar string in through the tail hole and out the treble f-hole, then looped it through the hole in the endpin jack. The jack can then be pulled in through the f-hole to the tailblock hole. The washer and locking nut can be slid along the string and tightened on to the exposed threads of the jack. The strap button threads on to cover the locking nut.

The pickup location inside the plate is indicated with tape on the outside surface in this photo. No problem reaching this location through the f-

hole. The putty side of the spruce disc was pressed firmly to the top, and the lead wire was secured with blue tape under the plate. The pickup is completely hidden with this installation.



The soundboard pickup sounds really good, very natural and balanced, especially when using a pre-amp. I purchased an inexpensive Behringer ADI 21 preamp (\$40) to use with the GOM, and it really warms up the tone.

The pickup installation in the guitar was completed in the same way. Since the neck is too narrow for the custom neck mounted magnetic pickup, we will only use the soundboard transducer and save the magnetic pickup and preamp for a future build.



[3rd] Starting with Number 3 we have been using JJB Prestige 200 transducers. These come as two encapsulated piezo sensors pre-wired to an endpin jack. For Number 4 and 5 we installed the sensors by reaching with fingers through the f holes, but this is tricky to do and achieve the desired positioning (and hard to avoid supergluing your fingers to the inside of the top!).

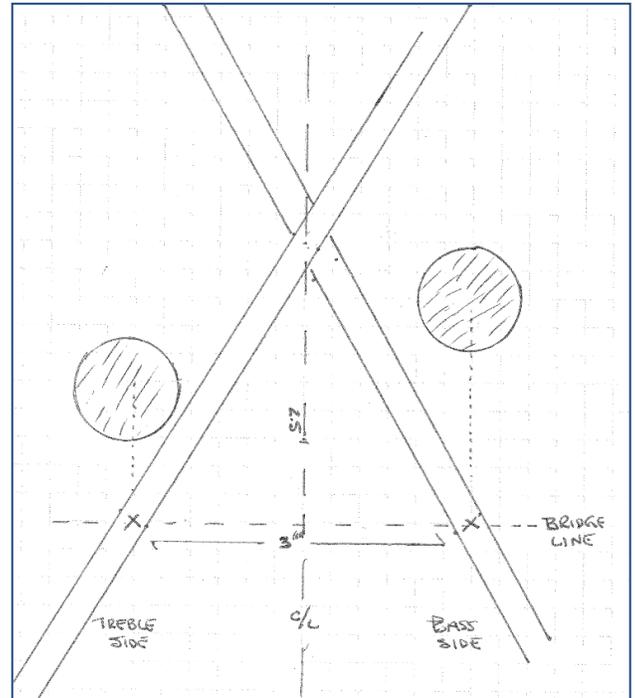
Number 4 (guitar) and Number 5 (GOM) both sounded a bit bass heavy with the sensors located just forward of the X-braces, so just in front of the bridge feet.

With Number 6 we have the optimized locations. The treble side sensor goes in front of the X-brace as before, just in front of the treble side bridge post (where it would rest on the X-brace on the outside).

The bass side sensor is placed in front of the X-brace, about $\frac{3}{4}$ " forward from the brace. This has balanced out the bass and treble volume and tone.

We use gel superglue to attach the sensors, and installed small wire clips to provide for strain relief.

Wide blue painters tape was used to temporarily hold the jack during the rest of the assembly, attaching it just inside the bass side f hole so that it can easily be reached after the finishing is completed.



[5th] Details on carving and modifications to allow for a surface mounted full humbucker are shown here: [Surface Mounted Humbucker](#)

Once everything is polished we can install the humbucker:

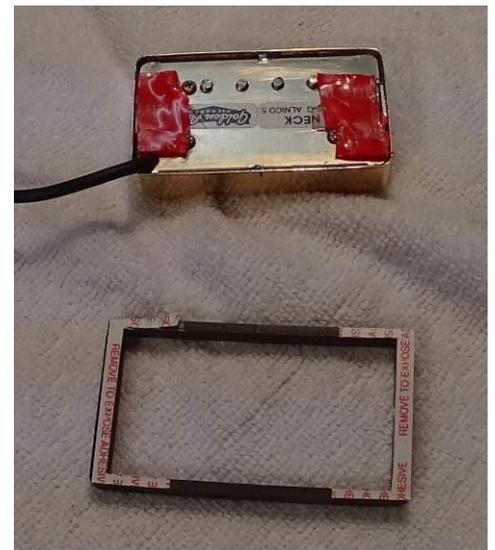


A 3/32" hole was drilled at an angle to feed a string ground wire connecting the tailpiece bracket to the endpin jack. The wire is fed out the endpin jack hole via a shallow groove, trapping the wire between the jack body and 1/2" hole.

Copper foil in the string anchor block connects the ball ends of the strings to the tailpiece harp.



3M double sided tape is used to attach the humbucker and ebony trim ring to the front plate.



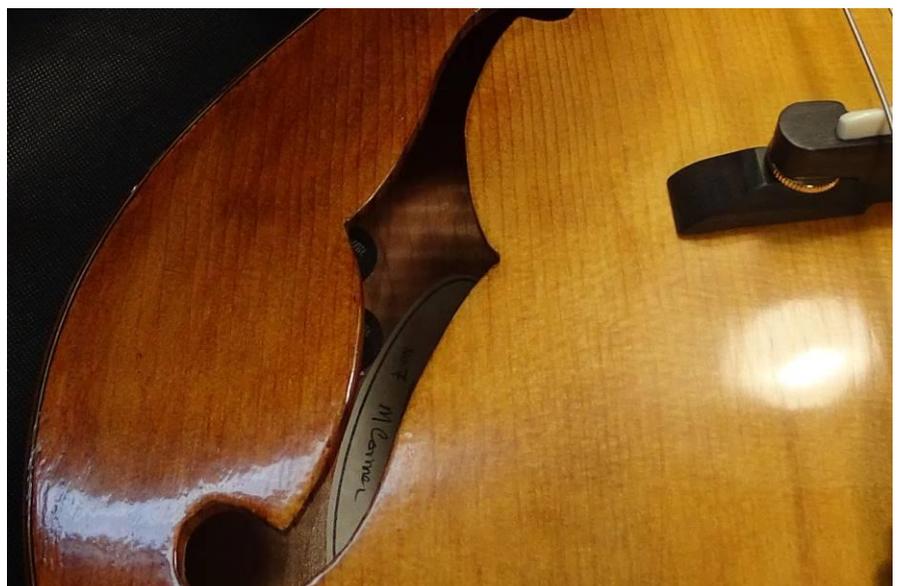
Pickup and trim ring installed.

(The trim ring is fitted to the front plate arch the same way the bridge base is fit – rubbing on sandpaper).



The 4.5 degree neck angle leaves ample clearance for the pickup, which is approximately level with the fretboard.

Shatten volume and tone pots are tucked inside the bass side f-hole.



Summing Up:

It was really satisfying to start with a drawing on our dining room table and work through to complete two playable instruments with decent tone.

We started building in April 2013 and were done by early September 2013 (five months). We kept a detailed log of all of the tasks and can summarize them as follows:

Stock Preparation (Milling wood)	28		
Jigs and Fixtures	37		
	Prep Total	65	hrs
Bodies (both)	71		
Necks (both)	28		
Bridge and tailpieces	7		
Finishing and rubbing out	5		
	Build Total	111	hrs
Setup in white, and finished	6		
Installing pickups	4		
	Setup Total	10	hrs

Reading various sources, we expected the build time to be around 125 hours (for one instrument). We have finished quite close to that for two instruments! Of course, time is saved when you are setting up for tablesaw or router cuts and a couple of more passes for the second instrument takes very little extra effort. We did not use any inlays in the fingerboard or headstock, and that would add considerably more time.

Most of the building process steps were firsts for us, so there was plenty of extra head-scratching time working out how to do things, or how to not mess up the second instrument after struggling with the first. We'd learned long ago with woodworking or home remodeling projects – if you are tired or frustrated it is far better to walk away for a while than to push it and mess up even more!

Some processes were far easier than expected. Bending the maple, cutting and installing the frets and carving the neck all went pretty smoothly. Bending the walnut binding was extremely frustrating. Carving the plates was the workout we expected, especially the maple backs, but it was easier to create the arches and carve the inside graduations than we had feared.

We could have purchased the bridges and tailpieces, but it was satisfying to make our own and did not take as much time as we had expected. Doing it ourselves, we got exactly what we wanted.

Costs:

The costs were not too extreme. We purchased some good lutherie tools for this project that will be ours for the future like an Ibex palm plane, FlexCut gouges and knife, fret saw and radius block (\$200). We purchased a trim router (\$100). We spent about \$100 on plywood for the molds and a bit more for glue, sandpaper and other normal shop supplies. We saved considerable cost by designing and building our own jigs for cutting binding channels, fret sawing and other special processes.

The front plates were from our Home Depot wood stash, and the red maple from our front yard. Considering this, we have spent about \$275 to build each instrument (not counting molds, jigs and tools). Add another \$100 for strings and case and the instrument cost was about \$375 each.

The guitar has a custom Vintage Vibe neck pickup (\$113) and a Shatten preamp and soundboard pickup (\$138) adding \$250 for a total of \$626.

The octave mandolin has a Shatten passive soundboard pickup (\$37) for a total of \$412.

We have the jigs and fixtures, and experience, so future builds should move along much more quickly. We should find a reasonable source for spruce front plates – web searching suggests we would spend around \$100 for a decent set of split wedges. We have all the red maple we need, but if we wanted some fancy curly maple back and sides it would likely cost more than \$200 for a set. So, with a base cost of \$375 adding the premium wood would push the cost to \$675 or more.

We need to find some more walnut for the neck, binding and headstock. We only paid \$10 for the rough sawn 5" wide x 1-1/4" thick x 5' long board we used, so the walnut not a significant part of the cost. Of course, upgrades to fancy wood bindings or headplates could add some to the total, as would any pearl or other inlays to the fingerboard or headplate.

Quality:

The playability and tuning stability exceeded our expectations. We seem to have stumbled onto a good design. The octave mandolin would really be worth building again!

The finish details could improve greatly with future instruments. I sanded the binding too thin in spots. There are some surface dings and flaws in the back plates that I did not find until after the finish was applied. The guitar neck is too narrow for our custom jazz pickup and caused a very tight string spacing at the bridge, and I am sure it will bother me until I can build a new wider neck. The neck volute is pretty crude and we need to develop a more refined design there.

Overall, we are thrilled with how the instruments play and sound. The octave mandolin is especially interesting and fun to experiment with.

Gallery

Some final photos of Numbers 1 and 2 ...



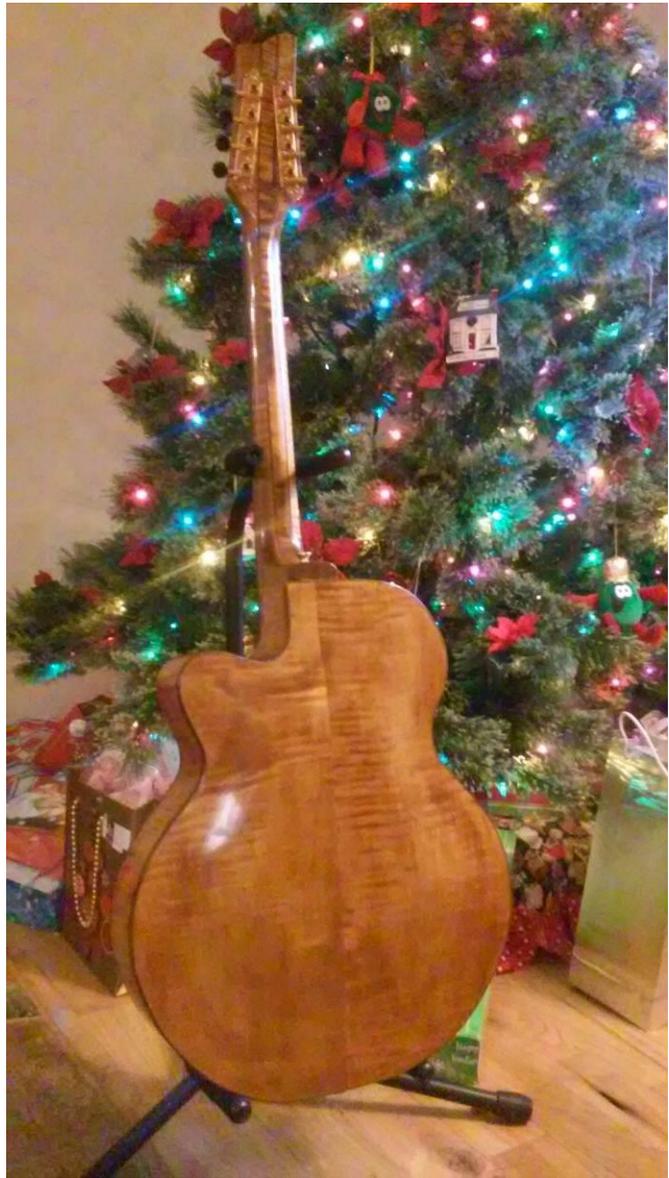
Here is **Number 3**: Guitar using Englemann Spruce front, Walnut back and sides, Red Maple neck and binding. Finished with Honey Amber dye then polyurethane...



Number 4 is an archtop guitar custom built for George VanBuskirk of Marble NC. Englemann spruce top with walnut back and sides, with curly maple for the neck and binding. This build was a surprise gift for him, and we sent the front plate to NC for family and friends to sign before assembling the guitar. The walnut has been filled with ebony paste, and the honey amber dye is more subtly applied. The finish is gloss Enduro-Var.



Number 5 is a GOM custom built for Josh Hicks of Hartwell GA. Englemann spruce top with curly red maple back, sides and neck. He wanted the darker dye on the maple, emulating the color scheme of Number 3.



Number 6 is an archtop guitar custom built for Bridget Marie Egan of Columbus OH (formerly of Farmington Hills MI). Englemann spruce top with lightly figured cherry back and sides. Neck and trim are red maple.

We posted a photo journal on Facebook showing each step in the build process. We also created a slide show video with music played by me on Bridget's guitar. The playing is pretty rough – just one take with no processing or effects, and plenty of mistakes.

[Building Bridget's Archtop Guitar](#)



Number 8 was moved ahead of Number 7 for Aiden Chastain's of Martin's Creek NC, a birthday present. Englemann spruce with rims, back plate and neck in curly red maple. Walnut binding. The curly red maple board had interesting mineral streaks that came out great after finishing.



Honey amber dye on the maple was sanded back to enhance the curly contrast, and the front plate was not dyed. Finish is Enduro-Var, and this is the best one yet.

The rim depth is 2-7/8", much deeper than the 2.5" standard for the GOM to have a more guitar like tone. Lots of volume considering the small size. Trouble is, it doesn't fit in the classical guitar case without some modifications.



Number 7 is from the same curly red maple board as Number 8. The front plate arch was modified and a steeper 4.5 degree neck angle to make room for a surface mounted Golden Age full size humbucker. This is our first attempt at a sunburst finish, sort of a dark Tobacco burst.



Registry of Instrument Builds

Number	1	2	3	4	5	6
Model	Guitar	GOM	Guitar	Guitar	GOM	Guitar
Front	Pine	Depot Spruce	Englemann	Englemann	Englemann	Englemann
Back & Sides	Red Maple	Red Maple	Walnut	Walnut	Curly Red Maple	Cherry
Binding	Walnut	Walnut	Red Maple	Curly Red Maple	Walnut	Red Maple
Neck	Red Maple	Red Maple	Red Maple	Curly Red Maple	Curly Red Maple	Red Maple
Frets	FW74	FW74	FW74	FW74	FW74	FW74
Inlay	None	None	None	Dots, MC	Dots, MC	Dots, MC
Pickup(s)	VV Neck Shatten single Shatten Artist Pre	Shatten single	Vintage Vibe Neck JJB 220 Stereo, Vol & Tone	JJB 220	JJB 220	JJB 220
Color	Natural	Natural	Honey Amber	Ebony filler on walnut, then Honey Amber	Honey Amber front Vintage Maple body	Honey Amber
Finish	Poly	Poly	Poly	Enduro-Var	Enduro-Var	Enduro-Var
Client				George VanBuskirk	Josh Hicks	Bridget Marie Egan
Date	Sep-13	Sep-13	Jun-14	Apr-15	Dec-14	Jun-15
Notes	Prototype guitar	Prototype GOM	1st: Englemann, Walnut body	1st: Dots and MC logo, Ebony filler, Enduro-Var	1st: Curly Red Maple body	1st: Cherry body

Number	7	8				
Model	Guitar	Guitar neck GOM				
Front	Englemann	Englemann				
Back & Sides	Curly Red Maple w/ mineral figure	Curly Red Maple w/ mineral figure				
Binding	Walnut	Walnut				
Neck	Curly Maple	Curly Maple				
Frets	EVO	FW74				
Inlay	Dots, MC	Dots, MC				
Pickup(s)	Golden Age HB (Surface mount) JJB 220 Stereo, V&T	JJB 220				
Color	"Tobacco Burst" Honey Amber-Vintage Maple-Med Brown	Honey Amber (sanded back)				
Finish	Enduro-Var	Enduro-Var				
Client	Me!	Aiden Chastain				
Date	Aug-16	Mar-16				
Notes	Deeper 2-7/8" Rims 1st: EVO frets, Surface mount HB, Sunburst	Deeper 2-7/8" Rims 1st: GOM w/ guitar neck				

Appendices

Appendix A: Fret Spacings Using StewMac Calculator

Standard fret spacings with Nut to Fret 1 distance reduced by 0.013"						Rev 21Jul15		
25" fret scale (Guitar)				23.5" fret scale (Octave Mandolin)				
fret	from nut	fret to fret		fret	from nut	fret to fret		
1	1.385	1.390" (nut-1)	*	1	1.301	1.319" (nut-1)	*	
2	2.712	1.325" (1-2)	*	2	2.547	1.245" (1-2)	*	
3	3.963	1.250" (2-3)	*	3	3.723	1.175" (2-3)	*	
4	5.143	1.179" (3-4)	*	4	4.833	1.109" (3-4)	*	
5	6.258	1.114" (4-5)		5	5.882	1.047" (4-5)		
6	7.309	1.051" (5-6)		6	6.870	0.988" (5-6)		
7	8.302	0.993" (6-7)		7	7.803	0.933" (6-7)		
8	9.238	0.936" (7-8)		8	8.683	0.880" (7-8)		
9	10.122	0.884" (8-9)		9	9.514	0.831" (8-9)		
10	10.956	0.834" (9-10)		10	10.298	0.784" (9-10)		
11	11.744	0.788" (10-11)		11	11.038	0.740" (10-11)		
12	12.487	0.743" (11-12)	Neck Extension	12	11.737	0.699" (11-12)	Neck Extension	
13	13.189	0.702" (12-13)		13	12.396	0.659" (12-13)		
14	13.851	0.662" (13-14)		14	13.019	0.623" (13-14)		
15	14.476	0.625" (14-15)	4.453	15	13.606	0.587" (14-15)	5.343	
16	15.066	0.590" (15-16)		16	14.161	0.555" (15-16)		
17	15.623	0.557" (16-17)		17	14.684	0.523" (16-17)		
18	16.148	0.525" (17-18)		18	15.178	0.494" (17-18)		
19	16.644	0.496" (18-19)		19	15.645	0.467" (18-19)		
20	17.112	0.468" (19-20)		20	16.085	0.440" (19-20)		
21	17.554	0.442" (20-21)		21	16.500	0.415" (20-21)		
22	17.972	0.418" (21-22)		22	16.893	0.393" (21-22)		
23	18.378	0.394" (22-23)		23	17.263	0.370" (22-23)		
24	18.750	0.372" (23-24)		24	17.612	0.349" (23-24)		
Distance from the fretboard edge of the nut to the break-angle of the string at the peak of the saddle.								
Treble "E" 25.087 " (±0.030")				23.639" (±0.030") from the nut to where the E-strings meet the saddle.				
Bass "E" 25.21 " (±0.030")				G-strings will be 0.060"-0.125" further from the nut				
* Additional 0.005" compensation spread from nut to fret 5								

Appendix B: Fractional, Decimal and Metric Conversion Table

fraction			decimal	mm	fraction			decimal	mm	fraction			decimal	mm
		1/64	0.0156	0.3969	1 1/64	1.0156	25.7969			2 1/64	2.0156	51.1969		
		1/32	0.0313	0.7938	1 1/32	1.0313	26.1938			2 1/32	2.0313	51.5938		
		3/64	0.0469	1.1906	1 3/64	1.0469	26.5906			2 3/64	2.0469	51.9906		
	1/16		0.0625	1.5875	1 1/16	1.0625	26.9875			2 1/16	2.0625	52.3875		
		5/64	0.0781	1.9844	1 5/64	1.0781	27.3844			2 5/64	2.0781	52.7844		
		3/32	0.0938	2.3813	1 3/32	1.0938	27.7813			2 3/32	2.0938	53.1813		
		7/64	0.1094	2.7781	1 7/64	1.1094	28.1781			2 7/64	2.1094	53.5781		
	1/8		0.1250	3.1750	1 1/8	1.1250	28.5750			2 1/8	2.1250	53.9750		
		9/64	0.1406	3.5719	1 9/64	1.1406	28.9719			2 9/64	2.1406	54.3719		
		5/32	0.1563	3.9688	1 5/32	1.1563	29.3688			2 5/32	2.1563	54.7688		
		11/64	0.1719	4.3656	1 11/64	1.1719	29.7656			2 11/64	2.1719	55.1656		
	3/16		0.1875	4.7625	1 3/16	1.1875	30.1625			2 3/16	2.1875	55.5625		
		13/64	0.2031	5.1594	1 13/64	1.2031	30.5594			2 13/64	2.2031	55.9594		
		7/32	0.2188	5.5563	1 7/32	1.2188	30.9563			2 7/32	2.2188	56.3563		
		15/64	0.2344	5.9531	1 15/64	1.2344	31.3531			2 15/64	2.2344	56.7531		
	1/4		0.2500	6.3500	1 1/4	1.2500	31.7500			2 1/4	2.2500	57.1500		
		17/64	0.2656	6.7469	1 17/64	1.2656	32.1469			2 17/64	2.2656	57.5469		
		9/32	0.2813	7.1438	1 9/32	1.2813	32.5438			2 9/32	2.2813	57.9438		
		19/64	0.2969	7.5406	1 19/64	1.2969	32.9406			2 19/64	2.2969	58.3406		
	5/16		0.3125	7.9375	1 5/16	1.3125	33.3375			2 5/16	2.3125	58.7375		
		21/64	0.3281	8.3344	1 21/64	1.3281	33.7344			2 21/64	2.3281	59.1344		
		11/32	0.3438	8.7313	1 11/32	1.3438	34.1313			2 11/32	2.3438	59.5313		
		23/64	0.3594	9.1281	1 23/64	1.3594	34.5281			2 23/64	2.3594	59.9281		
	3/8		0.3750	9.5250	1 3/8	1.3750	34.9250			2 3/8	2.3750	60.3250		
		25/64	0.3906	9.9219	1 25/64	1.3906	35.3219			2 25/64	2.3906	60.7219		
		13/32	0.4063	10.3188	1 13/32	1.4063	35.7188			2 13/32	2.4063	61.1188		
		27/64	0.4219	10.7156	1 27/64	1.4219	36.1156			2 27/64	2.4219	61.5156		
	7/16		0.4375	11.1125	1 7/16	1.4375	36.5125			2 7/16	2.4375	61.9125		
		29/64	0.4531	11.5094	1 29/64	1.4531	36.9094			2 29/64	2.4531	62.3094		
		15/32	0.4688	11.9063	1 15/32	1.4688	37.3063			2 15/32	2.4688	62.7063		
		31/64	0.4844	12.3031	1 31/64	1.4844	37.7031			2 31/64	2.4844	63.1031		
	1/2		0.5000	12.7000	1 1/2	1.5000	38.1000			2 1/2	2.5000	63.5000		
		33/64	0.5156	13.0969	1 33/64	1.5156	38.4969			2 33/64	2.5156	63.8969		
		17/32	0.5313	13.4938	1 17/32	1.5313	38.8938			2 17/32	2.5313	64.2938		
		35/64	0.5469	13.8906	1 35/64	1.5469	39.2906			2 35/64	2.5469	64.6906		
	9/16		0.5625	14.2875	1 9/16	1.5625	39.6875			2 9/16	2.5625	65.0875		
		37/64	0.5781	14.6844	1 37/64	1.5781	40.0844			2 37/64	2.5781	65.4844		
		19/32	0.5938	15.0813	1 19/32	1.5938	40.4813			2 19/32	2.5938	65.8813		
		39/64	0.6094	15.4781	1 39/64	1.6094	40.8781			2 39/64	2.6094	66.2781		
	5/8		0.6250	15.8750	1 5/8	1.6250	41.2750			2 5/8	2.6250	66.6750		
		41/64	0.6406	16.2719	1 41/64	1.6406	41.6719			2 41/64	2.6406	67.0719		
		21/32	0.6563	16.6688	1 21/32	1.6563	42.0688			2 21/32	2.6563	67.4688		
		43/64	0.6719	17.0656	1 43/64	1.6719	42.4656			2 43/64	2.6719	67.8656		
	11/16		0.6875	17.4625	1 11/16	1.6875	42.8625			2 11/16	2.6875	68.2625		
		45/64	0.7031	17.8594	1 45/64	1.7031	43.2594			2 45/64	2.7031	68.6594		
		23/32	0.7188	18.2563	1 23/32	1.7188	43.6563			2 23/32	2.7188	69.0563		
		47/64	0.7344	18.6531	1 47/64	1.7344	44.0531			2 47/64	2.7344	69.4531		
	3/4		0.7500	19.0500	1 3/4	1.7500	44.4500			2 3/4	2.7500	69.8500		
		49/64	0.7656	19.4469	1 49/64	1.7656	44.8469			2 49/64	2.7656	70.2469		
		25/32	0.7813	19.8438	1 25/32	1.7813	45.2438			2 25/32	2.7813	70.6438		
		51/64	0.7969	20.2406	1 51/64	1.7969	45.6406			2 51/64	2.7969	71.0406		
	13/16		0.8125	20.6375	1 13/16	1.8125	46.0375			2 13/16	2.8125	71.4375		
		53/64	0.8281	21.0344	1 53/64	1.8281	46.4344			2 53/64	2.8281	71.8344		
		27/32	0.8438	21.4313	1 27/32	1.8438	46.8313			2 27/32	2.8438	72.2313		
		55/64	0.8594	21.8281	1 55/64	1.8594	47.2281			2 55/64	2.8594	72.6281		
	7/8		0.8750	22.2250	1 7/8	1.8750	47.6250			2 7/8	2.8750	73.0250		
		57/64	0.8906	22.6219	1 57/64	1.8906	48.0219			2 57/64	2.8906	73.4219		
		29/32	0.9063	23.0188	1 29/32	1.9063	48.4188			2 29/32	2.9063	73.8188		
		59/64	0.9219	23.4156	1 59/64	1.9219	48.8156			2 59/64	2.9219	74.2156		
	15/16		0.9375	23.8125	1 15/16	1.9375	49.2125			2 15/16	2.9375	74.6125		
		61/64	0.9531	24.2094	1 61/64	1.9531	49.6094			2 61/64	2.9531	75.0094		
		31/32	0.9688	24.6063	1 31/32	1.9688	50.0063			2 31/32	2.9688	75.4063		
		63/64	0.9844	25.0031	1 63/64	1.9844	50.4031			2 63/64	2.9844	75.8031		
1			1.0000	25.4000	2	2.0000	50.8000			3	3.0000	76.2000		

Appendix C: Build Costs

Build Materials and Costs

				19-Jun-13	
	<u>Desc</u>	<u>Source</u>	<u>Part No</u>	<u>Guitar</u>	<u>GOM</u>
Neck					
Fingerboard	Macassar Ebony - std 1st grade (3)	LMI	WF1M	\$ 12.90	\$ 12.90
Truss rod	14-1/2 x 3/8" (15-1/2" overall)	LMI	TRSD	\$ 26.60	\$ 26.60
Tuning Machines	Gotoh 510 midsize gold w black buttons	LMI	GGM6GSBMC	\$ 101.25	
	Mandolin tuners	LMI	GMGBA		\$ 86.80
Nut - bone	Unbleached	LMI		\$ 3.60	\$ 3.60
Dot markers	1/16"D, 6" L white	StewMac	0483	\$ 1.15	\$ 1.15
Fret wire	4' l for one guitar	LMI	FW74	\$ 4.95	\$ 4.95
Body					
Linings	kerfed, reverse basswood	StewMac	4513	\$ 17.08	\$ 17.08
Purfling	BWB, .030 Thick, 64" Long	LMI	PFL7	\$ 4.10	\$ 4.10
Bridge	w afr ebony blank 8" x 3-3/8 x 1-5/8 2nd grade	LMI	WHAED158B	\$ 12.60	\$ 12.60
Bridge Post Thumbwheels	set of two, gold	StewMac	3960-G	\$ 4.95	\$ 4.95
Tailpiece	335 Style Tailpiece	WDMusic	T120G	\$ 27.95	
Tailpiece	335 Style Tailpiece - Short	WDMusic	T120SG		\$ 27.95
Strap button - neck	set of 2	StewMac	0170-G	\$ 4.44	\$ 4.44
Battery Box		StewMac	3578	\$ 10.42	
Soundboard pickup	Shatten Artist II Plus 2	Shatten		\$ 109.95	
	Gold Button			\$ 6.95	
	EP-01JG Utility Pickup non-terminated	Shatten		\$ 20.95	
	EP-01JG Utility Pickup w/ endpin jack, gold button	Shatten			\$ 36.95
Neck Pickup	Custom neck mount, adj poles, gold	Vintage Vibe Guitars		\$ 112.50	
Case	WolfPak Acoustic Guitar	Musicians Friend		\$ 107.00	
	Musicians Gear - Classical - Tweed	Musicians Friend	540947		\$ 69.99
Strings	Bulk 12-packs 022, 032 and 044	Musicians Friend			\$ 22.37
	Dunlop Phospor Bronze Acoustic Light	Musicians Friend		\$ 4.50	
	Elixir Electric Guitar Heavy	Musicians Friend		\$ 14.00	
				\$ 607.84	\$ 336.43
Tools					
Fret saw		LMI	SWB	\$ 23.25	
Fret rounding file		LMI	FFR	\$ 39.45	
Fret Cutter		LMI	SPE	\$ 28.75	
radius block	10"/12" 8 long	LMI	SRP1012	\$ 17.30	
Dovetail bit	3/4" 7 degree	LMI	SP7DT	\$ 21.75	
1/8" downcut bit		StewMac	5154	\$ 18.55	
Kerf clamps	set of 10	StewMac	3712	\$ 9.90	
Metric tap, Drills	For tapping bridge thumbscrews in ebony	Harbor Freight		\$ 45.55	
				\$ 204.50	

Appendix D: Sources

Publications:

“**Making an Archtop Guitar**”, Bob Benedetto [Amazon.com /Making-Archtop-Guitar-Robert-Benedetto](http://Amazon.com/Making-Archtop-Guitar-Robert-Benedetto)
The definitive work on the subject

“**Making a Laminate HollowBody Electric Guitar**”, James English [Amazon.com/Making ...](http://Amazon.com/Making...)
Interesting alternative methods from the electric guitar viewpoint

Web Resources (Forums):

Guild of American Luthiers <http://www.luth.org/>
Outstanding source for lutherie information, plans and the American Lutherie Quarterly Journal

Musical Instrument Makers Forum MIMF • Index page
Great practical source for lutherie information and plans, including our GOM design!

Frets.com <http://www.frets.com/FretsPages/pagelist.html>
Frank Ford's excellent site – one of the best, almost a classic!

Liutaio Mottola Lutherie <http://liutaiomottola.com/>
Really well written and detailed information on lutherie, as good as any book!

Mandolin Café <http://www.mandolincafe.com/forum/forumdisplay.php?45-Builders-and-Repair>
Builder and Repair Forum – probably the best mandolin site around the web!

Jazz Guitar Online <http://www.jazzguitar.be/forum/guitar-amps-gizmos/>
Lot's of good archtop guitar information and discussions

Premier Guitar Magazine <http://www.premierguitar.com/topics/1597-guitar-bass-mods>
Some useful how-to articles

Suppliers:

Luthiers Merchantile International <https://www.lmii.com/>
Primary source for wood and tools

Stewart-MacDonald <http://www.stewmac.com/>
Alternative source for wood and tools

Musicians Friend <http://www.musiciansfriend.com/>
Cases, strings, accessories

Vintage Vibe Guitars <http://www.vintagevibeguitars.com/pickups.html>
Pete Biltoft, custom neck pickup

WDMusic http://www.wdmusic.com/335_style_tailpiece_gold
Lots of guitar parts, source for tailpiece

Shatten Design <http://www.schattendesign.com/>
Soundboard pickup, preamp

JJB Electronics [JJB Electronics](http://www.jjb-electronics.com/)
Soundboard pickup