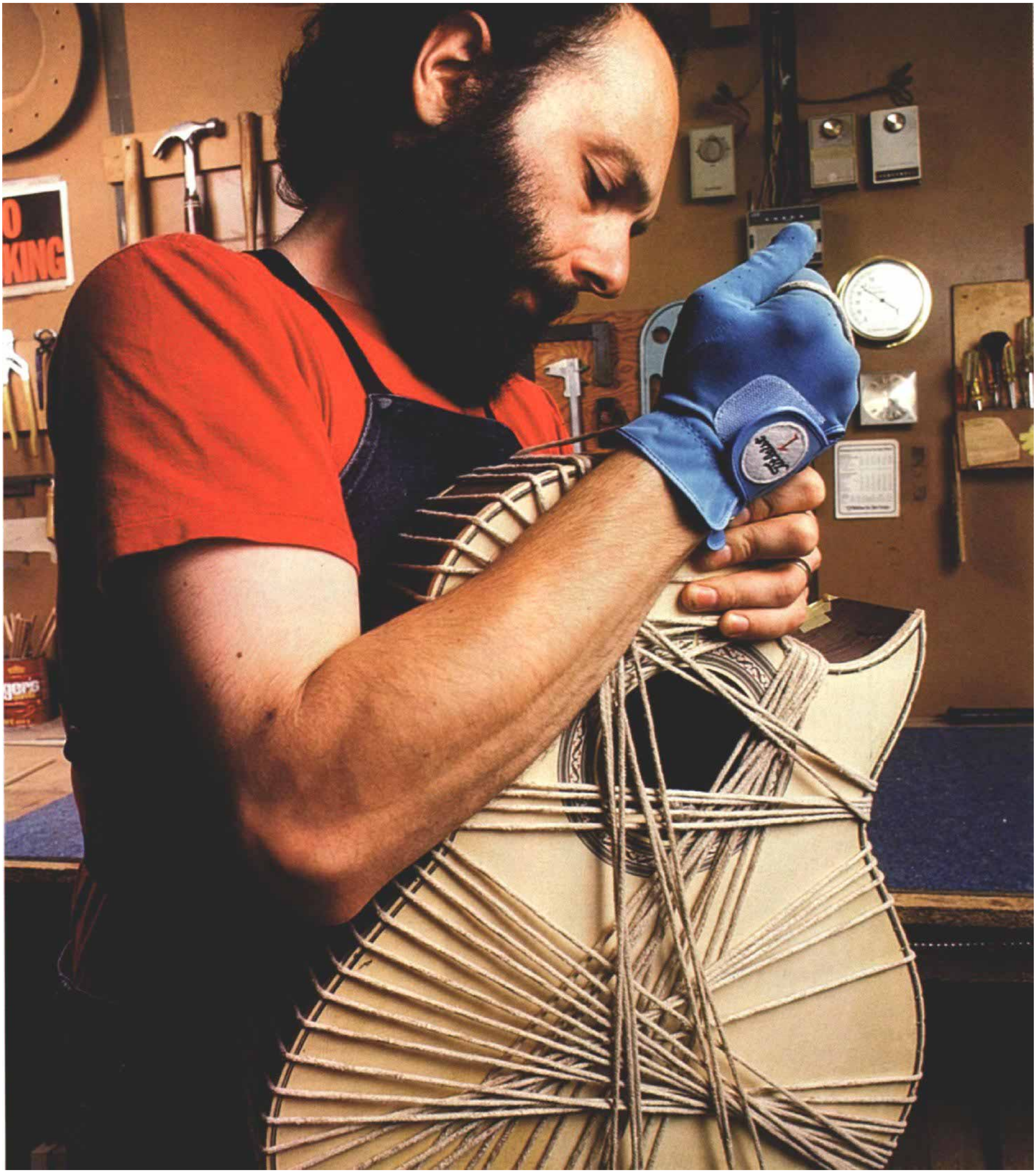


Purfling is bound tightly into its rabbets by windings of awning rope, one side at a time. Any areas where the joint is not tight can be snugged up with additional windings. This body shape, called a cutaway, allows the musician to reach farther up the fretboard.

Guitar Body Construction

Bending and purfling the frame

by William "Grit" Laskin

A guitar body is a hollow box that epitomizes balance: The precise symmetry of the curves, the compromises between strength and lightness, the artful fitting of minimal glue joints; all these elements combine in what at first glance seems to be half woodworking and half magic. Yet, taken step by step, making a guitar body is fairly straightforward.

Briefly, the process is as follows: The thin sides are bent to the shape of a mold, a plywood or particleboard form that surrounds the instrument in the early stages and acts as a template to ensure symmetry and accuracy (see photo, next page). With the sides inserted in the mold, mahogany endblocks are glued in place at the top and bottom of the body to span the joints where the two sides butt together. The glued-up rim, or frame, is removed from the mold and the top endblock, or heel block, is dovetailed to receive the neck of the instrument.

Next, linings—wooden strips that both stabilize the frame and increase glueline area—are glued around the inside edges at the top and bottom of the frame. The guitar's soundboard, or top, and its back are braced with supporting strips of wood on the inside to make them stiffer, then glued to the instrument. Finally, narrow strips called binding and purfling are let into rabbets cut on the top and bottom edges of the body. This completes the basic "box," the body.

In a magazine, I can't possibly hope to give you a complete how-to for making an instrument—for that, I referenced a number of books in my first article *(FWW* #67), which covered body shape, the woods used and stock preparation. Here then is another brief look at how an instrumentmaker relates himself to the structural, the visual, and eventually auditory, beauty that is a guitar.

Bending sides—The most convenient way to bend guitar sides is to heat them until the wood plasticizes, apply pressure by hand to form the curve, then let the wood cool to set the bend. Once bent, the sides are immediately in a workable, glueable state.

You'll need to rig up what I call a bending iron—a hollow metal tube clamped or bolted in place with a heat source inside. For this project, I suggest supporting a propane torch so it flames into one opening of a piece of tubing or pipe. A few other accessible ways of making bending irons are shown in William Cumpiano and Jon Natelson's new book *Guitar Making: Tradition and Technology,* which was listed in the bibliography in part one. I've only just seen this book—since writing the first part of the series—and it turns out that I can recommend it very highly. I feel it is the most thorough guitarmaking manual in print.

Leave your book-matched side pieces slightly oversize in length, but cut their width down to the final size of 105mm (the thickness of the top and the back will bring the eventual full measurement of the instrument to 110mm, as shown in the drawing in part one). Run one edge across your jointer, then slice down to size with a tablesaw. Thickness the sides to 2.5mm or bending will be tough going. Final sanding and scraping will bring the sides down to the 2.3mm thickness shown in the plans.

Match the grain symmetrically where the bottom endblock joint will come, and mark with a pencil the top edge of both pieces. For reasons I will clarify later, have the grain run down to the back edge as it travels toward the neck block.

You may want to bend a trial piece or two, because skills come from discovering the correct feel. The balance of pressure and movement will come in short order if you work at it.

With your mold as reference nearby on the bench, you will start your shaping at the lower bout endblock joint. Allow the side about a 2.5cm excess overlap of the joint line. Here are some hints to get you bending: First, your bending iron is hot enough when your spit will ball up and bounce off. Second, run your wood under the tap just to wet the surface. (You may want to do this occasionally throughout the process.) This lessens surface burn marks. Third, never hold your wood stationary on the iron, always keep it in either a side-to-side rocking motion or a slow slide across the iron combined with a constant jiggling action. This is the only way to achieve smooth, unkinked curves.

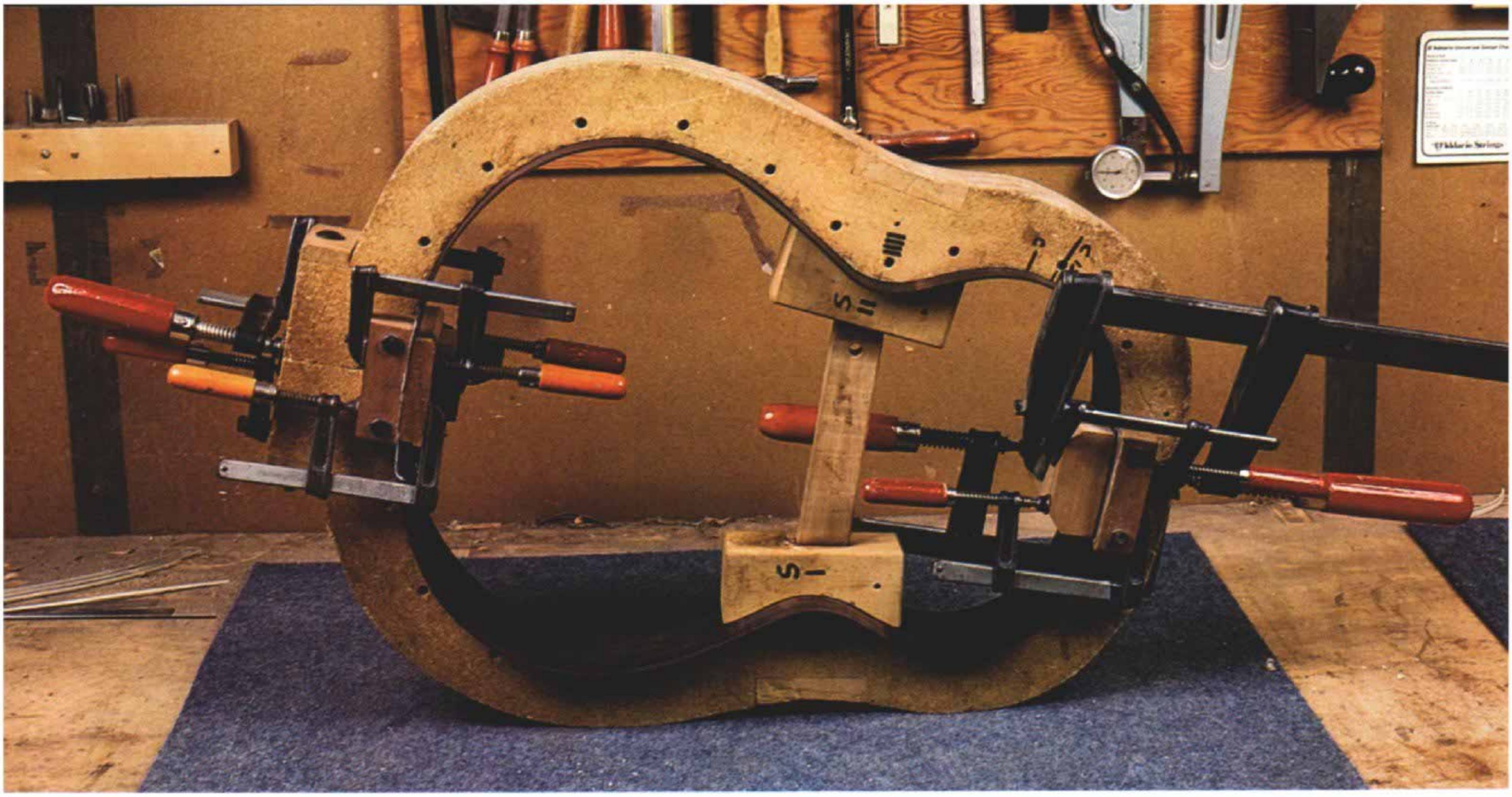
Both hands must exert a small amount of downward pressure to bend the wood into the desired position. Do not worry if you overbend a section of the curve too tightly. You can correct it by simply bending the curve out from the opposite side.

When bending the lower bout, work in 6-in.- to 8-in.-long sections. I match the first section to the curve of the mold, then shift to the adjacent section. I slightly bend the section to the left of the one I am concentrating on as well, so the gradually emerging curve will blend smoothly. If you work solely on one area, with no thought to the adjacent sections, you can cause kinking at the transition points. Test the lower bout bend by holding it against the inside of the mold. Correct any underbent, flattened spots on the bending iron -while the section is warm.

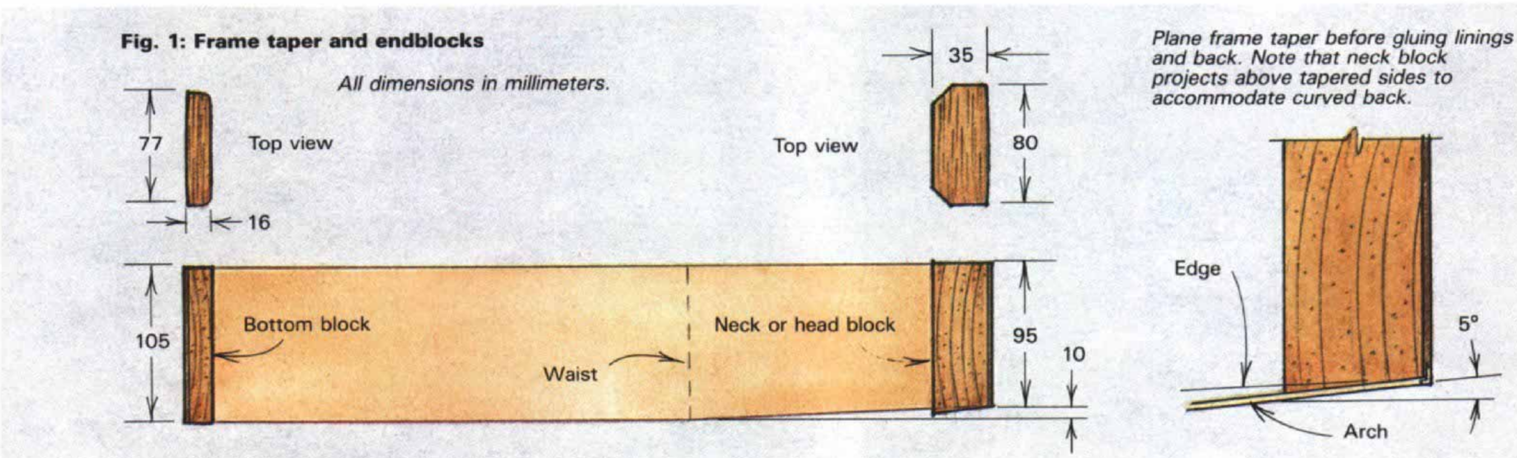
The waist is next. Hold the partially bent side in position in the mold, then rock it until it is pressing against the very center of the waist curve (for reference, mark the center on your form). Pencil this point on the side and center it on the bending iron's circumference. Lean alternately to the right, partially bending that side of the waist, then to the left and back, across the whole curve of the waist until it is completed.

Bend the upper bout curve in 3-in. to 4-in. sections. When the side is finally shaped enough so it can slip down into the mold, refine and fair all the bends as necessary. Being slightly overbent

Guitarmakers shape the sides to conform to the guitar mold by bending the dampened wood over a heated pipe, moving the wood constantly to avoid kinks and scorching. With a little practice, the mold can be matched exactly.



Guitar sides and blocks are clamped and glued in the mold. Shaped blocks at the waist, wedged apart by a stick, hold the pre-bent sides tight in place. Next the body will be tapered, as shown below, the neck block dovetailed, and linings added, as shown on p. 63.



is fine. Just be sure that when you hold the side at its waist and push in each end against the mold, the curves fall into proper place. Be sure to check the bottom edge of the side as well. Should one edge differ from the other, correct it by concentrating hand pressure on the problem edge only as you press against the iron.

Repeat the above procedures with the second side, working with the mold turned upside down and the bottom edge of the side facing up. Double check that the grain direction is symmetrical with the first piece.

Immediately after bending, the sides are able to be joined together with the mahogany endblocks to form the rough frame. If it will be more than a week before you can move on to this next step, clamp the sides in your mold to prevent any springback.

Frame assembly—The frame will be glued up in the mold, as shown in the photo above. Regular woodworking clamps hold the endblocks, while the waist is pressed tight to the mold by two shaped blocks wedged into place with a loose stick.

The first step is to trim the sides to length. Hold one side at a time into the mold using one of your waist wedge blocks and a clamp. Separately press each bout section flush to the mold and mark the location of the joint at the centerline. Unclamp the side and squarely cut off the excess. Confirm the fit by placing both sides in the mold, ends butting against each other, and wedge the waist blocks tight. If the waist will not make contact with the mold, one or both of the sides are too long—trim one end of one side 0.5mm at a time until both sides fit snugly. If the fit is loose, insert a small strip of rosewood in the joint at the neck end.

The endblocks that reinforce both joints should be cut and sanded to the dimensions shown in figure 1. Be sure their grain runs as shown. The surfaces that clamp against the rosewood sides must be matched to the curves of the mold. I do this by rocking them across my stationary belt sander.

When the blocks and sides are prepared, rest the mold flat, top down on the bench, waist-wedge the sides into position and insert wax paper between the rosewood and the mold at the joints. Dry clamp the blocks in place on the top side, then lift the mold onto its edge to finish clamping from the back. If all is well, apply white or yellow glue and clamp for real. These and all other glue joints should be well cleaned immediately after clamping. Allow the frame to remain clamped overnight.

Tapering the sides—This guitar back curves in two directions: across its width, because of the curved back struts; and up its length, because of the tapered sides of the frame, as shown in figure 1. Looking from the side, the taper can be seen to be straight, neither concave nor convex. I chisel, then hand plane the side taper, working from the waist toward the neck block. If the grain direction of the sides is as I instructed earlier, the sides will plane smoothly while completing this stage, and not chip out.

The frame edge should be even with the top of the heel block for approximately 10cm on both sides then rise upward to the waist. To confirm that the slant is correct, do two things: One, place a straightedge on the edge of the block and allow it to extend over the sides, as shown in the photo on the next page. There should be a clearance of approximately 2.5mm. Two, lay a small flat board along the tapered edge—it should lie flat, touching all along. If either condition is incorrect, you will have flat and/or concave sections in the back.

Now that you have the frame tapered, go ahead and glue in the linings, shape and sand them, and sand level the outsides of the

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Bending with an electric blanket

by Wade Hampton Miller

While bending instrument sides with a hot pipe is a time-tested and proven method, today many luthiers are taking a more modern approach using a high-tech heating blanket as a heat source. As Bob Baker of Blue Lion Musical Instruments (4665 Parkhill Road, Santa Margarita, Calif. 93453) explains: "Bending a guitar side with a hot pipe used to take me about 25-30 minutes, and I'm pretty good at it. But by using forms with this heating blanket, I can do a set of sides in less than half the time, and the result is even more accurate."

The heating blanket is manufactured by Watlow Electric (12001 Lackland Road, St. Louis, Mo., 63146, 314-878-4600). Designed originally to keep satellites warm enough to function in the ultrafreeze of deep space, the Watlow heater is a silicon rubber blanket Imbedded with a grid work of fine wire that can generate a constant heat of up to 500°F. Very light and very flexible, the Watlow heaters are now used for purposes as diverse as thermoplastics manufacture and the heating of oil pans on automobiles in Arctic Alaska.

Baker makes no claim to have originated the use of the Watlow heater in luthiery. He first read about blanket bending in *Frets Magazine,* a publication that specializes in acoustic instrument performance and construction. The advantage of the Watlow heater in woodbending, Baker says, is that "you can design just about any shape and stick this heating blanket on there."

To build a heating form for an instrument side, Baker begins by cutting the shape he wants out of dense particleboard or ¾-in. plywood. "I cut out the basic shape in however many pieces I need to make up the width of the side . . for a guitar side I'll use seven or eight pieces of plywood." These pieces are then glued with either Titebond or a heat-setting epoxy, then bolted together (to prevent the heating action of the blanket from loosening the glue). Once the pieces are glued and bolted, Baker trims the edges flush with a bandsaw and then scrapes them to get the surface as smooth as possible.

Baker then cuts a piece of sheet aluminum to size and screws it to the face of the form. This prevents the wood from scorching and also makes a smoother surface for the heating blanket to stick to. Next comes a mastic that's unaffected by heat, (available with the Watlow heater) and the blanket is attached.

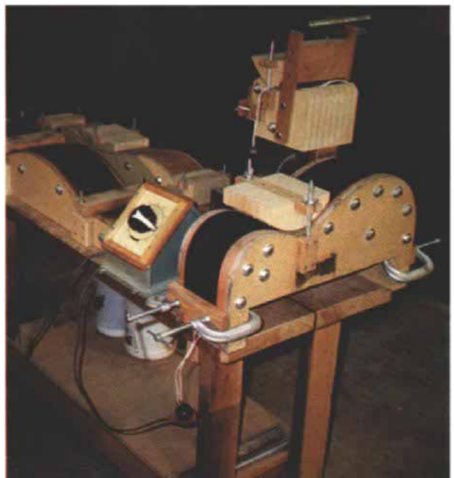
The Watlow heaters are available in widths of 1 in. to 6 in., and in lengths ranging from 5 in. to 40 in., in 5-in. increments. Baker uses the 5-in. by 35-in. size for the main heating element, and a 4-in. by 5-in. heater for a formed block that he clamps at the waist. "The waist block isn't strictly necessary," Baker says, "but it cuts the bending time about in half."

What's needed now is a control element to regulate the electricity going into the blanket. "You can get thermostats," says Baker, "but I use a high-capacity Variac I salvaged from a hotel ballroom that was being demolished. Basically you need something that can handle the high wattage of the blanket."

The sidebender is now ready. The instrument sides are prepared as they would be for hand bending—cut to size, thinned to 0.085 in. and moistened. Baker heats the waist block first to bend the middle, then unplugs that heater and clamps the ends of the instrument side down with C-clamps cushioned with scrapwood. Then the main heating element is turned on.

"How long the side stays in and how high the setting on the Variac goes," Baker explains, "is a matter of experimentation." In general Baker finds that a koa guitar side needs about 10 minutes in the form, and a rosewood side needs about 12 to 13 minutes.

A problem that can occur as the wood heats up and dries out is that the edges of the side can begin to curl. Currently Baker counters this by clamping additional blocks of wood across the problem spot. But this can be time-consuming, and he intends to prevent it from coming up at all by fabricating two flexible pieces of stainless steel cut to the size of a guitar side. The guitar side will be sandwiched between the two sheets of steel when it is placed in the form, and the edges will be unable to curl.

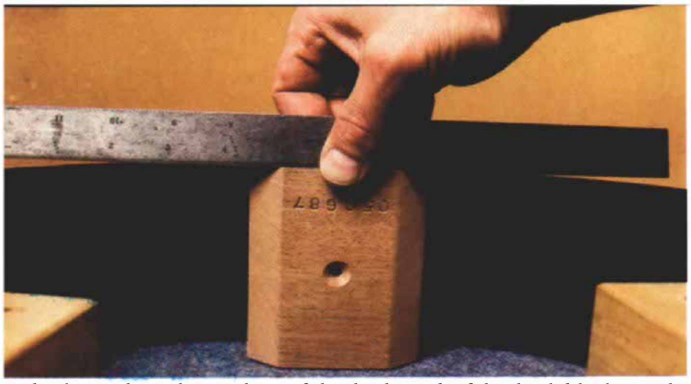


For production work, sides can be bent in forms heated by blankets of silicon rubber. Forms for a guitar's waist and bout curves are in the foreground. In the background are a pair of dulcimer forms.

Since most of his guitars are built on a custom basis, Baker will usually let guitar sides cool in the form. But Blue Lion is one of the leading dulcimer manufacturers in the country, and so Baker's dulcimer production is geared toward maximum efficiency,

"I have a form that will bend two dulcimer sides at once, and another mold to put them in to cool so they'll retain that shape. In the meantime, I've put another pair of sides in the form to bend. Both bending and cooling of the dulcimer sides take about six to seven minutes each, so this way I maintain a steady stream of parts." □

Wade Hampton Miller is a writer and musician living in Anchorage, Alaska. His playing won the U.S. Mountain Dulcimer Championship in 1980.



Checking the relationship of the high end of the heel block to the tapered sides. Also see figure 1, for measurements.

To rout the dovetail socket for the neck, the author uses a standard dovetail bit with a plastic template and a guide bushing.

frame. Any of the texts will see you through these steps. The next step after that is to machine the neck dovetail socket.

I use a router and two template-guide jigs to rough out both parts of the dovetail, then do the final fitting by hand. The jig for the dovetail socket is shown in the photo above. The collar on the guide bushing follows the edge of the Plexiglas during the cut, which is made to a depth of 13mm.

The last thing I do, relating to the female cut, happens after the back and top are glued to the frame but before purfling. I want the area of the frame around the dovetail slot, on which the neck will rest, to be perfectly flat. You'll see the reasons for this when we look at adjusting the neck angles, in part three. The tapering flattened area is as wide at the top and as narrow at the bottom as the finished neck will be—refer to the plans drawing in part one. Though I do this flattening with a belt sander, I suggest you take the safer route of a large flat block and sandpaper.

As I stated at the beginning of this series, this is not a step-by-step guide to guitar construction. Hence, I once again shall scoot you past some stages. For example, I spend two full days preparing, bracing and gluing the top and back to the frame, and there is simply no way to get the necessary information into a magazine article. So, once more, I refer you to the outside texts for guidance: David Russell Young's book, *The Steel String Guitar: Construction and Repair,* shows a method very like my own.

Binding and purfling—On this guitar, as with most of good quality, there are at least three different types of decorative strips comprising the purfling, the wooden bindings around the body's edges. These are shown in detail in figure 2.

We have to cut steps of three different depths around the edge of the body to accommodate all the purfling. There are hand methods and a variety of machine methods to accomplish this. I do it with my router, held stationary in a jig, the idea for which came from my teacher's teacher, Edgar Mönch. The photo on the facing page shows the idea. I use this jig by gently pushing the body along, resting the sides on the turned aluminum cylinder, while at the same time pressing snugly against the router's baseplate. The smaller the diameter of the rod, the more the bit projects beyond it, which fixes the depth of cut.

I grant you this is a fairly complicated jig to construct if you don't intend to make a number of guitars. I suggest first of all, that you make this jig out of hardwood. That would be faster and easier than metal. If that doesn't suit, many of the texts, even those dealing with classical guitars, will take you through some other hand or machine method. Allow me to say though, that the time required to make my jig plus the resulting cutting time is only about one and a half times as long as cutting the purfling grooves by hand, plus it leaves cleaner, more accurate cuts. The bit I use is a Rockwell #43706, a carbide, straight, three-flute rabbeting bit with an overall diameter of about 1⅛ in., though the diameters of the turned rods can be adapted so that any similar bit can be used. The bit's pilot bearing should be removed.

Regardless of the method chosen, finished edges must be as smooth and clean as possible. After routing, I go around the top and back edges with fine files to smooth out any irregularities.

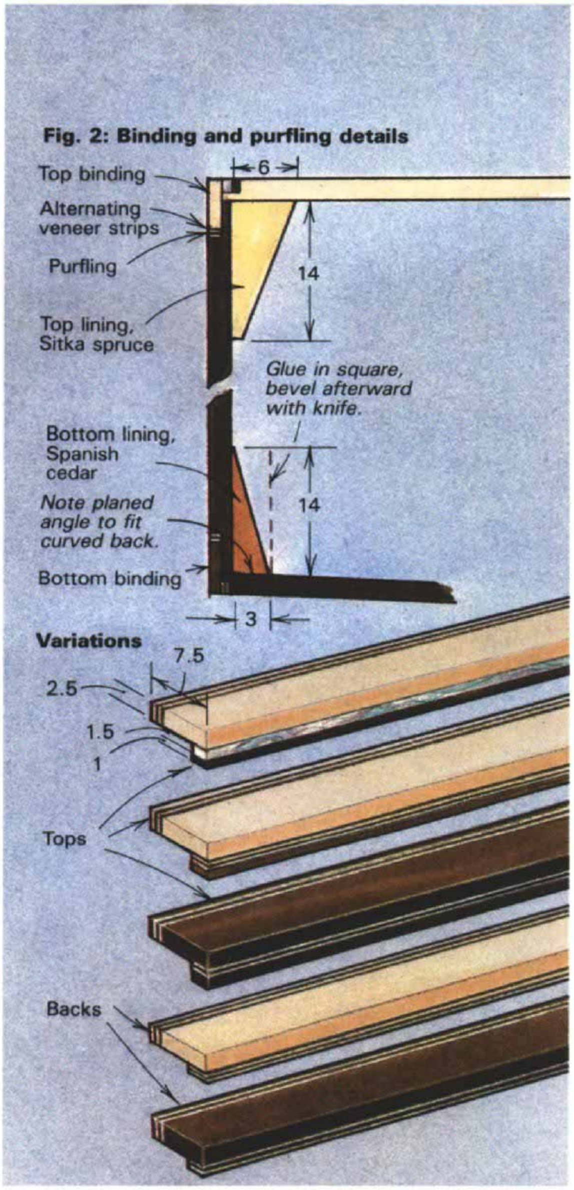
When you have the purfling grooves prepared, you must prebend only the outermost strips for the front and the back. Temporarily join all four strips—the two front strips and the two back strips—together with masking tape at both ends making sure that two strips are bottom edge down and two up. The bending procedure is the same as for the sides except that a little less pressure will be needed. Do not rush. However, try not to work too long in any given area as you may start to melt the glue joints holding the veneers to the strips.

The purflings are glued to the body in four separate stages, one front side, then the other front side, then repeating with the back strips. This allows you the freedom to adjust and fit most of the joints without the time pressure of setting glue. You must protect the edges not yet purfled nor being worked on with other scrap wooden strips bent and temporarily masking-taped in place. These protective strips are necessary to guard against the pressure of clamping, which in our case, is done with 150 ft. of awning rope.

Clamping all along the guitar's irregular curved surface has traditionally been done with rope or, more recently, different styles of strong cloth tape. I have found awning rope to be ideally strong and to offer a slight stretching that helps tighten its pressure. Also, its comparatively narrow diameter leaves more of the purfling joint visible for inspection while gluing. A 15cm-long piece of doweling is tied to one end of the rope to anchor the rope to the guitar through the soundhole.

To begin the gluing process, first trim your main purfling strip to match the centerline of your top. You will be starting the gluing of each strip at this endblock area.

Apply glue along approximately 5 in. of the routed grooves, then do the same to the outer side of the unbent, inner strip. Place this strip in position with its end slightly proud of the



To rout the different-size grooves around the edges of the guitar for inlaying binding and purfling strips, Laskin made this router jig. The side of the guitar bears on the turned aluminum rod as the instrument is moved through the cutter, while the front or the back of the instrument is pressed against the router base. Various rods control the width of the cuts; the depth is controlled by the router's own depth-setting adjustment. The tapered top edge of the small pad in the center of the base allows clearance for the curved back of the guitar. A duct-tape shield directs dust down and away from the operator.

centerline (you'll trim it later). The main strip is then held in place and the rope, its dowel gripping the inner edges of the soundhole, is pulled snug across the purfling pieces 2mm or 3mm from the trimmed edge and around the body to grip at a point directly opposite where you're working. The first pull must be gentle to ease the dowel's pull on the soundhole edges. Your next pulls, with the rope crossing the purflings at about 2cm divisions, can be hefty.

Once the first 5 in. are clamped, keep the tension by wedging the free end of the rope under and around one of the taut winds. Now apply glue to the remainder of the purfling, tape the strips in place at two or three spots, wipe off the excess glue, trim the purflings' superfluous length at the neck joint (I quickly clip them with wire cutters) and continue winding the rope.

Wedge the rope again and inspect your work for gaps. If you're suspicious of a slight gap, press the purfling strip home by hand, looking for evidence of glue squeeze. If you do find any gaps, you should have enough rope to wind back to the spots and pull them in. Another choice is to use lightweight clamps and minimal pressure.

I let each section dry for at least one hour. I then unclamp the rope, letting it fall loosely onto a clean section of the floor ready for the next section.

The purfling strips around the top have a visible joint only at the bottom of the instrument; but the two sections of the back purfling have a second joint at the neck-block end. Leave the last few inches at the neck glue-free and undamped, allowing you to fit the joint. Cut the strips one at a time just slightly overlong, and use a sharp chisel and/or fine file to trim them until, with hand pressure, they fall accurately into place. Apply glue, finish your clamping and finally, give your hands a deserved break.

Though I remove the rope after an hour, I don't clean down the purfling until the next day when the crystallzed glue won't clog sandpaper.

Using a good sturdy scraper is the simplest way to level the purfling edges with the body. (I use my belt sander to even off the top and back edges, but that method can be dangerous to the guitar if you're not practiced at it.) My router jig, fit with a -in., straight-fluted cutter and ¾ in.-dia. bar, can be used to remove most of the excess purfling off the side edges, but even with that method, hand scraping finishes the job.

Let me close with a reminder that you'll not regret working carefully and taking your time. Purfling work is often the first visible clue to an instrumentmaker's work standards. Doing it well shows respect for the entire tradition, and future, of the craft. □

Grit Laskin makes and regularly plays guitars in Toronto, Canada. Photos by Brian Pickell.