Designing and Building Chairs

THE NEW BEST OF FINE WOODWORKING

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The Editors of
Fine Woodworking

The Taunton Press

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Working wood is inherently dangerous. Using hand or power tools improperly or ignoring safety practices can lead to permanent injury or even death. Don't try to perform operations you learn about here (or elsewhere) unless you're certain they are safe for you. If something about an operation doesn't feel right, don't do it. Look for another way. We want you to enjoy the craft, so please keep safety foremost in your mind whenever you're in the shop.

Acknowledgments

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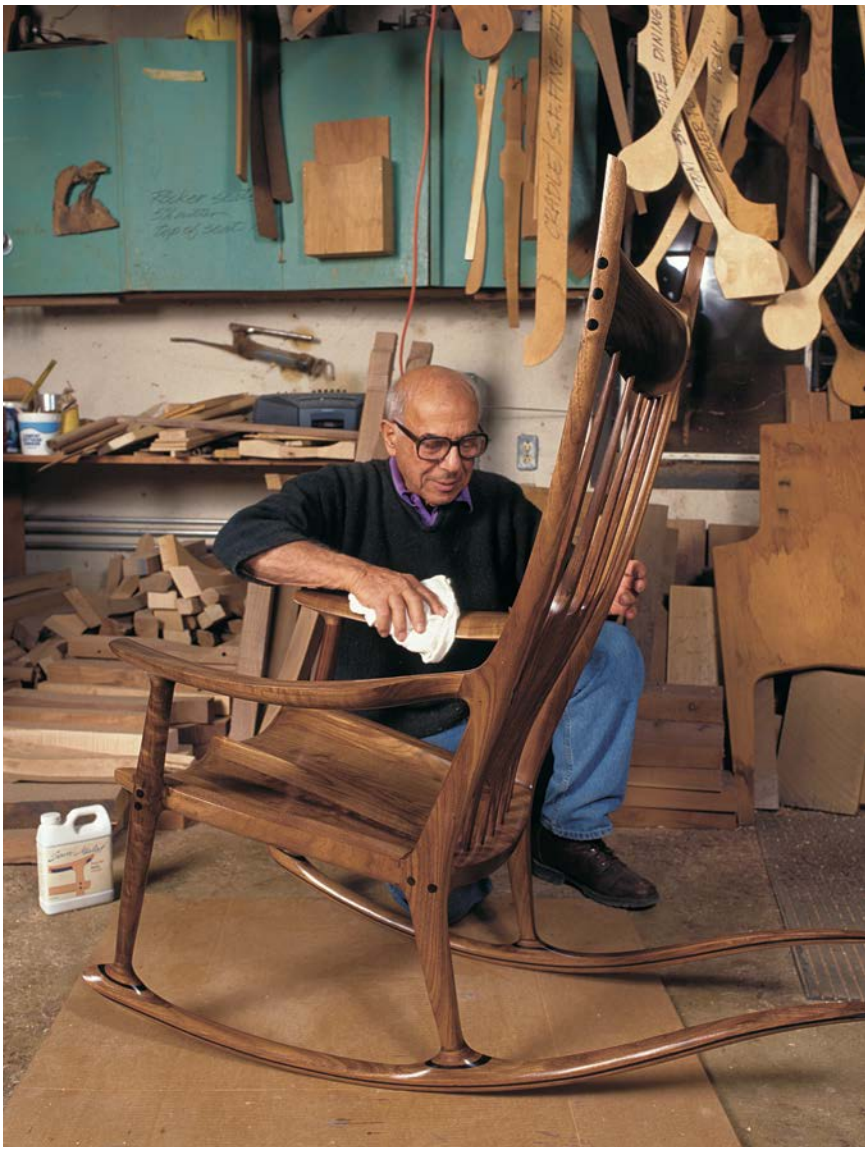


Those of us in developed cultures take chairs for granted. No matter where we go—to work, to the doctor's office or to a bus stop—there is usually plenty of seating available so that we may take a load off our feet. And even the most basic of mass-produced chairs are a welcome sight for the weary. Sure beats sitting down on a log or squatting.

Despite the incredible evolution in chair design over the past several hundred years, too many examples exist that are not comfortable and not well built nor well designed. Some, like the chairs designed by architect Frank Lloyd Wright, succeed exceedingly well on one front but fail on two others. His high-backed chairs are striking to look at, but don't look too closely at the joinery (put together by carpenters) nor even try to sit down for more than a few back-breaking minutes. My theory is that he didn't like people overstaying their welcome at his home.

One of my favorite chair designs is the Shaker rocker (see p. 118). Now here's a chair that was built for longevity, has simple, beautiful lines, and will keep you comfortable as long as you wish.

Chairs pose unique challenges. For one, a chair engages more intimately with your body. You will feel poor design in the

small of your back. A chair has to be strong to put up with occasional racking forces. And a chair (well, most chairs) has to be light enough to move around easily. To build a good chair, one must understand its engineering and ergonomics.

Despite these issues, chair making can be simplified and accomplished with the most basic of tools. You can make a crude but functional chair using nothing more than a froe to split a log, then shape the parts with a drawknife and spokeshave. If you add a lathe and some basic steam-bending tools, your chair making ability soars, allowing you to build very elegant and comfortable seating. And if you have a fully equipped workshop with the basic machines, your chair making possibilities are limitless.

Many woodworkers shy away from making chairs or even stools. Granted, there are not too many square parts to most chairs, and compound angles are somewhat

intimidating. But the articles in this book, reprinted from *Fine Woodworking* magazine, should help dispel any questions or fears you may have about chair building. Not only can you build them, you can make them better than the average commercially made models.

—Anatole Burkin,
Editor-in-Chief, *Fine Woodworking*

Chair Making Simplified

BY GARRETT HACK

Even the most basic chair must support a body comfortably and be strong enough to take lots of rocking and rolling. This likely involves angled joinery; add some grace to the design, and you're probably working with curved parts as well. A lot of woodworkers shy away from making chairs, but there are many good reasons for building them. Design a dining table or a desk, and it seems only fitting to complete the project by building the chairs, too. Dealing with angled joinery and curved parts exposes you to making patterns, full-scale drawings, mock-ups, and thinking in three dimensions. Also, chairs are great for improving hand skills such as fitting joints and smoothing curves.

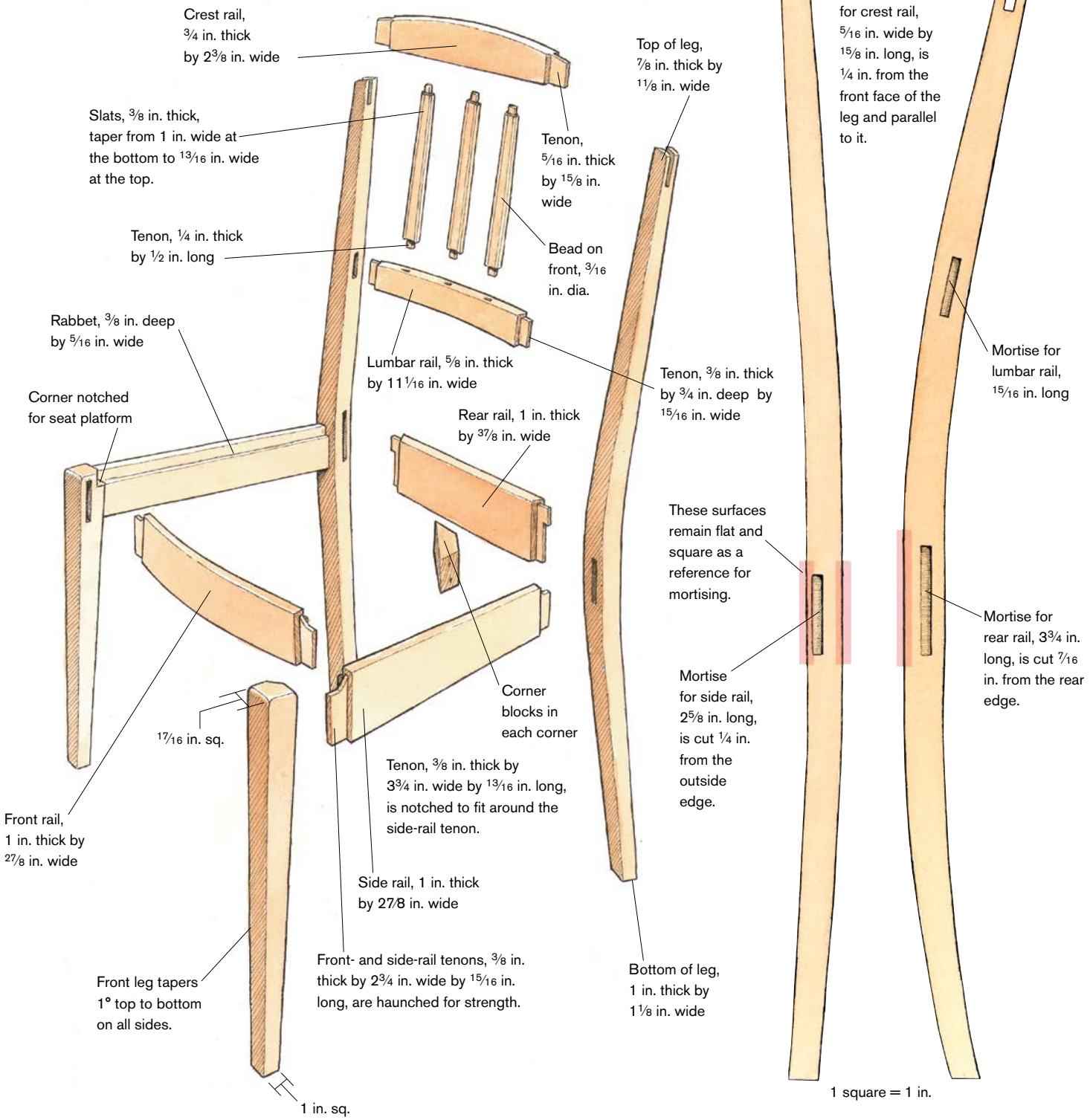
By design, this chair is not overwhelming in its joinery or curves. Build one or two, and you'll soon be tweaking the design and construction to suit your own tastes and needs.

Rather than steam-bending or laminating parts, I designed all of the curves to be sawn from 8/4 stock. To give the back a dramatic splay toward the top, I used a design trick common to chair makers: rotating the curved rear legs inward by 4 degrees. Also common to many chairs, the seat narrows toward the back to give it a graceful look and tilts slightly backward for comfort.

By carefully working out the curve of the rear legs, the tilt of the seat, and the taper and angle of the front legs, I was able to keep the joinery square in the side view, avoiding compound angles in most cases.

FULL-SIZE DRAWINGS AND TEMPLATES AID CONSTRUCTION

Building a comfortable, attractive chair is never easy, but these joints have been simplified as much as possible. Most are angled in only one direction. In the front seat rail, the curve is cut after the joinery has been laid out and cut. Make a full-size drawing and templates for each part to keep track of lengths, curves, and joinery. The lengths of the upper rails and slats are determined after the base of the chair has been built and dry-fitted.



Left Rear Leg

17/16 in. thick by 15/16 in. wide at seat rails, 37⅞ in. long

Cut Out and Shape the Legs

USING THE SIDE TEMPLATE, cut all of the legs from one wide 8/4 board to ensure uniform color (left). Lay out the legs for best grain orientation and strength (above).

This type of chair requires a slip seat, basically an upholstered platform that sits in a rabbet in the seat rails. You can make your own or just cut out a plywood platform and bring it to an upholsterer.

Choose Chair Stock Wisely

Strong and beautiful chairs can be made from a variety of woods. Mahogany and walnut have been high-style choices for centuries. Ash, maple, beech, cherry, and oak are equally good in terms of strength, although each has a unique color and grain that impact the design. Softer woods are to be avoided. For this chair, I chose white ash because of its exceptional strength along the grain and its pronounced grain pattern. However, white ash is tough to work. Cherry or walnut are more forgiving with more subtle grain patterns.

Both 8/4 and 5/4 stock are required, ideally from the same tree for harmonious color and grain. Wide stock will yield more parts with less waste if you stack the curved rear legs side by side and cut the front legs from the odd shapes in between. Plan on cutting extra legs for trial setups and for backup in case of miscuts. Grain that follows the outline of the leg is ideal. Avoid wild grain that angles sharply off edges and defects that might weaken parts.

Make Full-Scale Drawings, then Patterns

To help manage all of the parts and joinery in a chair, a full-scale drawing that includes front, side, and seat views is invaluable. It's on the full-size drawing that I work out all of the curves, the dimensions of parts, and the joinery. I then make patterns and lift dimensions directly from the drawing, making fewer errors than I would by measuring alone.

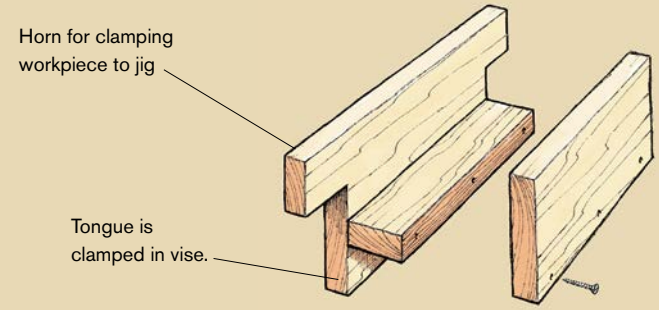
Thin wooden patterns are useful for more than just helping to cut out the parts with pleasing grain. They also allow me to

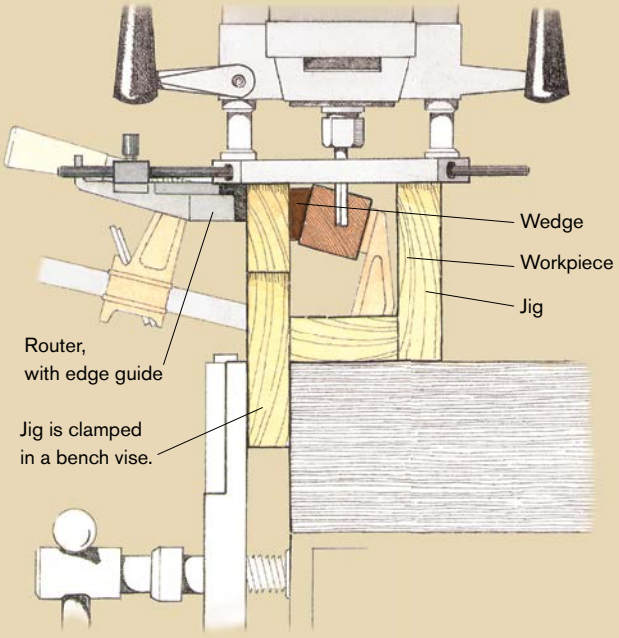
Angled Mortises Are Cut with a Router Jig

Aside from the crest rail, the mortises in this chair are angled, and the tenons are straight. Most of the mortises are cut with a plunge router, with the legs wedged at the appropriate angle in a box-type jig. The mortises are squared up by hand.

Jig Simplifies Angled Mortises

This jig is a simple, open-ended box made of thick hardwood. Small wedges help clamp the workpiece in place, with its upper face parallel with the top of the jig. The router and its edge guide ride on top of the jig.



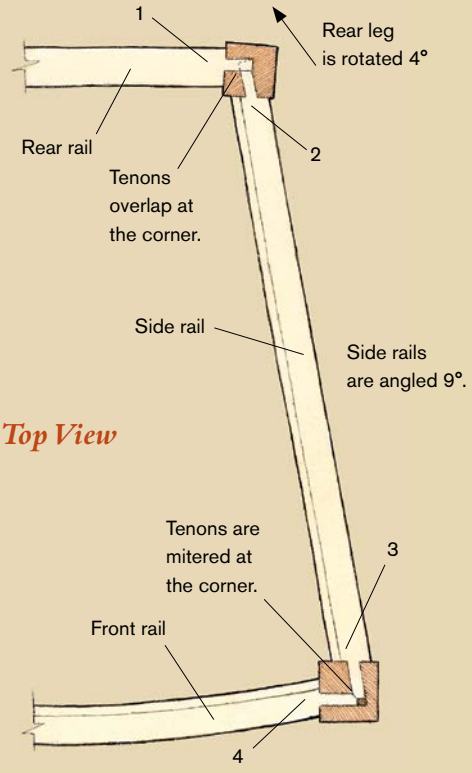


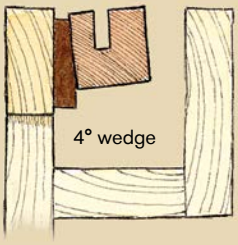
THE SIDE-RAIL-TO-FRONT-LEG MORTISE. Wedge the leg at 9° in the jig and place a block under the leg for extra support. Note where the entire box is being squeezed to hold the leg in position.

Angled Mortises are Cut with a Router Jig continued

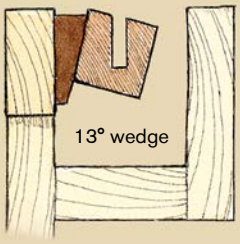
Seat-Rail Mortises

Wedges position the workpiece for the proper mortise angle. The outside face of the leg is placed against the wedge, and the top face is parallel to the top of the jig, lengthwise.

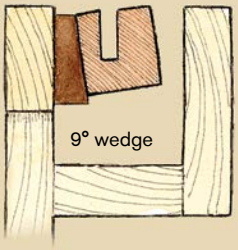




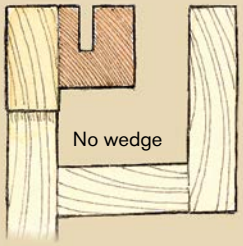
1. Rear rail to rear leg



2. Side rail to rear leg



3. Side rail to front leg



4. Front rail to front leg

Lumbar-Rail Mortises

THE CURVED, ANGLED BLOCK (foreground) is necessary for firmly clamping the curved rear leg in the jig and setting the mortise angle at 4½°.

Crest-Rail Mortises

THE OPEN MORTISE for the crest rail must be parallel to the front face of the leg. Cut it on the tablesaw using a tenoning jig and a dado set. An extra block prevents tearout at the back of the cut.

refine the shape of each part before cutting into my stock. And it is on the pattern where I mark out the locations of the joinery for transfer to the actual legs. Later, when fitting the crest and lumbar rails to the rear legs, I use other, simpler patterns to get the angles of the shoulders and tenons right. In the end, the stack of patterns becomes a record to refer to if I build this chair again.

Cut Out and Shape the Rear Legs

Cutting out the rear legs requires two patterns: one for the side view and another for the front view. Both include reference surfaces (see the leg templates on p. 5), which are flats where joints are cut and flats that help orient the leg when mortising.

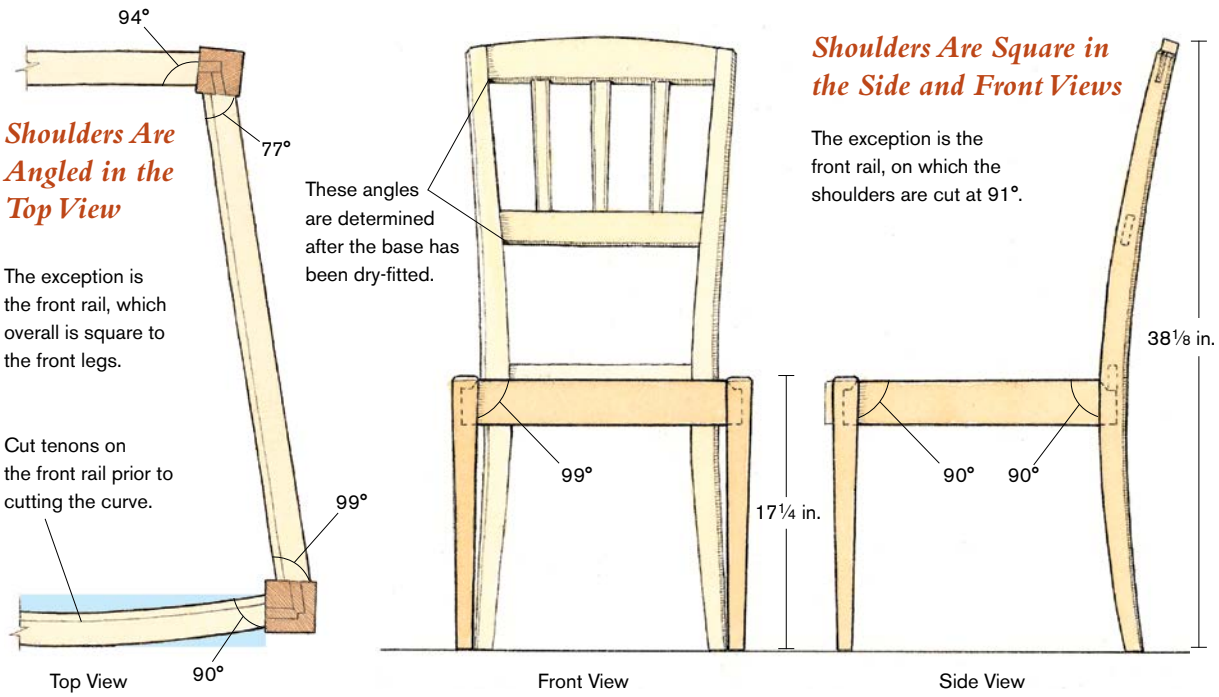
On 8/4 stock, lay out and cut the side view first. I cut each of the legs from the rough plank to yield parts as thick as possible and to avoid the labor of milling what will be waste. Bandsaw the legs about ¼ in. oversize in width and about 1 in. extra in length. Joint and thickness the rear legs to 1¾ in., retrace the pattern (which you can shift a little to improve the grain), and bandsaw, just leaving the layout line.

There are no tricks to shaping the rear legs; just compare the pattern and leg, and plane and spokeshave off the high spots. Use the bandsaw marks to guide you, taking them off evenly, as they should be square across the surface. Pay particular attention to the reference surfaces, keeping them flat, square, and precisely aligned with the pattern. Before cutting the rear legs in the front-view profile, lay them face up and choose the best right and left legs from the pair. Then trace the front-view pattern, bandsaw, and smooth the shape with a plane and a spokeshave.

Now, Cut and Taper the Front Legs

The front legs on this chair are tapered on all four sides from the top to the bottom, unlike some other chairs that have flat areas at the top for a simpler joint with the rails.

CRITICAL ANGLES



Tenons Are Shaped on the Tablesaw

The tenons are straight on every piece except the crest rail, but all of the shoulders are angled in one direction or another to mate with the mortised pieces. Lay out every joint clearly to avoid mistakes when setting up and orienting parts on the tablesaw.

LAY OUT THE ANGLED shoulders. On the front rail, the shoulders are square in one direction (left). But a bevel gauge set to the angle of the leg taper (1°) is necessary for laying out the vertical shoulders (right).

CUT THE CHEEKS FIRST. Use a tenoning jig on the tablesaw and stay shy of the shoulder lines.

NOW CUT THE SHOULDERS. Set the miter gauge to 1°, being careful not to angle the cut in the wrong direction. The curve is cut after the joinery has been completed.

DRY-CLAMP THE SEAT FRAME. **After hand-fitting all of the joinery in the seat frame, clamp it together and fit the upper cross-pieces to the actual chair.**

One advantage of the unbroken taper on all sides is that the best-looking faces can be chosen after tapering the leg. Plus, I believe the unbroken taper gives a more refined look to the chair.

On the front rail, cut the tenon shoulders at an angle (1 degree) that will make the centerline of the front legs plumb.

Join the Seat Rails to the Legs

To add strength to this chair, the side rails should be 1 in. thick. The extra thickness will be hidden beneath the seat, but it allows for large and strong tenon shoulders. Cut the front rail out of 8/4 stock so that it can be shaped into a pleasing outward curve after cutting and fitting the joinery.

The key to a good chair is tight-fitting joints. Sloppy or undersize joints are going to fail eventually. I've repaired lots of those chairs. It's not too much trouble to haunch the tenons that go into the front legs for maximum resistance to racking forces. On the other hand, the rear tenons can be nearly full height with only small shoulders on the top and bottom to hide any slight defects in the mortise. The tenons on the front and side rails are mitered together inside the legs for maximum length and strength. To strengthen the mortises, I made the front legs a bit higher than the rails and then rounded their tops. In the rear, the side-rail tenons, which are the most critical joints in the chair, are cut to the full depth of the mortises. The wider rear-rail tenons are notched around them.

Angle the Mortise, Not the Tenon For the most part, both angled and straight tenons are equally strong, except for an extremely angled tenon with weak short grain. That said, I chose straight tenons rather than angled ones for this chair because I knew I would make fewer mistakes laying out, cutting, and fitting them. Basically, every tenon is in line with

its workpiece. Also, it is just as easy to cut angled mortises with a plunge router and a box-type jig as it is to cut angled tenons on the tablesaw.

However, there is one part that must have angled tenons: the crest rail. For the best appearance, the open mortises in this bridle joint must be square to the tops of the legs, an angle that requires angled tenons. But I have a neat way for laying out these tricky tenons.

Cut the Mortises First with a Router Jig

The router jig for the mortises is a simple, open-ended box made of thick hardwood. The parts are clamped inside with their upper face parallel with the top of the jig. Various wedges and angled blocks are used to locate and clamp the legs in the proper positions. Then the plunge router rides along the top of the box, with its edge guide riding the outside edge. Afterward, the ends of the mortises are squared by hand to accommodate square tenons.

Cut all of the chair's mortises before any of the tenons. Use the leg patterns to lay out the top and bottom of each leg and the location of each mortise, including the ones for the lumbar rail. Each mortise has a face that it is cut into and an adjacent reference face that is clamped against the mortising jig. At the top, leave the front legs long by at least ¼ in. to strengthen the mortise while fitting the rails (when a little extra twisting could split it).

One important tip: Because most of these mortises meet another mortise inside the leg, the bottom of one mortise is the side of its neighbor. Thus, cutting a mortise too deep weakens the adjacent joint by cutting into some of its cheek glue surface. To keep the joints strong, set the router depth to come up a bit short for both mortises, then chisel away by hand the small step left at the bottom.

Tenons on the Tablesaw A ⅜-in.-thick tenon on a 1-in.-thick rail is a good compromise between tenon strength and ample shoulders. Cut only the seat-rail tenons at this time; hold off on the upper crossmembers. There is no telling exactly what the dimensions and angles will be in the upper part of the chair until the bottom has been joined and dry-fitted.

Before cutting the tenon cheeks on the tablesaw, clearly mark the shoulder angles with a pencil. Also, remember that the front rail's tenons will be set back from its front face to allow for later shaping. Cut the cheeks with a tenoning jig on the tablesaw and cut the shoulders using a miter gauge, with the blade and miter gauge angled as necessary. Cut very close to the layout lines but leave a little extra for fitting by hand.

Another important tip: There are a lot of angles to deal with and a lot of parts to flip around in various positions on the tablesaw. To avoid mistakes and to be sure the cut is going in the right direction, make an intermediate cut well shy of your layout line when you get each part into position.

To miter the tenons within the front-leg mortises, assemble a rail and leg. Then reach in through the opposite mortise and mark the beginning of the miter. Next, take apart the joint and hand-cut the miter from this line to the tip of the tenon so that there is no chance of the miters meeting inside and keeping the shoulders from coming up tight. Do the same thing in the rear legs, where the rear-rail tenons must be notched out to butt against the side-rail tenons.

Fitting and Sculpting the Seat Frame

After the joinery has been fitted on the seat rails, the front rail can be shaped into its curve. Make a pattern from the drawing, checking that it is symmetrical around a centerline. Trace the outside curve on the rail, bandsaw close to the line, and smooth it into a fair curve. Then bandsaw the inside of the rail parallel with the outside curve,

Dry-Fit the Base, then Build the Back

The rails and slats in the upper part of the chair (the chair back) are fitted to the rear legs after the base of the chair has been assembled and dry-fitted. The rails go in first, then the slats are arranged by eye and fitted to the rails.

1. FIT THE LUMBAR RAIL

MAKE A PATTERN FOR FITTING the lumbar rail. Plane the ends of the template until it rests perfectly at the base of the lumbar mortises. This is now a record of the shoulder angle and the location of the tenons.

DETERMINE THE VERTICAL ANGLE of the shoulders. With the pattern resting at the base of the mortises, use a bevel gauge to record the angle. Align the gauge's fence with the opposite mortise to keep it in line with the workpiece.

LAY OUT THE TENONS. Use the pattern to lay out both the tenon shoulders and the beginning of the cheeks. These tenons are straight. Then use the bevel gauge to lay out the vertical shoulders.

leaving it the same thickness as the other seat rails. To accommodate a slip seat, cut a rabbet around the front and side seat rails. This can be done on a router table with a small curved fence or a bearing-guided rabbeting bit. To see where the rabbets hit the front legs, dry-fit the seat frame. This is where the front legs must be notched to accommodate the seat platform. Do not glue up the seat frame yet.

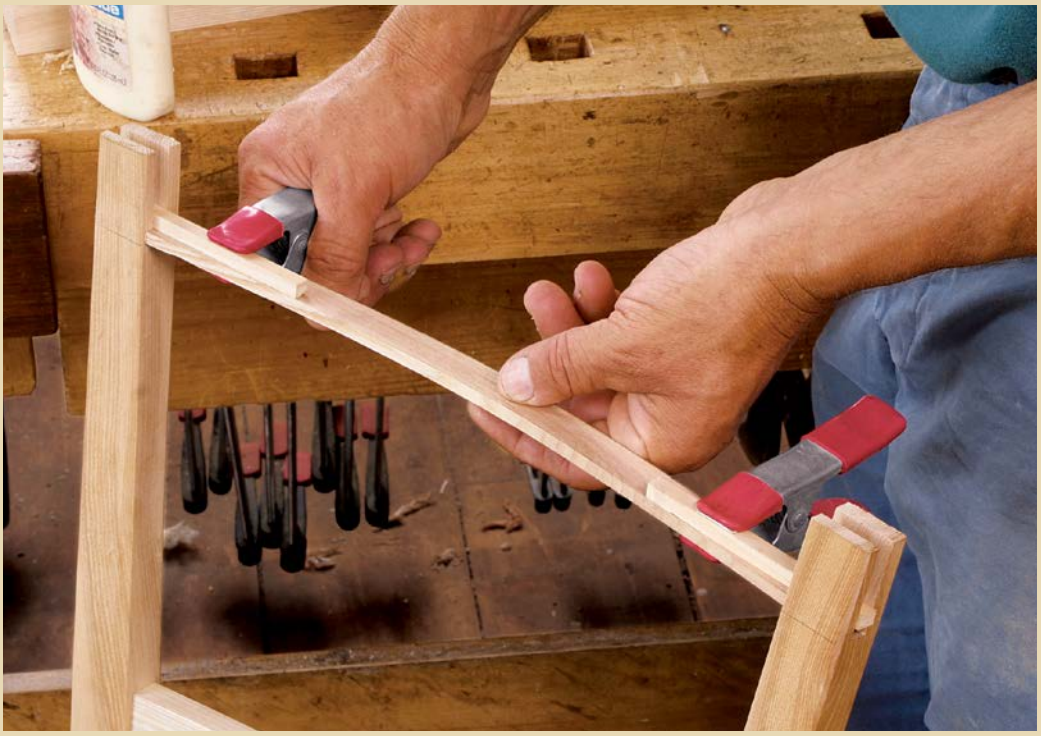
Fit the Back in Steps

The next job is to cut and fit the lumbar rail, the crest rail, and the three small slats. One of the advantages of the bridle joint on the crest rail is that the slats can be fit last, after the rest of the chair has been glued up.

First, cut the open mortises for the crest rail on the tablesaw with a tenon jig and dado blade. These deep slots are cut parallel to the front faces of the legs. Clear layout lines will help prevent mistakes.

Cut and Fit the Crossmembers Because of the curve of the rear legs and the splay between them, the length of the lumbar rail and crest rail and the angles of their tenon shoulders can't be read easily from a

2. FIT THE CREST RAIL



AN ADDED TWIST for the crest-rail template. These tenons are angled, so after fitting the pattern between the legs to find the shoulder angle, fit mock tenons into the mortises and glue them to the pattern.

LAY OUT THE CREST-RAIL tenons. Use the pattern to lay out the cheeks and shoulders. Flatten one side of a pencil to ensure an accurate transfer.

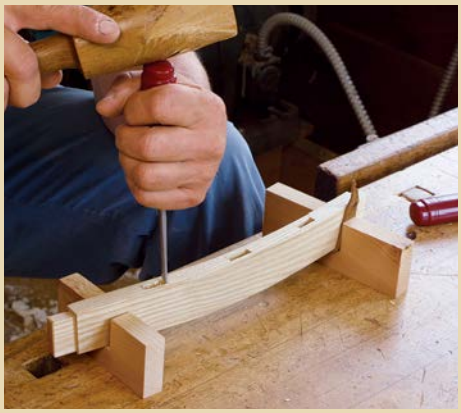
drawing. I use patterns to determine these. The crest rail is the only part with angled tenons. These require a new twist on the template technique to record the angles and location of the tenon cheeks. The crest rail is exposed, so it is critical to get a good fit. Last, cut the curves in the crest and lumbar rails using a pattern.

Cut and Fit the Three Slats Make the slats and form their delicate beads, leaving them a bit long. Then clamp them in front of the crest and lumbar rails. When you have their positions right, make lines on the slats for the shoulder angles and tenon locations; then lay out the mortises and the overall angle of each slat on the lumbar and crest rails. A router setup is cumbersome, so lay out the mortises, drill out the waste, and chop them by hand.

Now you can assemble and glue everything but the crest rail and slats. Place glue to get no squeeze-out, as this is easier than trying to clean up dried glue later. Glue up the chair sides first, then connect them with the front- and rear-seat rails and the lumbar rail. Measure the diagonals between the lumbar rail and seat rail to check that the assembly is true.

3. FIT THE SLATS

CLAMP ON THE SLATS to find a pleasing array. Then mark their angles and tenon locations on the lumbar and crest rails.



DRILL OUT THE WASTE and chop the mortises in the lumbar and crest rails by hand. Fitting the slats and the crest rail is the most challenging part of the construction, as all must seat simultaneously in their mortises.

Fit the shoulders and length of the slats between the crest and lumbar rails. This is tricky because the crest rail must bottom out in its mortises at the same time the shoulders of the slats are butting up tight to the lumbar rail and crest rail. If you cut one of the slats too short, you can drop the entire crest rail by deepening its mortises in the rear legs.

Now glue up the crest joints and slats. Glue blocks, fitted carefully into each corner of the seat frame, will stiffen the chair considerably and offer a convenient place to secure the slip seat. Finish and wax the chair. Finally, make the slip-seat platform slightly smaller than the space within the rabbets to accommodate two layers of fabric wrapped around each edge.

Building this chair will not be as hard as you think. If you tackle it in steps—with drawings, patterns, and patience—the joinery will come together fine. Build one chair, and you'll build another.

GARRETT HACK is a contributing editor to *Fine Woodworking* magazine.

Compound-Angle Joinery

BY WILL NEPTUNE

For me, chairs are easily the most satisfying projects to build, but students often are puzzled by the compound-angle joinery between the legs and seat rails. I learned how to draft, lay out, and cut these joints when I was a furniture-making student years ago, and now I teach it at North Bennet Street School. Once you answer two critical questions—"Where do the layout lines come from?" and "How do I get the layout lines on the wood?"—you'll see that cutting these joints isn't all that hard. What's more, once you understand how to cut compound-angle joinery, cutting joinery with a single angle becomes simple.

Recently, I built a set of Chippendale chairs. Most Chippendale chairs—and a lot of other styles of chairs—have rear legs that cant inward as they go toward the floor but front legs that are perpendicular to the floor line. Although this design lends a refined sense of upward motion to a chair, it also introduces a fussy situation when it comes to joining the rail to the back leg. To allow for the cant of the legs and the trapezoidal shape of the seat, most of the time you'll have to cut compound-angle tenons between the legs and seat rails.

It is tempting to angle the mortises, in either the plan or elevation, to simplify the tenon problem. In the first case, the mortise would angle in the plan view at the seat-frame trapezoidal angle. In the second case, the mortise could be cut square to the back rail in front elevation to correct for the cant angle. Both of these moves force you to shorten the back rail tenon, which would weaken this critical joint.

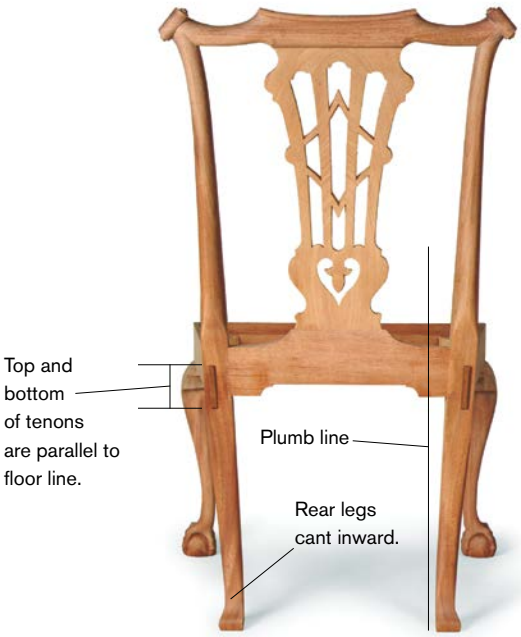
Both historically and for chair making today, I think compound-angle tenons represent the best possible technical solution to this problem. Once you have a system for laying out these joints, cutting them is not that difficult.

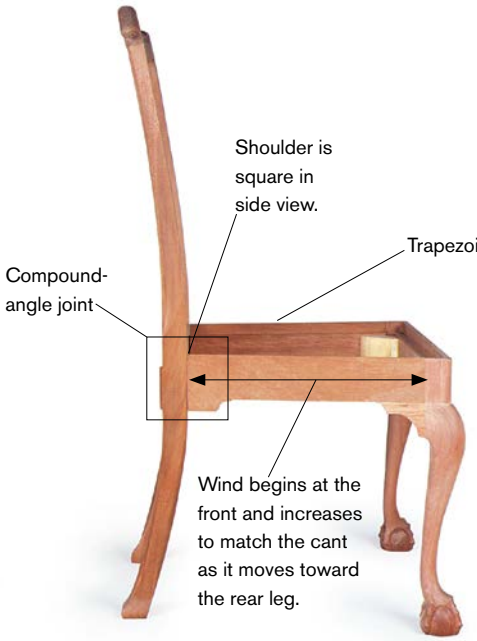
Draw Simple Elevation and Plan Views

No matter what style chair you're building, there are two angles to consider: the cant of the leg, seen in a front elevation, and the seat-frame trapezoidal angle, seen in a plan (overhead) view. Start by doing a partial drafting job, just enough to get the information you need for layout.

First draw the leg from a front view and show the mortise. The mortise in the rear leg should be as far to the outside of the leg as possible without sacrificing the thickness of the mortise walls. The mortises can be cut square and slightly short in length, then chiseled to the correct angle at the top

CAREFUL TENON LAYOUT IS KEY

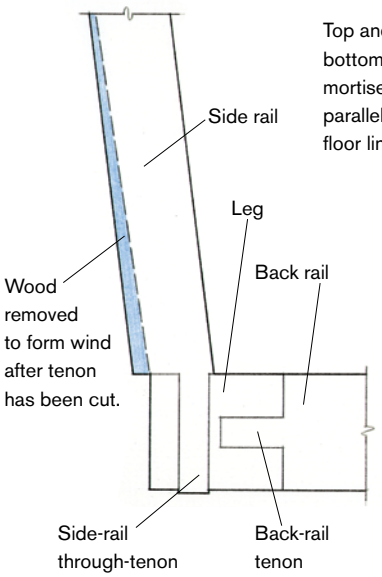




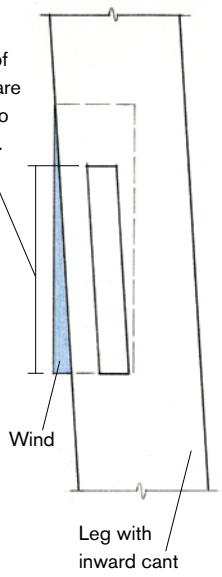
The Chair

The side-rail to rear-leg joint on a Chippendale chair—and many other types of chairs—must account both for the trapezoid-shaped seat and for the cant angle of the leg, making it necessary to cut and use a compound-angle tenon.

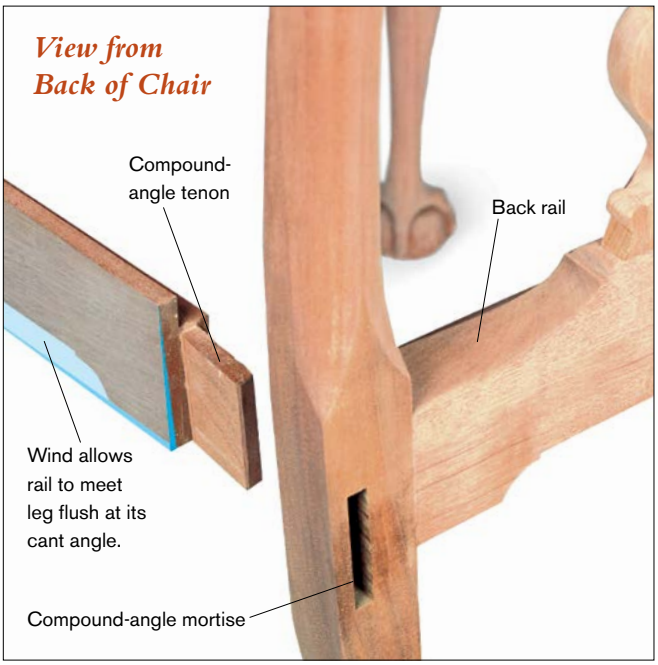
Plan-View Section



Rear-View Section



View from Back of Chair



The Drawing

I teach students to lay out this joint with only two partial drawings—a plan (overhead) view at the bottom edge of the side rail and a front elevation view. This article will show you that simple drawings are all you need to know to cut this joint.

The Joint

Although the joinery looks intimidating, the drawings make it easy to transfer the layout lines to the rail. Once the layout lines are in place, it's simply a matter of cutting the joint—by handsaw, bandsaw, or other means.

COUNTRY CHIPPENDALE–IN ANY STYLE. **Made of curly maple, Mary Conlan's Chippendale chair of simple form (below) is built using the same leg-to-rail joinery as a more flashy, high-style chair.**

FEDERAL PERIOD–IN THE HIGH STYLE. **Made by Steve Brown, this heart-back Hepplewhite design has curved seat rails and more complex shaped legs, but the leg-to-rail joinery is the same as the Chippendale chair below right.**

CHIPPENDALE–ONE JOINT, MANY CHAIRS. **No matter what kind of chair you're building, if your back legs are canted and your seat is trapezoidal, you'll need to use compound-angle tenons to join them, as was done with this Chippendale chair by Rich Heflin.**

and bottom, making the mortise a parallelogram. Cutting a mortise in the shape of a parallelogram not only helps you register the rail, because it makes the rail's top and bottom edges parallel to the floor line, but it also makes the through-tenon look better from the back of the chair.

Transferring information from the elevation, draw the sections of the leg at the bottom of the rail. Then you can draw the side rail and its angle. Notice that the side rail must be thick enough to allow wood for the top outside corner as well as the bottom inside corner, as seen in the elevation drawing on p. 17. I also like to have extra rail thickness to allow for a shoulder at the bottom inside corner.

First draw the line representing the outside face of the rail blank and its angle. Here I'm assuming that the outside face of the rail lands flush to the top of the leg, but you could leave a shoulder if your design calls for it. Then draw a parallel line showing the bottom inside face of the rail, choosing a rail thickness that will allow for an inside shoulder of 1/16 in. to 1/8 in.

As a last check, draw a detail of the top section of the leg in plan view. I draw this as if the leg mortise runs all the way up to the top edge of the side rail. Extend the line that represents the outside face of the rail back through the leg to be sure that the tenon lies within the thickness of your rail.

This construction has the side rail forming a simple angle, which leaves wood sticking out from the canted leg on the outside. These surfaces will be reconciled by fairing a wind into the outside face of the rail once the joinery has been cut. The front end of the rail is left alone for the leg joints, so the rail starts plumb at the front and develops a wind that becomes the cant angle of the rear leg.

To show this, draw a dotted angled line from the bottom outside corner of the rail

out toward the rail's front end. This transfers the information from the elevation onto the plan view (as in the drawing on p. 17). The plan view is simplified but contains all of the crucial points seen in the elevation. These two drawings provide the information necessary for laying out the joint.

Follow the Drawings to Lay out the Joint

To make the layout easier, I pretend the mortise is extended up to the rail's top edge. Once the tongue of the tenon has been cut using the method of your choice, it will be easy to shoulder down the tenon to match the real mortise (see p. 22).

Extend the lines of the mortise opening up to where the edge of the rail will land. From the bottom inside corner of the mortise, square up a line to the top edge of the rail. Where these three lines cross the top rail edge will become the source of the layout information.

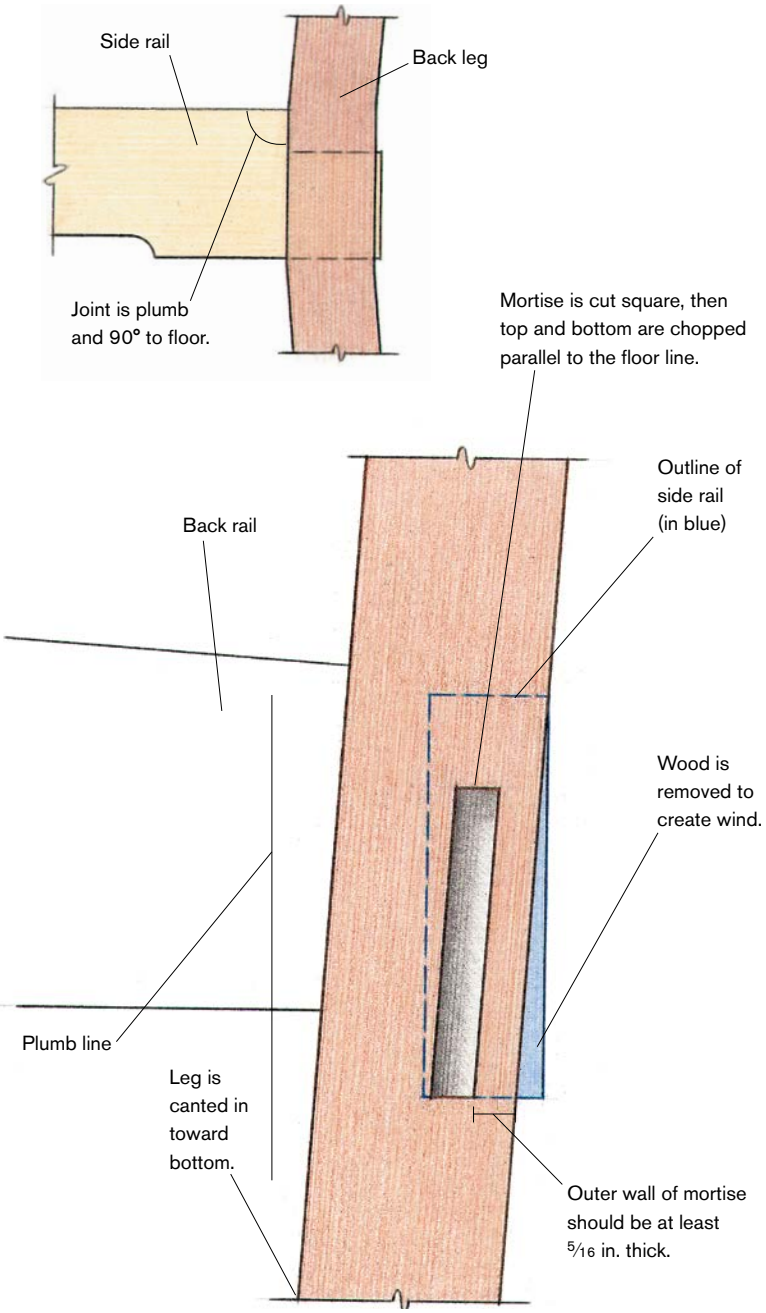
The important thing to realize is that the information seen here is true only at one location along the rail: the plane of the shoulders (see the plan view on p. 17).

On the inside face of the rail, square a line across that shows the correct shoulder location, measured in from the end. Here I've left extra length for later cleanup. Then, using a bevel gauge set to the seat angle, run the shoulder lines across the top and bottom edges of the rail. These should then connect with another square line, up from the outside face of the rail, describing the plane of the shoulders. Your drawing should now show the location of the tenon at this plane (see the drawing on p. 21).

Working from the elevation drawing, set a marking gauge to x and mark this distance across the top and bottom shoulder lines, measuring from the inside face of the rail. From the mark on the top edge, use a pair of dividers set to the distance y to make another mark along the shoulder. The new mark on the top edge and the first

Lay Out and Cut the Mortise

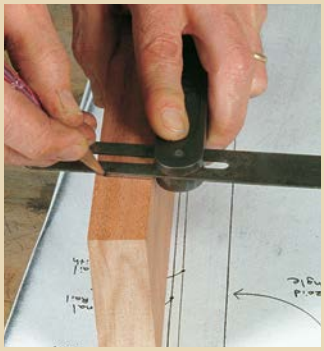
Set the mortise to the outside of the leg as far as possible, taking care to see that the outer mortise wall is at least 5⁄16 in. thick for strength. Lay out and cut the square mortise parallel to the side of the leg. Then chop the top and bottom of the mortise parallel to the floor line, making the mortise a parallelogram. The rail joins squarely to a flat section of the leg; cut a wind to keep it flush.



Consider Length and Seat Angle when Laying Out Tenon Shoulders

While the joints at the front of the chair are simple angles, compound-angle joints are required where the side seat rail joins the back leg. Use simple full-size drawings to determine the angle of the top and bottom tenon shoulders at the back of the seat rail. Then transfer measurements from the drawings to the rails.

1. FULL-SIZE DRAWINGS HELP YOU TO AVOID ERRORS. **Working from a full-size plan (overhead) view, set the bevel gauge to the angle between the back rail and side rail on the seat frame.**



2. LOCATING THE TOP AND BOTTOM SHOULDERS. **Register the bevel gauge against the line for the inside shoulder, then mark the bevels at the top and bottom of the rail. Check that your angles match those in the drawing.**

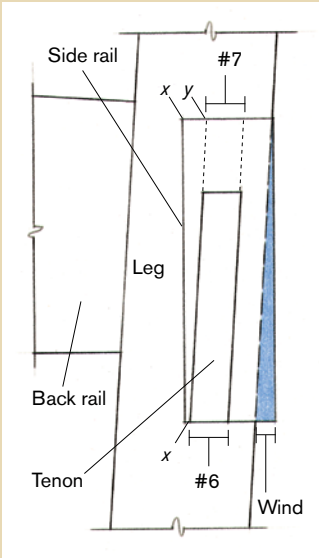
3. MARKING THE FIRST FACE. **Set the side rail into place over the drawing (make sure there's enough stock for the full tenon). Make a tick mark on the bottom inside corner of the side rail, and pencil in the shoulder line on the inside face.**

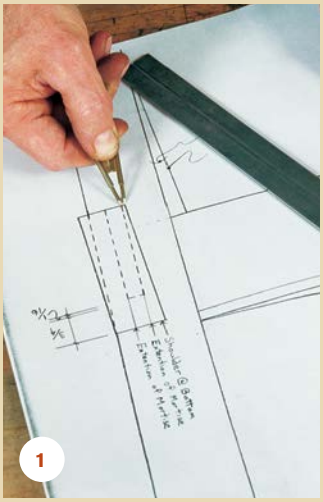
4. KNIFE MARKS ARE MORE EXACT. **Once the tenon shoulder has been correctly marked, knife-mark the lines on all sides of the rail. The knife marks provide a specific line to pare or shoulder-plane to.**

SECTION AT RAIL BOTTOM

Carefully Lay Out the Angled Tenon on the Stock

Laying out and cutting angled tenons is a methodical process, but it's not a difficult one. Work from simple but accurate drawings and mark out each measurement from a single reference line on both the top and bottom of the tenon.





1. Use a simple elevation drawing, as seen from the front of the chair, and set dividers to *x*–the distance from the bottom inside corner of the rail to the inside corner of the tenon.

2. Set a marking gauge to the distance *x* between the inside face of the rail and point *x* and scribe a line across the top and bottom shoulders from the inside face of the rail.

3. Set the dividers to the distance between *x* and *y*.

4. Use the divider setting from step 3 to locate point *y* on the top edge of the rail, measuring from point *x*.

5. Set the dividers to match the mortise width on the rear leg of the chair itself.

6. From point *x* on the bottom of the rail, transfer the width of the mortise.

7. With the dividers still set to the mortise width, measure from point *y* to mark the tenon width at the top of the rail.

8. Tenon cheeks are marked perpendicular to the shoulder line by registering a square against the bevel gauge–which is still set to the trapezoidal seat angle.

9. After the top and bottom of the tenon have been marked, use a straightedge to connect the points and complete the layout.

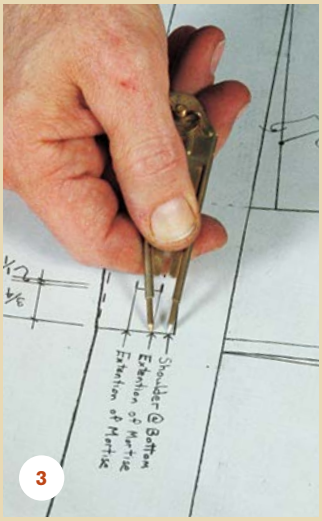
10. After knife-marking the shoulder lines, cut the tenon and shoulders with a backsaw, then trim to fit.

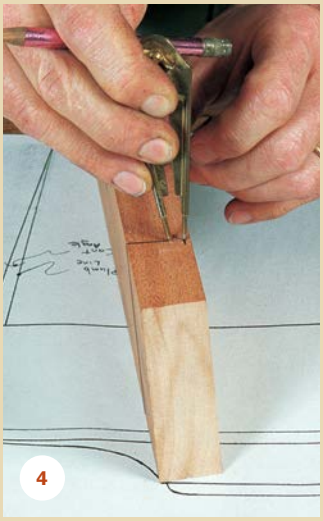
mark on the bottom edge locate the inside cheek of the tenon. From these marks, transfer the size of the mortise to locate the outside tenon cheek.

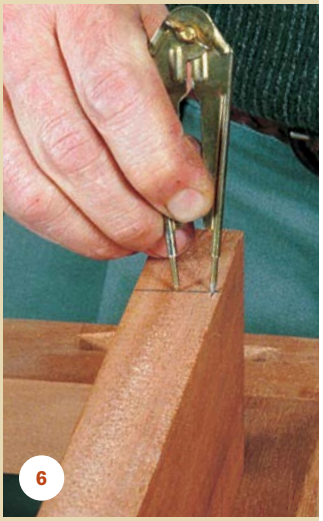
This may sound confusing, but all you're doing is converting the cant angle to a rise/run problem. The rail width is the run, and y is the rise. The reason for the initial marking gauge line is that it's more difficult to measure from a corner using dividers. The goal here is not just to get a tenon that fits—the rail should also land on the post at the correct location and project at the trapezoidal angle.

Once the base of the tenon has been located, the plan view (see p. 17) shows the next move. The tenon is simply square to the shoulder. Clamp the bevel gauge to the rail and square all four tenon marks out to the end of the rail. Once you've connected

Carefully Lay Out the Angled Tenon on the Stock continued







these lines across the end grain and knife-marked the shoulders, layout is complete, for now. Once the tenon cheeks and the side shoulder have been planed, the top shoulder can be marked out and cut. After fitting the tenon, mark the wood to be faired directly from the leg (see the photos above).

Make Practice Cuts in Scrap before Cutting the Real Joint

One very direct way of cutting a compound-angle joint is with a handsaw. First the cheeks would be sawn in the ordinary way. The only tricky part is remembering that the shoulder cuts are at different depths on each edge. Begin sawing with the shallow edge facing you, and avoid cutting into the tenon.

TAKE IT SLOW. The author uses a shoulder plane to trim the cheeks, checking the tenon frequently against the mortise until he has a tight fit. He then trims to the layout lines with a shoulder plane.

A bandsaw is good for cutting the cheeks, too. Setting the table for the cant angle (remember to keep track of lefts and rights), you can follow the cheek lines on the top edge and the blade will follow the cant angle on the rail's end.

The tablesaw can probably get you closer and thus avoid a lot of cleanup with hand tools, but the explanation is a story all by itself.

Whatever method you use, lay out with pencil first and confirm that you have things correct. Often, the cant and seat angles are close enough that it's easy to grab the wrong bevel gauge during layout. The shoulder won't look bad, but the front legs will be way off. It's also possible to get the lefts and rights mixed up and lay out the correct angle in the wrong direction. These mistakes make for a long day, so when in doubt, mill a practice rail and check both your layout and cutting method. Once the joinery for the back end of the chair has been cut, the simple angles on the front ends of the rails will seem easy.

WILL NEPTUNE teaches furniture making at North Bennet Street School in Boston, Massachusetts.

Marking Out the Wind

Once the tenon has been cut and fitted, dry-fit the joint tightly and mark out the section of the rail that needs to be planed away. Notice that there is no material removed at the front of the rail.

ESTABLISH LAYOUT LINES. Connect the bottom line of the wind with the bottom front corner of the rail. Planing to this line gives you an even wind and lets the rail meet flush at both the front and back legs.

Working Green Wood

BY HARRIET HODGES

Green woodworking delights our desire for thrift and speed. In a few days, you can fashion a chair from the forest. The tools are few, the techniques simple, and the work satisfying. Green wood is simply wood that's still in possession of most of the moisture it had when it was a tree. This moisture makes the wood much softer and more responsive so that working it is pure delight. It's also a lot easier: The froe, drawknife, spokeshave, brace, and auger bit—the main tools of the green woodworker—all respond much better to wood that is not yet dry and brittle. To use these tools on green wood is to understand how simple cutting tools are meant to respond. While still wet, hickory peels like a carrot. Dry, it rings like stone.

Why bother, though? Machine tools have taken much of the labor and difficulty out of working dried woods. But there are several reasons why a woodworker in the 21st century should be interested in a technology that's more than 1,000 years old, and they all hark back to the essential nature of wood itself. A woodworker uses a drawknife to dimension green stock to follow the plane of one of the tree's growth rings. That maintains long, continuous fibers. These bundles of long fibers are strong: Because there are no severed bundles (short grain), there's no danger of any portion of a drawknifed spindle, for example, shearing or springing under stress. A Windsor chair, belying its delicate lines, can take a terrific beating (see the photo on p. 26).

Another reason green woodworking has endured is that phenomenally strong joints are possible. Green-wood joinery takes advantage of the high moisture content of freshly felled trees (or well-preserved tree sections, more on this later) and of the fact

A SHAVING HORSE IS IDEAL for green woodworking. Other holding devices will work satisfactorily, but with the shaving horse, you can flip the workpiece around instantly and repeatedly so that you're nearly always cutting with the grain.

that wood shrinks much more in the tangential plane than in the radial plane. Wet-dry joinery takes a stretcher or spindle, dries it for a short while in a makeshift kiln, and then inserts its tenoned ends, properly oriented, into properly situated mortises in the still wet legs or seat. This kind of joinery relies more on the nature of wood than on the strength of the glue for its longevity. As the two parts reach equilibrium in moisture content, the joint becomes tighter. A dry tenon in a wet mortise is a joint for the ages.

Another advantage of working green wood is the ease with which it can be bent. Green wood bends readily as long as your bending stock is free of defects. That's because it hasn't had the chance to dry out, and kiln drying hasn't baked the wood and set the lignin.

One of the most satisfying aspects of green woodworking for me is to take what many would consider no more than firewood—logs in their raw form—and make of it something as refined as the Windsor chairs I build professionally. It's an elemental process, from felling a tree and bucking it into lengths, to riving blanks for the various parts and squaring up those blanks with a drawknife, to shaping the parts and attending to the joinery. Then a bit of sanding, a couple of coats of milk paint, and you have a unified, elegant whole, a strong, handsome chair that will last for generations.

The best way to learn the basics of green woodworking is to take a course with a good teacher. The hands-on experience will give you the confidence to dive in. I learned most of what I know from Curtis Buchanan in a class I took a number of years ago and a private tutorial a year

later. But if you can't afford a class or don't have the time, you can still learn the process on your own. The craft is forgiving, and you need no jigs, just good eyes and hands.

Getting Logs

The first thing you need to do is get some stock. Fortunately, this is simple and cheap in most parts of the country. You want logs. Look in the local paper for a firewood dealer or check the yellow pages for a sawmill nearby. Or if you live in a rural area and have a truck, many farmers will let you cut your own for a lot less than you'd pay even a firewood dealer. If you're going to cut down your own trees, look for perfectly straight boles with no limbs. Make sure there aren't any bark striations or irregularities revealing twisted grain or buried knots. If your project involves bending, you'll do best to get a hickory, white-oak or red-oak log. Other trees that bend well are beech, birch, and ash. Sugar maple is ideal for many purposes, particularly for turned legs (it takes crisp, sharp detailing), but beech, red maple, birch, walnut, cherry, and almost any North American hardwood is fine.

Your log should be freshly cut, no more than a week old. After that, checking starts, and you lose useable stock. Logs should be crosscut to no longer than 5 to 6 ft. for easy handling, though there are exceptions. A settee, which has the longest bent member of common Windsor designs, requires nearly 7 ft. for the rough back blank. I've also found that trees in the neighborhood of 12 to 14 in. dia. are just about right. Smaller trees can also yield good stock, but often, by the time you rive (split) off the sapwood and the pith, neither of which is particularly desirable, you will get no more than one blank from each pie-slice-shaped wedge that you split out, which makes it kind of a waste. At the other end of the spectrum, a great hickory tree came down when Hurricane Hugo blew through our neck of the woods. At nearly 30 in. across, there's plenty of useable wood, but moving sections around is all but impossible.

For stock that won't be bent, I crosscut bolts, or short log sections, fairly close to their final length as spindles or legs or whatever. For your bending stock, you want no more than 15 growth rings to the inch; eight is about ideal. This may seem counter-intuitive, but for ring-porous hardwoods (oak, ash, hickory—all your best bending woods), the greater the ring density, the higher the proportion of weak, large-pored earlywood to overall tissue.

Bending wood must be virtually perfect: If the first log you split for bending doesn't split easily into quarters to reveal perfectly straight grain, try another log. You can

WINDSORS ARE THE ULTIMATE expression of the green-woodworking tradition. They're tough, resilient chairs, making up in engineering what they lack in mass. Shaved components with long, continuous fibers; wet-dry joinery that mechanically locks the various parts; and choosing specific woods for specific uses all contribute to the chairs' great strength.

Preparing Green Stock

GREEN-WOODWORKING STOCK is cheap and easy to prepare (far left, top). Log sections can be split out by driving a wedge into the end and then leapfrogging wedges in the crack that opens on the sections' inner face.

A FROE AND CLUB WORK well to separate sapwood from heartwood (far left, bottom). Although the sapwood can be used, its moisture content differs from the heartwood, which could result in uneven or unpredictable shrinkage.

A FORKED LOG, called a brake, holds a wedge-shaped section upright (left) while the author removes bark, sapwood, and pith and rives the section into rough chair-part blanks.

always use sections of the first log between defects for shorter pieces. Just don't kid yourself about bending flawed stock. Bending perfect wood is quick and easy. Bending stock with even a pin knot usually turns out to be a waste of all the effort you put into shaping the bending blank.

Preparing Green Stock from Logs to Square Blanks

The absolute minimum in tools is a steel maul and three wedges, but a froe and club work well on smaller stock and will make the job more pleasant. Starting with a log, you position a wedge with one hand at the center of the log and strike it. Follow the split back with other wedges, leapfrogging them as one loosens the other. Then repeat with each half, quarter and so on, starting the splits at the log ends (see the top left photo above).

When your log is down to manageable pie-slice-shaped wedges, move one to a brake (a propped-up horizontal portion of a forked tree), as shown in the photo at right above, or brace one end against another tree. The nice thing about the brake is it holds a pie-shaped piece well. Mark the end of each piece to be rived just where you intend to make divisions. Always mark divisions and begin splits from the smaller end of a log section; that way, if it wanders, you won't end up with a piece that's too small. If you need a 1-in.-sq. piece for a chair back, try for 1½-in.-sq. pieces until you can do that consistently and have a good feel for how a log will split. Be generous in your divisions. I've ruined a lot of

A DRIVE PLATE HELPS size tenons precisely. Simply a thick piece of precisely machined steel, the drive plate helps to match tenons exactly to the auger bit used to drill the socket mortises. Such precise joinery ensures the longevity of the final product.

pieces trying to make one perfectly good, but slightly oversized, blank into two that were "just right." Make extras of everything.

Always try to halve each section, and then halve again and so on. By keeping the mass on each side of a division equal, the split runs truer. You can correct a split somewhat, but it's not a precise science. If you're using a froe and a brake, for instance, and your split begins to run to one side, you can exert pressure on the thicker side and possibly force a correction. With a maul and wedge, your only recourse is to flip the stock and start again from the other end as soon as you see a split start to drift.

You're interested in heartwood only. Bark and pith are obviously out, but even sapwood's tricky. You can use it, but its moisture content is so much different from heartwood that it's usually more of a pain than it's worth. To remove bark and sapwood, I usually wait until I'm down to a pie-slice-shaped wedge to froe it off (see the bottom left photo on p. 27). The pith generally gets discarded with the small triangular section I discard from a final split.

I take rough blanks to the shaving horse (see the photo on pp. 24–25), although other holding devices such as a bench vise would also work. I begin drawknifing, bevel down, in the radial plane, shaping a flat side perpendicular to the growth rings. Sight down stock frequently, and correct wind, or twist, as necessary. Then flip stock to an adjacent side, and square it to the first, being careful to follow the line of one growth ring. When in doubt, study the piece from the side, marking the ring line you're trying to follow. Reverse stock as necessary so that you're cutting with the grain as much as possible. Once adjacent sides are square and true, score down from those faces with a marking gauge to mark your needed dimension. The dimension chosen must allow for shrinkage. For a chair back-bow that must be ¾ in. dry, I square to about 13⁄16 in. Square to your marked lines, and your piece is ready for drying or bending if you're going to make a stool or rustic chair with square members. For Windsors and other pieces requiring round members, you have a bit more work.

The closer to a perfect square you produce, the more nearly perfect your round. A perfect round bends perfectly. A round begins as a square, which is turned into an octagon and then rounded. To turn squares into octagons, remove corners with a drawknife. Then just spokeshave the high points off to get a round. A concave-sole spokeshave is particularly handy here.

Stock that you're not going to be using right away needs to be stored properly if it's to stay green. Minimally, stock should always be stored out of the sun, but ideally, it should be kept immersed in water. I keep blanks in a pond by my house, but even a trough would do the job. Log halves and smaller sections also can be stored heart

side down on damp ground, out of the sun and covered with a tarp. Stock that you intend to bend requires more care in this regard than wood that will be used for straight parts.

Joining Green-Wood Components

Green-wood joinery techniques take advantage of wood's tendency to dry predominantly in the tangential plane, or roughly parallel to the growth rings. Bone-dry tenons (0 to 5 percent moisture) are created from the green stock by drying the shaved components, generally stretchers and spindles, in a kiln for 48 hours or so. My makeshift kiln consists of scored, foil-faced building insulation folded into a box, with wooden ends and a light bulb for a heating element. The dry tenons are then sized to a very tight fit in the tangential plane, eased slightly in the radial plane to prevent splitting out the socket mortise, and inserted into mortises drilled in moist, green wood (15 to 20 percent moisture). As the tenon picks up moisture from the surrounding wood, glue, and air, the tenon swells in the tangential plane, locking itself permanently in place. One important caveat: A tenoned member that will also have a mortise drilled in it needs to have the mortise area protected from drying. An aluminum-foil wrap works well.

Glue in this joint acts initially to reintroduce water to an artificially dry tenon, and then it acts as a barrier to overly quick moisture exchange, protecting the wood from drastic changes. The glue is actually of secondary importance to the strength of the joint, though; it's primarily a mechanical bond.

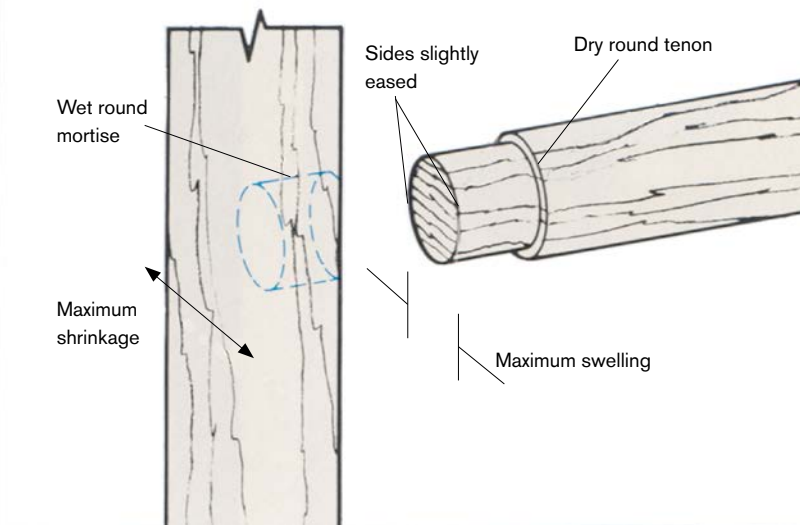
These joints depend on close tolerances for optimum strength. A less-than-perfect joint won't usually relegate a chair to the scrap pile, but the sturdiest, most long-lived chairs will be those with perfect joints. For that reason, I had a machinist make a drive plate for me. It's nothing fancy, just a ¼-in.-thick sheet of ground steel with holes bored in it at precisely ⅜ in., ½ in. and ⅝ in. and above and below each of these in 1/64 in. increments (see the photo on the facing page). That way, I can size my tenons to the auger bit I use for the socket mortises, thereby ensuring a perfect fit. The incremental steps also allow me to take a roughly shaved spindle and gradually work it down to exactly the dimension I need by driving it to depth in successively smaller holes. Any metalworking shop should be able to make one of these plates.

A word of caution: Some woods react better to being driven than others, especially in small diameters. I've had good luck with hickory mostly and with an occasional piece of red oak, but you should take your time and get the spindles as close to tolerance as possible before driving them.

HARRIET HODGES raises sheep and harvests chair wood on a Craig County, Virginia, farm. She is also the indexer for *Fine Woodworking*.

WET-DRY JOINERY

Dry round tenon is oriented in round mortise so greatest swelling of tenon occurs in same plane (tangential) as maximum shrinkage of mortise, locking the joint.



Shaping the Arm of a Chair

BY SAM MALOOF

PATTERNS OF THE PAST. **As the author starts making a chair, he can choose among the hundreds of patterns of past chairs hanging in his shop.**

What do I use to shape the arm of a chair? The best tool for the job. I don't get hung up on using all power tools or all hand tools. If you get too mechanized, you have to design around the capabilities of the machines, and your furniture won't have the feel of handmade work. If you move to the other extreme and become a purist who won't use power tools at all, well, that's okay. But be prepared—you may starve to death. My philosophy is closer to Wharton Esherick's. He once said to me, "I use any tool that'll do the job. If I have to use my teeth, I use my teeth."

When I started woodworking, I used to cut out the arms of my chairs with a handsaw. I didn't have any power tools back then. I bought a little keyhole saw, and I cut out chair arms with that. Then I used a drawknife and a spokeshave and a rasp to take it to its final shape. My technique now isn't that different; the main thing is I use a bandsaw instead of a keyhole saw. And it's a lot faster.

Picking the Wood

When I select the wood for a chair arm, I aim for uniformity. I don't mix quarter-sawn stock with slash-cut, and I try to get the same color all the way through because I don't use stains on my pieces. I usually try to match the wood of the arms and the wood of the seat. If the seat has a lot of beautiful grain in it, I want the arms to have the same beautiful grain. I'll pick the same wood for the crest rail, too, because the crest rail, the seat, and the arms are the places where the character of the wood is most prominently displayed.

Most wood I use is first air-dried and then kiln-dried. Sometimes I get some purely air-dried walnut, and I find—now this is my own notion—that it seems to retain more of the original color. Air-dried

INTERLOCKING LAYOUT. **Tracing a plan-view pattern, the author lays out chair arms in a 12/4 walnut board. He flops the pattern and nests the layouts to get as many arms as possible from the board.**

ADDING ANOTHER DIMENSION. **With the arm blank jointed and planed, the author traces a second pattern to establish the general contours of the arm's elevation.**

GOOD REFERENCES. **The compound angle where the arm will join the chair's back leg is cut on the tablesaw while the arm is still flat on the top and bottom. A simple, curved plywood jig steadies the curved side of the arm for the cut.**

Maestro of the Bandsaw

Impressive work . . . but not advisable. With 50 years of constant practice, the author has developed extraordinary skill in a hazardous art: freehand shaping on the bandsaw. We present these photos to document a remarkable skill but strongly caution against emulating what is plainly a dangerous technique.

walnut tends to have redder tones, whereas walnut that is air-dried and then steamed and kiln-dried tends to be a sort of grayish brown. I really like both of them, but I don't mix them.

Of all of the woods that I've used, walnut is the friendliest for making furniture. People talk about this exotic wood or that exotic wood, but walnut is still my favorite.

Shaping the Arm

I do most of the shaping of chair arms freehand on the bandsaw. I can shape a pair of arms in about 15 minutes. It works well for me, but I do not recommend this method. It's very dangerous because the workpiece is inadequately supported as you cut. The only reason I do it this way is that I didn't know any better when I started. I'm very careful when I do it, but being careful doesn't remove the danger. I have had a piece of wood slam down on my fingers and thought I had broken a finger or two. If I feel the blade grabbing, I take my hands off the piece of wood immediately and sacrifice the workpiece if I have to.

I have had people tell me they shape a chair's arm with a router, following a pattern. I have never tried that. The only alternative I can advise is to use a keyhole saw, a drawknife, and a spokeshave—the way I did when I started out.

Once I have roughed out the arm on the bandsaw, I use a Surform® (Stanley® model No. 295). This tool does about the same job as a spokeshave—it can take off a lot of wood very quickly—but I can use it without worrying about grain direction. I'm not taking out a lot of wood with it; I'm mainly fairing the curves and straightening the lines I cut on the bandsaw (see the bottom photos on p. 34). As soon as I buy a new Surform, I cut its handle off so that I can control it better. With the handle removed I can really feel the work and get into it.

The Surform cuts quickly, taking little, noodlelike shavings and leaving a rough surface. To clean up after it, I use a very coarse cabinetmaker's rasp. I have a range of rasps, but typically I'll use three rasps to finish an arm, perhaps starting with a Nicholson® No. 11, then using a No. 48 and finishing up with a No. 1. Depending on the contours I'm smoothing, I use both the flat and rounded sides of the rasps.

With the rasp work done, I go over the arm with a Japanese tool that is a cross between a Surform and a rasp. Called a saw rasp, it is made by Shinto and has a cutting surface that is comprised of sawblades in a waffle pattern. They are sold in coarse and fine and are available in the Japan Woodworker catalog (800-537-7820).

To do all of this hand-shaping, I hold the workpiece in a regular bench vise. I do have two old pattern maker's vises, which work beautifully for clamping odd-shaped pieces. But I'm not doing production, so I just use the regular vise that is on the bench where I usually work.

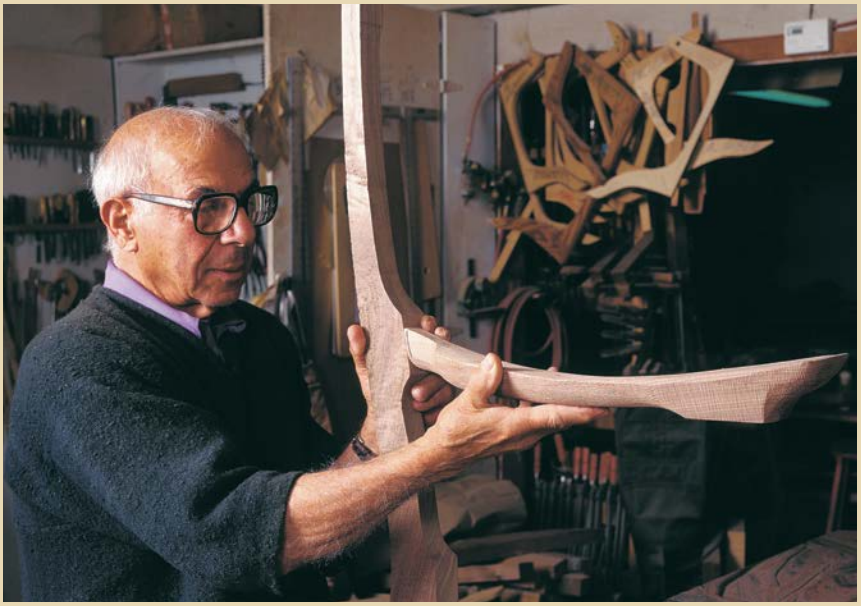
Sanding and Finishing

With the shaping finished, I attach the arm to the chair. After the chair has been glued up, I do the final shaping and scraping. Then the sanding begins. I start out with an air-powered random-orbit pad sander. But 80 percent of the sanding is done by hand, beginning with 80-grit paper and going through the steps—100, 150, 220. Then I'll use a 400-grit wet-or-dry paper without lubricant. I can spend up to a week just sanding a chair. I think if I used lacquer I would not need to be nearly so thorough. But when putting an oil finish on, like the one I use, you see every single scratch.

Of all the woods that I've used, walnut is the friendliest for making furniture.

From Bandsaw to Final Shape in Minutes

Once an arm has been bandsawn to shape, it takes the author about 15 minutes to refine the shape with a Surform, rasps, and a Japanese saw rasp until it is ready to be attached to the chair. With the arm fresh off the bandsaw, the author uses a Surform to fair the curves and smooth the bumps. He removes the Surform's handle to give him a better feel for the work. Next, he uses a range of progressively finer cabinetmaker's rasps to refine the shape. The saw rasp presents a flat face to the work and completes the smoothing-tool sequence.



After sanding with 400-grit paper, I rub down the whole chair with 0000 steel wool and follow that by burnishing it with a cloth. The cloth is equivalent to about 2,000-grit paper, and its effect is amazing. You think you have a wonderful smoothness in the piece of furniture, but after you rub it down with a plain cloth, there's a sheen that is just unbelievable.

All of my chairs receive an oil finish, except the ones made from exotic woods such as zircote, rosewood, and ebony (I apply a wax finish to these woods). I developed the finish years ago, and it's now available commercially from the Rockler® catalog (800-279-4441), formerly The Woodworkers' Store. It is a mixture of one-third linseed oil, one-third raw tung oil, and one-third semigloss urethane varnish. I apply it generously and then rub it off completely so there isn't a wet spot left anywhere. I let it sit overnight

RUBBED THE RIGHT WAY. **The author's chairs get four coats of oil finish and two coats of wax, each coat thoroughly rubbed out.**

and then add another coat. The process is repeated about four times. Then I make a batch of finish that is half linseed oil and half tung oil with some shredded beeswax mixed in. I put two coats of that finish on, and the chair's finished, ready to be used.

SAM MALOOF is a designer and chair maker whose furniture appears in museums and galleries around the world.

Building a Basic Stool

BY HARRIET HODGES

A Windsor stool makes an ideal first project for beginners or a quick exercise for woodworkers who have been at it for a while. A stool comes in handy in most households, and it can make a welcome gift. Tool and wood needs are simple. Hardwood for the undercarriage must be clear and straight-grained, but you can use wood of dubious quality for the seat. The process of building a stool allows for mistakes: I once made a tenon ½ in. too long on one leg of a stool, and it still went together just fine.

Decide on a Design

To get started with a stool project, you need to decide the number of legs, style of turning, how tall, seat shape, and whether to upholster. You can choose the finish later.

Three legs or four? Even if you live in a house with a pitted earth floor, a stool with three legs will never teeter. Do decide the height now. Legs can be cut down later, but tapers look clumsy when they are sawed off too close to the end, and stretchers look silly too close to the ground.

Turned bamboo patterns are handsome and easy to make. I would advise against plain legs—they bespeak factory work. Add some coves and tapers or some beaded balls. Why not make your stool interesting or even playful? Make some cardboard templates, paint them black, and live with them a little. Leg diameters in the drawing on the facing page are minimums for strength.

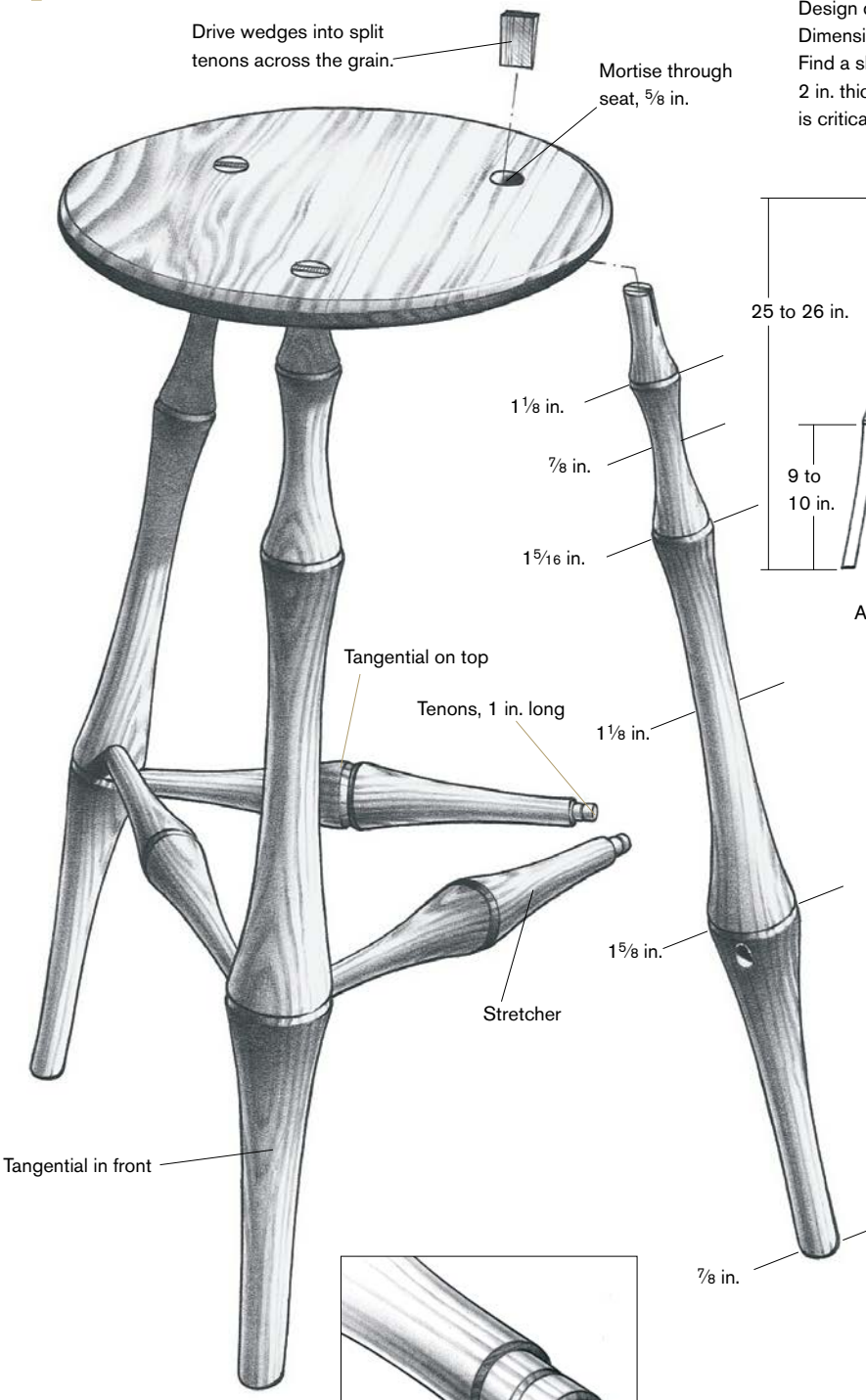
A bead or two on the perimeter of a seat makes a nice touch. If you dish the seat, don't overdo it. The dish doesn't add much to comfort. With a leather top—a luxurious touch—a groove accepts the leather and a rattan spline. Or, if you're using a soft wood, brass tacks secure the leather to the seat and add a decorative touch.

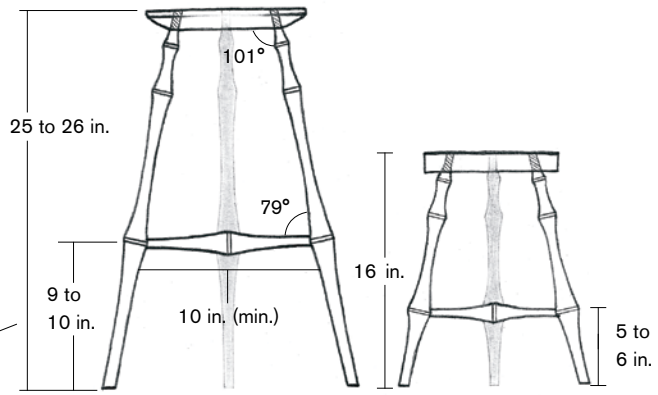
A seat diameter of 10 in. to 11 in. is approximate. Larger or smaller works. Allow enough space above the stretchers for two big feet. (I didn't do that on my delicate first stool and quickly renamed it a child's stool.) I like to limit the splay of the legs, but the more stability you want, the more splay you must have.

You'll need a brace and a sharp 58-in. bit, a bevel gauge, a protractor, a lathe and some turning tools, a thin-bladed saw, a chisel or two, and some splitting implements. Find a reamer for shaping tapered holes in the underside of the seat and a tap wrench to hold it. Turn a test taper of very dry wood for the tops of the legs. Match the shape to your reamer to use as a master when turning the legs.

THE BASICS OF A WINDSOR STOOL

Design details can vary depending on how the stool will be used. Dimensions are those the author often uses but are not critical. Find a shape that's pleasing to the eye. Softwood seats are 1½ in. to 2 in. thick and 10 in. to 11 in. dia. Correct grain orientation is critical to the strength of Windsor stools.



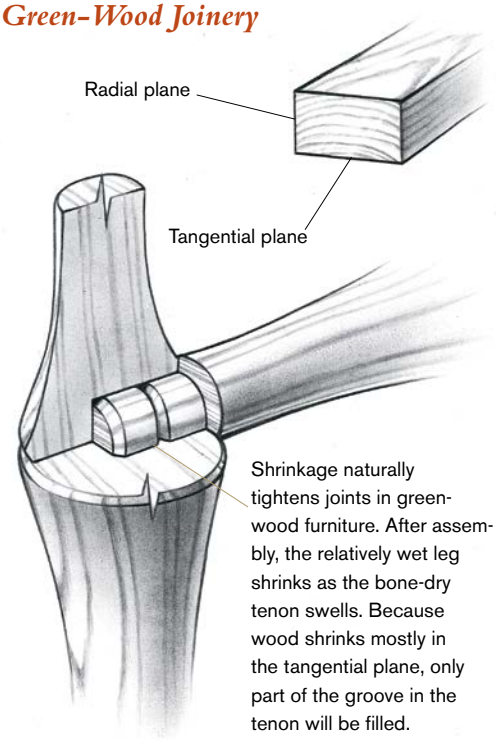


Adult bar or drafting stool

Dining or fireside stool

File tenons to an exaggerated oval, removing material from the radial plane.

Green-Wood Joinery



Shrinkage naturally tightens joints in green-wood furniture. After assembly, the relatively wet leg shrinks as the bone-dry tenon swells. Because wood shrinks mostly in the tangential plane, only part of the groove in the tenon will be filled.

For the joinery to hold, the legs must be green hardwood; walnut, maple, cherry, or beech all work well. But the seat, particularly for a first stool, should be a soft wood such as basswood, horse chestnut, pine or poplar. The wood will more easily compress around the tenons of the legs and make better-looking joints that go together smoothly. For the legs, secure a bolt of hardwood about 12 in. dia. and as straight-grained as possible. The bolt should be recently felled and, exclusive of the pith and the sapwood, should allow 2½-in.-sq. pieces to be split from it. Minor defects are acceptable. The leg should be long enough to remove any checking.

Split the bolt with an ax or a froe as close to 2½ in. as you dare. Square up the shapes with a bandsaw if you have one, taking special care to make cuts parallel to an annual ring in the radial plane. You want to follow the grain of the wood to build in maximum strength. Cutting across the grain allows fibers to lift and form a split. For the seat, almost any piece of 1½ -in.- to 2-in.-thick wood is fine as long as it has been dried for at least six months and has been stored outside to around 30% moisture content. Have on hand some dry, straight-grained hardwood for wedges.

Turn the Seat and Legs on a Lathe

I like to use an English prick plate and double-faced tape to hold the seat blank in the lathe. A prick plate is a round blank screwed to a faceplate, through which sharp nail points protrude by about 3⁄16 in. It will, with the tailstock tight against the workpiece, hold a flat blank nicely in the lathe. You can also drive screws through your faceplate into what will be the bottom of your seat. (Call it vanity, but I don't like screw holes, filled or not.) With either method, turn the underside and the side edges first.

Once you've roughed out your leg stock, cut it to length. Make a story stick of your design, with marks to indicate diameters. Round stock to its largest diameter; turn the middle before heading for the ends. The tenon is the only part of the leg needing precision. It must match your test taper but be a hair oversized to allow for shrinkage in a makeshift kiln you'll use later.

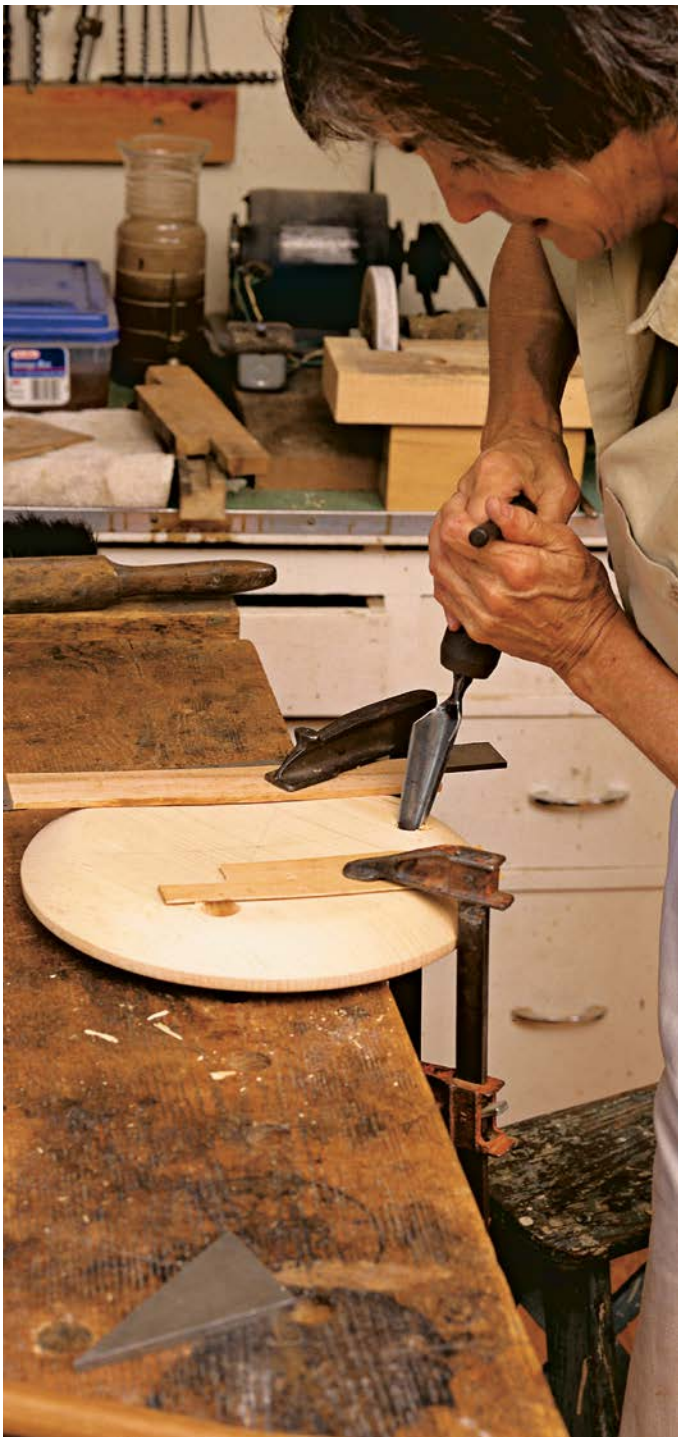
If you are fairly new to turning, I recommend removing your first leg from the lathe and setting it upright to look at it. What looks good horizontally is often clumsy in the vertical plane—a trick the eye plays. Once you are pleased with the design and proportion of your first leg, turn the rest. Mark the line where the stretchers go with a skew tip. Sand the legs through 220 grit for a paint finish and 400 grit for a natural finish. Moisten them, let dry, and lightly sand off the raised grain.

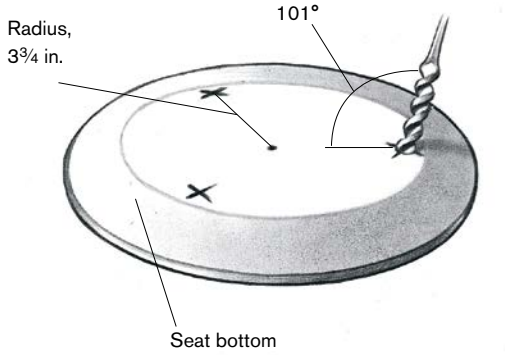
Bore and Ream the Holes in the Seat by Hand

You want the leg holes on the bottom of the seat to line up properly with the grain pattern in the seat. With three-legged stools, put one leg on the centerline. Mark sight lines from each leg hole to the seat center. Prick the hole centers with an awl, and clamp the seat to the workbench so that the area you bore through will overhang the bench.

Set your bevel gauge to 101 degrees, or another desired angle, and center it on the sight line. Bore with a 5⁄8-in. bit in a brace until you can just feel the point poke through. Check angles as you drill with a mirror and by eye (see the photo at left on the facing page). Flip the seat, and bore through the other side to prevent tearout on the top of the seat.

Ream the holes from the bottom of the seat (see the photo at right on the facing page) until the test taper fits a hair proud all around the top of the seat. As you ream,





BORING HOLES IN THE SEAT. The author sights angles from two directions using a sliding bevel gauge and a mirror to align bit to bevel (photo and drawing at left). The reamer (above right) cuts a taper in the hole to match that on the tops of the legs.

DRY-FIT THE LEGS to measure the stretchers. Stretchers are cut to fit; it doesn't matter whether all the stretchers are the same size.

WEDGES AND DOGS hold the legs in place when boring holes for the stretchers. Three dogs hold the workpiece firmly at a comfortable height off the floor.

COLORED TABS MAKE A QUICK visual index of one part of the stool to another. The author supports the seat on scrap blocks when pounding legs in place.

test the angle with a bevel gauge set parallel to the sight line and a try square set perpendicular to it. If this is your first stool, it is likely your tapered holes will vary, so aim to match each leg to a hole. I use colored stick-on tabs to match them up (see the bottom photo on the facing page). Fit a leg to a hole until the leg is slightly proud on the topside. Mark around the leg. You want all legs proud by about the same amount, roughly ¼ in. or so. Mark the ends of the legs for wedges, and saw thin kerfs.

Once your legs are fitted, align them in the holes so that the grain orientation is correct; the grain pattern will be in the tangential plane facing out at the points where the stretchers go (see the drawing on p. 37). Pound them lightly into place. Sight through one leg to find the center of its opposite. Mark this spot with an awl. Turn the stool. Sight again and mark the other leg. Do the same to mark all the holes for the stretchers. Measure and record the distances between the awl marks on matched pairs, and add for tenons. Don't be alarmed if stretcher lengths are not equal. It doesn't matter. Cut stretchers to size, turn them on the lathe, and sand them.

Fit the Stretchers to the Legs

Just as you fit leg tenons to the seat, stretcher tenons must be matched to leg mortises. Wrap legs and stretchers in aluminum foil, except the tenon ends, and put them in a kiln, such as a gas oven with the pilot on. The tenons should come to near zero moisture content, and the rest of the leg should retain enough moisture to shrink around the tenons. The pieces should feel faintly damp when you unwrap them.

File a small amount of material from a tenon on one of the stretchers in the radial planes. This intentional slop is where swelling will take place once the pieces are joined. Chamfer the end slightly. Try the fit in a scrap that can be split off the tenon if it gets stuck. If the tenon slips in easily, it's too small. If the tenon won't penetrate with moderate hammer blows, it's obviously too big. Judicious filing works. Or put the piece back on the lathe. When the tenon fits tightly, record its diameter with vernier calipers and prepare the others.

For boring holes in the legs, a reliable holding system is a must, no easy matter with tapered stock. Drill all the holes in the legs using a bevel gauge and a mirror. As for jigs, you don't need them: Your hands and eyes are capable of more than enough accuracy.

Assemble the Stool, and Level the Legs

Once you're sure all the joints will align and fit right, glue the stretcher assembly first. Pound parts together with a mallet. Be quick; the tenon is swelling.

After legs and stretchers are together, place the seat upside down on blocks on the bench, and swab the mortises lightly with glue. Work glue into the tenon kerfs, and wrestle the assembly into place. Pound legs alternately, stopping when the sound changes. Turn the stool over. Hammer in glue-smeared wedges. Cut small wedges to fill in any smaller gaps. Let the glue dry before trimming tenons. Scrape and sand the seat smooth. Set the stool on plate glass. Make sure it's level and steady, blocking it up if not. Mark all around, saw off the legs on the marks, and chamfer the edges.

HARRIET HODGES makes Windsor chairs and stools at her farm in New Castle, Virginia. She is also the indexer for *Fine Woodworking*.

Jigs for Joints on Curving Parts

BY BRIAN BOGGS

When I plunged into woodworking 26 years ago, chairs looked like the easiest furniture to make with the small kit of hand tools I had. Chairs have no parts to be laboriously handplaned flat and square, and chairs are composed mainly of parts that are connected only at the ends, leaving a lot of room for creative irregularity in between. By necessity, I became good at cutting joints by hand without benefit of flat and square reference surfaces. These days, with my business growing, I do most joinery by machine, but I am still wrestling with parts

that curve, and I've had to come up with jigs to make those parts compatible with flat machines. For cutting joints on parts that I make over and over, I build dedicated jigs. But I also have a number of more universal jigs that could be adapted to any shop and to many uses other than chair making.

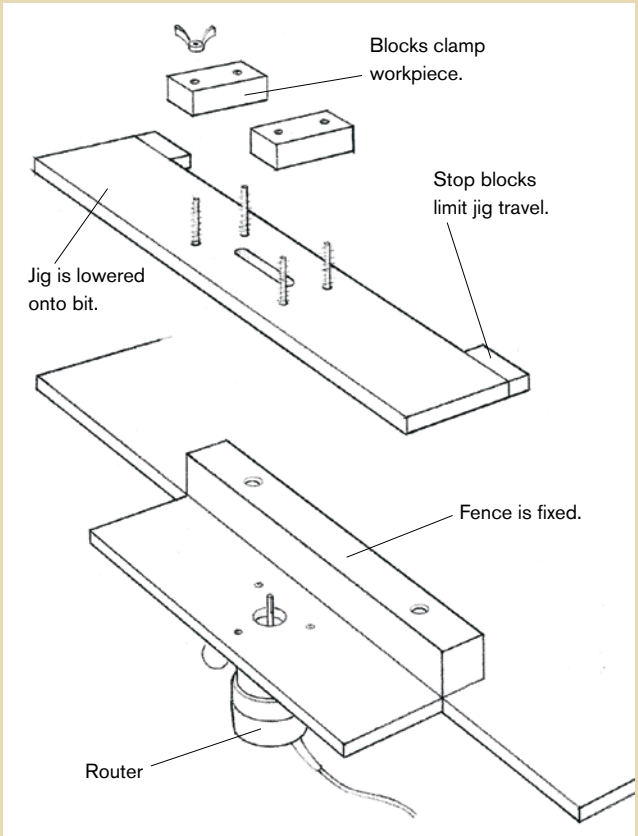
What all the jigs have in common is a simplified approach to locating the part on the jig. Instead of trying to cradle the curved part with a customized fence—which would introduce to the joinery any variations in the part—I skip the fence altogether and orient the part with layout lines, either on the part or on the jig.

For mortising, my most versatile jig is a board with a hole in the middle (see the drawing at right). I use it in conjunction with a router table that has a fixed fence and a section of the table that juts out in front. To locate the part, I begin by laying out the centerlines of the mortises on the side of the part opposite the side to be mortised. I then use those lines to register the part on the jig. I clamp the part to the jig and, keeping the jig pushed against the fence, make a plunge cut onto the router bit. Stops on both ends of the jig limit the length of the mortise.

Whereas this mortising jig requires layout lines on the workpiece, my tenoning jigs use a line on the jig itself. This system is in its most basic form in my bandsaw tenoning jig, which is nothing more than a piece of plywood with a diagonal line drawn on it (see the drawings on p. 44) and a simple hold-down. I start by jointing the part, then planing it. The part's flat sides must be parallel because it will be flipped in the jig to cut the tenon on the other end. I place the jointed part on the diagonal line so that the line intersects the tenon shoulders. Then I clamp the piece and cut the tenon. To cut the second cheek, I insert a spacer that equals the thickness of the tenon plus the blade kerf.

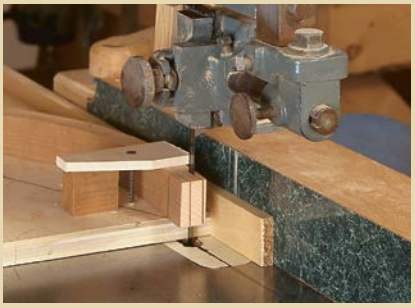
Most Flexible Mortising Jig

To make his router mortising jig work with a wide range of curved parts, Boggs devised a flexible system of positioning the workpiece. He starts by marking on the workpiece the centerline of each mortise–on the face opposite the one where the mortise will be cut. After setting a combination square to the center point of the bit (top), he positions the workpiece so the centerline meets the end of the square (center). He begins the cut (bottom) by holding the jig against the fence, pushed against the right stop block, and lowering the right end of the jig.



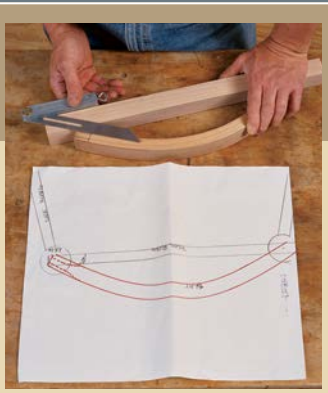
Fresh Angle on Tenons

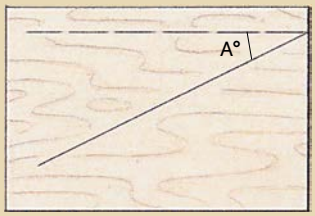
At the heart of Boggs' method of cutting angled tenons on curved parts is a fiendishly simple technique for positioning the workpiece on the jig.



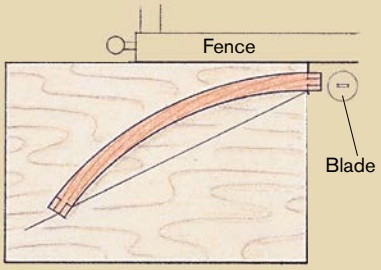
HOLD ME DOWN. Boggs uses a screw, a cutoff from the workpiece, and another scrap of wood to fashion a quick hold-down. The spacer (above) for cutting the second cheek of the tenon is sized to the thickness of the tenon plus the kerf of the blade.

Strike a chord? Boggs begins by transferring the tenon angle from his drawing to the part.

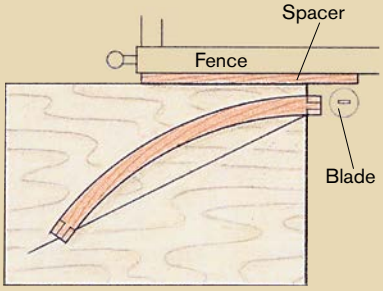




Transference. The tenon angle is then transferred to the plywood carriage.



Crossing the line. The workpiece is placed along the angled line and clamped down. The line should intersect the workpiece at points equidistant from each end.



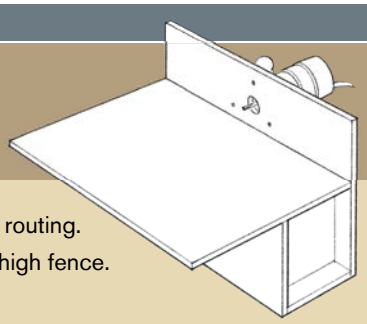
Spaced out. After the first cheek is cut, a spacer is inserted between the jig and the fence to cut the second cheek.

The bandsaw jig works well on parts like chair slats, whose tenon shoulders will be cut away. But for shouldered tenons, I often use the router table. For cutting tenons with a router table, I made a jig that is a higher evolution of the bandsaw jig. The method of locating the part is the same, but on this jig, the board to which the part is clamped can be adjusted to the left and right of 90 degrees, enabling me to cut tenons whose shoulders are not square to the length of the workpiece (see the photos and drawings above).

Here, again, the part is jointed before the joints are cut, and the second cheek is cut by inserting a spacer below the jig, which raises it up by the width of the tenon plus the diameter of the router bit.

I have a second jig for the router that I use for parts whose tenons are in the same

Tenoning Jigs on a Router Table

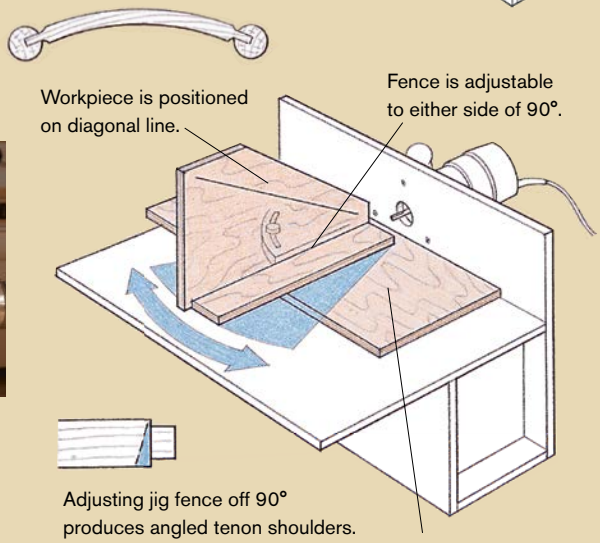


Boggs cuts shouldered tenons on curved parts with a shopmade table for horizontal routing. The jigs he uses would also work with a conventional router table equipped with a high fence.

A Jig for Angled Tenons

To locate the part in this jig, Boggs uses the same angled-line idea as in his bandsaw jig. But here, the line is on a vertical fence and the fence pivots, so he can make tenons with angled shoulders.

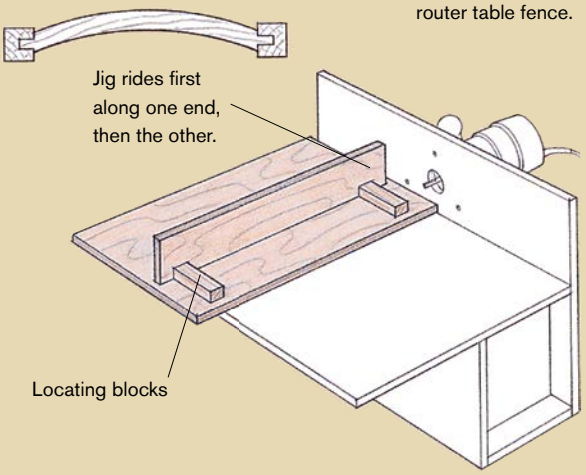
GIVE ME A LIFT. Twin spacers connected by a cleat elevate the jig to cut one tenon cheek (left). The other cheek is cut with the spacers removed (right).



A Jig for In-Line Tenons

With this jig, built just longer than the curved part, both tenons can be cut without unclamping the workpiece. The jig first rides along one end; then it's flipped to ride against the other.

TWO POINTS. The two blocks tacked to the jig are used only to locate the workpiece at two points equidistant from its ends. The workpiece is then clamped to the jig's vertical fence.



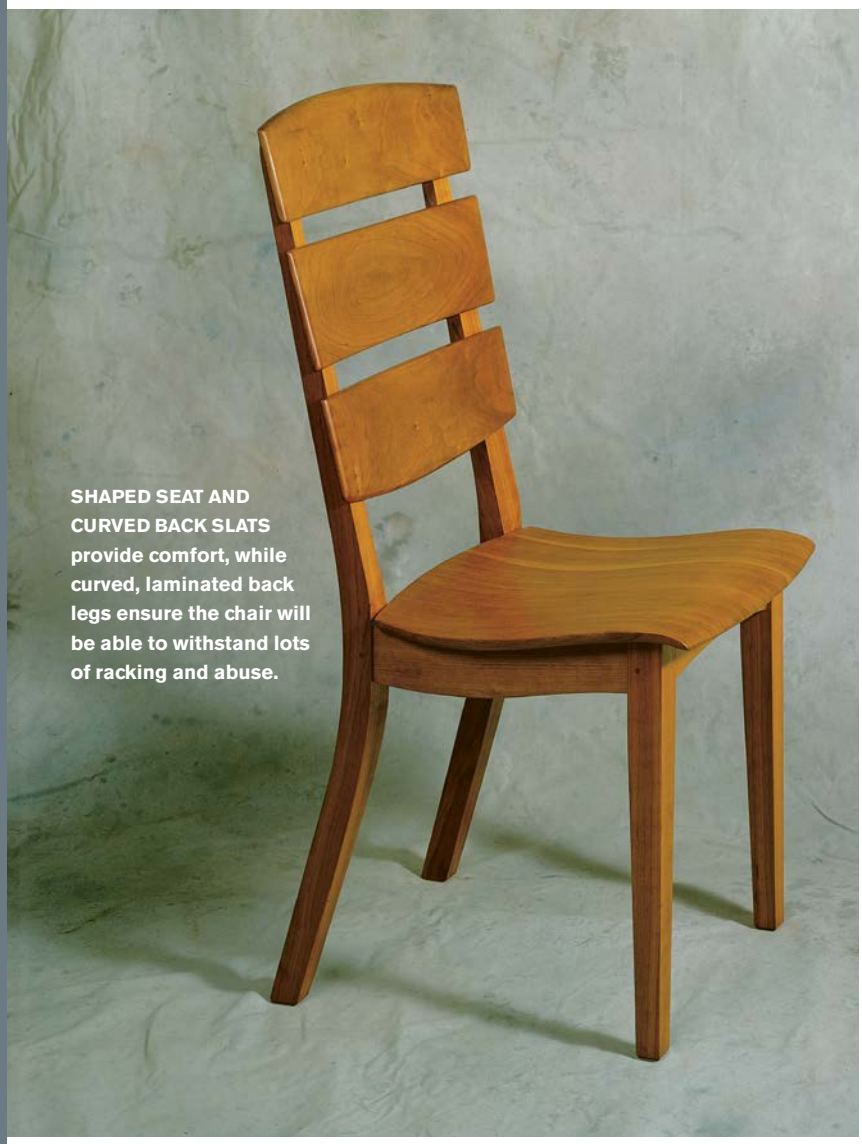
plane. With this jig, I can cut both tenons start to finish without unclamping the part. Two blocks tacked to the jig take the place of a pencil line to locate the part. Because both tenons are cut without repositioning the part, they come out perfectly in line even if there is some twist or unfairness in the curve. The jig also guarantees that all the parts will have the same shoulder-to-shoulder dimension even if the overall lengths of the raw parts vary slightly.

Of course, a lot more can be said about cutting accurate joints on curved parts, but hopefully, these techniques will get you around the next bend.

BRIAN BOGGS is a chair maker in Berea, Kentucky, and teaches seminars on ladderback chair making.

Built for Comfort: The Three-Slat Chair

BY CHRISTIAN H. BECKSVOORT



SHAPED SEAT AND CURVED BACK SLATS provide comfort, while curved, laminated back legs ensure the chair will be able to withstand lots of racking and abuse.

Comfortable chairs, especially wooden chairs, are notoriously difficult to design. Consequently, I'm always on the lookout for good chairs. Whether in a restaurant, at a friend's house, or in a waiting room, every time I sit down, I instinctively analyze what makes my seat comfortable, or not.

Several years ago, my wife bought a double folding chair at a flea market for the grand total of $2. The chair is of a style that was mass-produced around the turn of the century and used almost everywhere, in auditoriums, schools, Grange halls, and libraries. Although not much to look at, it's a very comfortable chair. The two contact points, the seat and back, are well formed and provide support right where it's needed. I decided to borrow the back curve and seat shape, the elements that make the chair so comfortable, and incorporate these features into a nonfolding, four-legged dining chair with mortise-and-tenon construction.

I also adjusted the back angle to 14 degrees from vertical because the original was a little too "laid back" for a dining chair. After a series of sketches, I came up with the chair shown at left and in the drawing on pp. 48-49. Once I'd worked out the details, I made a full-size drawing

SIMPLE FORM MAKES bent-lamination easy. Plywood scraps form two mating halves with square outside edges to provide even clamping pressure over the length of the back-leg lamination.

from which I later made patterns for each chair part.

Laminating and Shaping the Legs

One of the first decisions I made was to laminate the curved back legs rather than cut them from a big blank. Having repaired countless older chairs, I've learned that curved back legs cut from solid stock are extremely vulnerable to breaking: The short grain where leg meets floor invariably breaks, sometimes with the slightest tap.

I made a form for the leg-blank lamination from six pieces of scrap ¾-in. plywood. I bandsawed the plywood to rough shape and then disc-sanded the two halves of the glued-together form until I had a fair, smooth curve on each half with a nice match between the two.

I cut 5/16-in.-thick strips for the lamination from a 4-in.-wide piece of 16/4 stock that was 38 in. long. That way, I was able to match the grain from front to back and get both back legs from the same lamination. I marked each bandsawn strip in order of cut, applied glue between each, wrapped them in plastic wrap so they wouldn't stick to the form, and clamped them in the form for 24 hours (see the photo above). The next day, I cut the lamination in half lengthwise along its face, ran the outside edge of both pieces over the jointer, and then ripped them to 1½ in.

I cut the back legs so that the tops are 35 in. high and the bottoms are at 73 degrees to the floor (see the drawing on p. 49). Then I marked and disc-sanded a flat section perpendicular to the floor on the front faces of the back legs, where the side rails will intersect the legs.

Next I bandsawed a taper on the inside edges of the bottom section of the back legs, from 1 in. sq. at the floor to 1½ in. sq. just below the flat at the side-rail intersection (about 12½ in. from the floor).

I also tapered the tops of the back legs to 1 in. wide on their inner edges, as viewed from the back (see the drawing at right), and to ¾ in. front to back, cut from the back and originating just above the flat for the side-rail intersection. If I'd tapered the tops of the back legs on their front edges, I would have changed the seat-back angle, making the chair slightly less comfortable.

I prepared the two front legs of the chair by jointing, planing, ripping and crosscutting rough 8/4 stock to end up with two 1½ by 1½ by 17½-in. blanks. Then I tapered them on their inside faces from 1 in. sq. at the floor to 1½ in. sq., 3 in. from their tops.

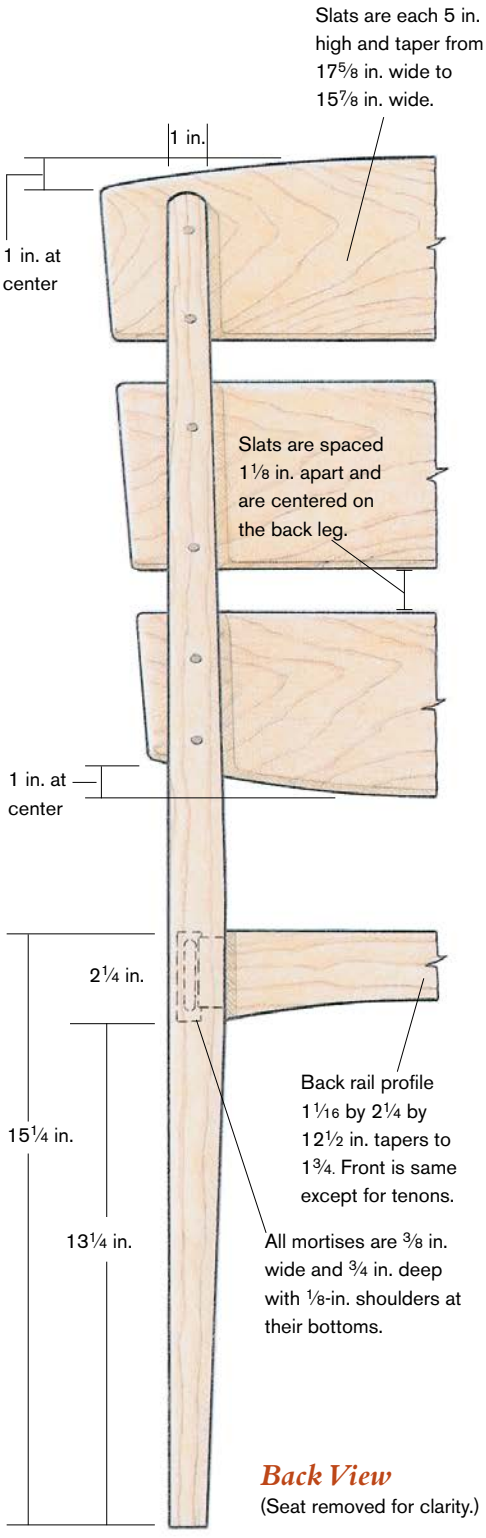
Leg-to-Rail Joinery

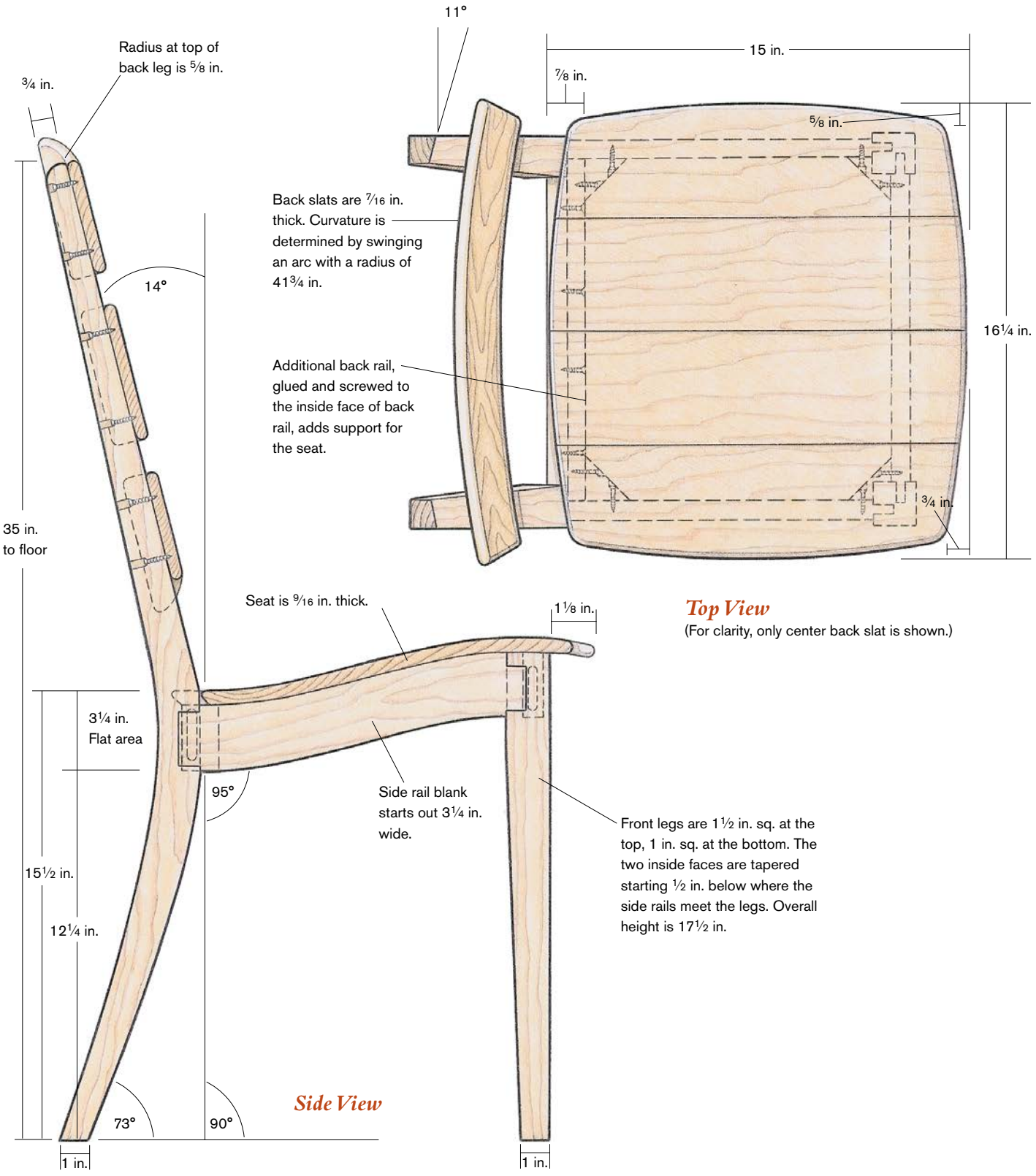
I used mortise-and-tenon construction on this chair because it has no stretchers, so the strongest possible leg-to-rail joinery was necessary. I laid out all the rails with a 3/16-in. reveal at the leg intersections except the back rail, which I made flush to the inside of the chair.

I cut the four rails from rough 4/4 stock that I planed to thickness and cut to shape from my full-size patterns. The front and back rails start out as 2¼-in.-wide blanks, but the side rails start out 3¼ in. wide to allow for the bandsawn curve that dictates the seat's contour. This takes the side rails down to 2¼ in. Also, I cut the side rails at 5 degrees on both ends (85 degrees in the front and 95 degrees in the back), which makes them parallel, though slightly skewed uphill.

At this point, I cut the tenons to fit the mortises. All tenons are centered on the rails except for the back rail. I offset it to within 1/16 in. of the back face to keep it from being too close to the inside corner of the leg, thus compromising the integrity of the joint. Next, I dry-fitted the legs and rails together. I held the chair together with band clamps while I checked the fit of the joints, dimensions of parts and angles.

THE THREE-SLAT CHAIR




11°
15 in.
7/8 in.
5/8 in.
Radius at top of back leg is 5/8 in.
3/4 in.
Back slats are 7/16 in. thick. Curvature is determined by swinging an arc with a radius of 41 3/4 in.
Additional back rail, glued and screwed to the inside face of back rail, adds support for the seat.
16 1/4 in.
3/4 in.
14°
35 in. to floor
Seat is 9/16 in. thick.
1 1/8 in.
3 1/4 in. Flat area
95°
Side rail blank starts out 3 1/4 in. wide.
Front legs are 1 1/2 in. sq. at the top, 1 in. sq. at the bottom. The two inside faces are tapered starting 1/2 in. below where the side rails meet the legs. Overall height is 17 1/2 in.
15 1/2 in.
12 1/4 in.
73°
90°
1 in.
1 in.
Side View
Top View
(For clarity, only center back slat is shown.)

Fitting a Shaped Seat

To fit a seat that isn't flat onto a base that is takes a bit of trial and error. I place the seat in position on the chair base, its back edge touching the back legs and its sides centered. By looking beneath the seat on the sides, I can see where the high points are and where I need to remove stock from the rails and legs. Most of the fitting involves fairing into the front legs and hollowing out the side rails where the back of the seat is lowest. With the chair base clamped into the bench vise for stability, I use my belt sander with an 80-grit belt to do most of the work. After one or two test-fittings, the seat begins to look like it belongs on the chair.

By now, points of contact have become difficult to see. To circumvent this, I take two sheets of carbon paper (yes, it's still available at office-supply stores) and place them, carbon side down, on the front edge of the chair. I press the seat down and move it slightly back and forth, which leaves dark patches at the points of contact. I work down these points with a rasp and file. After just a few more fittings, I've got a custom fit between seat and chair base.

While the chair was dry-clamped, I also cut a wooden pattern of the seat profile (from the side) and of the back slats (from the top) from my full-size drawing. I drew the pattern for the back slats by swinging a pair of 18-in.-long arcs, ½-in. apart, using a piece of string to create a 41¾ in. radius. Then I laid this pattern onto the top of the two back rails so that the back of the pattern intersects the front outside corners of both back legs. I scribed this line of intersection onto the top of the back legs, extended the line down the insides of the legs and then jointed down to the line, using the jointer fence to maintain the angle. Given the leg spacing and the radius of the back slats, the scribe marks formed about an 11 degrees angle from the front edges of the legs, allowing the back slats to sit flush against the back legs. At this stage, I finish-sanded the four legs and rails to 320 grit. Then I assembled the back legs and rail as a unit, pinned the joints and set the assembly aside to dry. I did the same for the front assembly. When it was dry, I connected the two assemblies by gluing and pinning the two curved side rails.

Making the Seat

I cut the seat from a 6-in.-wide, 17-in.-long piece of 16/4 stock, choosing a piece with nice color and devoid of sapwood. I also laid out the pattern on the flatsawn face of the board so that the seat surface would be quartersawn (see the photo the facing page). This reduces the amount the seat will move side to side, and it's quite attractive. Also, the parallel grain makes it less obvious that the seat is glued up from a number of pieces. I jointed the edges and glued the seat blank together. When the blank was dry, I bandsawed the seat to match the pattern and then disc-sanded to fair in the four curved edges.

Shaping the seat top and bottom is probably the most time-consuming step in the whole chairmaking process. I clamped the seat upside down between two bench dogs and beltsanded across the grain with an 80-grit belt. I've found that by holding the sander perpendicular to the grain but moving it in a rocking motion with the grain, I can remove stock quickly without gouging the workpiece. As it turned out, the concave portion of the underside of the seat near the front legs was just about the tightest radius possible with this technique, but it worked. I flipped the seat over and sanded the top using the same technique. The top went much faster because its concave section was so much shallower.

Next, I use a 1-in. by 5-in. soft sanding pad (see sources on p. 52) chucked into an electric drill. This soft pad, with a 100-grit disc on it, took out the 80-grit cross-grain scratches and conformed well to the contour of the seat. I repeated on the front and the back of the seat through 180-grit paper. Then I switched to a round, 5-in. orbital finish sander at 220 grit because it leaves fewer and smaller swirl marks. I continued with the finish sander through 320 grit.

When the seat was smooth and scratch-free, I beveled its sides and back edge. I shaped the front edge to a rounded point (see the drawing on p. 49). This went quickly using a combination of block plane, rasp, file, and sandpaper. The seat was now ready to be fitted to the chair. I did this with a couple of sheets of carbon paper, using a technique similar to one used by machinists with their bluing (see the box on the facing page).

Because the back of the seat is beveled and has such a pronounced curve, the ends of the back rail are exposed (see the drawing on p. 49). This doesn't provide as much support for the seat as I'd like, so I added a second rail on the inside of the back of the chair. I glued and screwed it to the inside of the back rail and made sure it's tight and flush to that original rail. For additional strength and because the chair has no stretchers, I added corner blocks to the inside of each corner, notching the front blocks on the bandsaw to accommodate the leg corners. When screwing these blocks into place, I'm careful not to mount the blocks too high, which would interfere with the fit of the seat.

At this point, I finish-sanded the seat by hand to 600 grit. Then I screwed the seat to the chair base with two screws up through the front rail and two through the auxiliary back rail, both of them about 6 in. apart.

Preparing the Back Slats

I took my pattern for the back slats from the full-size drawing, transferred the shape three times onto a piece of 18-in.-long, 5-in.-wide 12/4 stock, and bandsawed the slats out (see the bottom photo). This keeps the grain and color nearly the same on all three slats, from top to bottom. I shaped the top and bottom slats by giving them the same radius at the corners (viewed from the front) that I gave them front to back by cutting them on the bandsaw (see the drawing on p. 48). I also tapered the slats' width from top to bottom. I set the slats on my bench and used spacers to keep the slats 1⅛ in. apart as they will be on the chair. I marked a 1¾-in. taper from the top corner of the top slat down to the bottom corner of the bottom slat, bandsawed to the line and then smoothed the taper with rasp and file.

QUARTERSAWN BLANK FROM flatsawn stock. Quartersawn lumber is more stable than flatsawn and is easier to grain-match, but it's hard to come by and more expensive. By starting with thicker stock and laying out adjacent seat parts on top of each other across a board's width, the author created quartersawn parts.

ACHIEVING A NEARLY PERFECT GRAIN and color match is possible by sawing the pieces from the same board. A steady hand and slow feed rate will keep the cuts on line, and sanding will take out the slight bandsaw ripple seen on the outside face of this board.

Sources

Econ-Abrasives
P.O. Box 865021
Plano, TX 75086
800-367-4101

I repeated the sanding process I used on legs, rails, and seat, except that I used a pneumatic spindle sander for grits 80 through 150. A random-orbit sander will also do the job, just not as quickly. I also rounded all the edges on the front faces of the back slats at this time to make the seat more comfortable and to give the chair a softer appearance overall.

I clamped the slats to the chair temporarily with spring clamps, the top one at 36 in. from the floor, the other two with 1⅛-in. spaces separating them. Then I marked the centers of the back legs, top to bottom, and I located the screw holes, two per slat on each leg.

I removed the slats and drilled countersunk pilot holes for the screws from the back side of the legs. Because the back slats were only 7/16 in. thick after sanding, I drilled through the leg just until 5/16 in. of the bit was showing. Then I reclamped the slats to the back legs and drilled into the slats until I felt the countersunk portion of the bit just bottom out. Finally, I glued and screwed the slats to the legs, plugged the screw holes carefully, and resanded the backs of the legs.

I used three coats of tung oil as a finish. For a final touch, I added leather pads to the bottoms of the legs to protect fine hardwood floors from being scratched by the end grain of the chair legs.

CHRISTIAN H. BECKSVOORT builds custom furniture in New Gloucester, Maine, and is a contributing editor to *Fine Woodworking*.

Building a Chair, Arts and Crafts Style

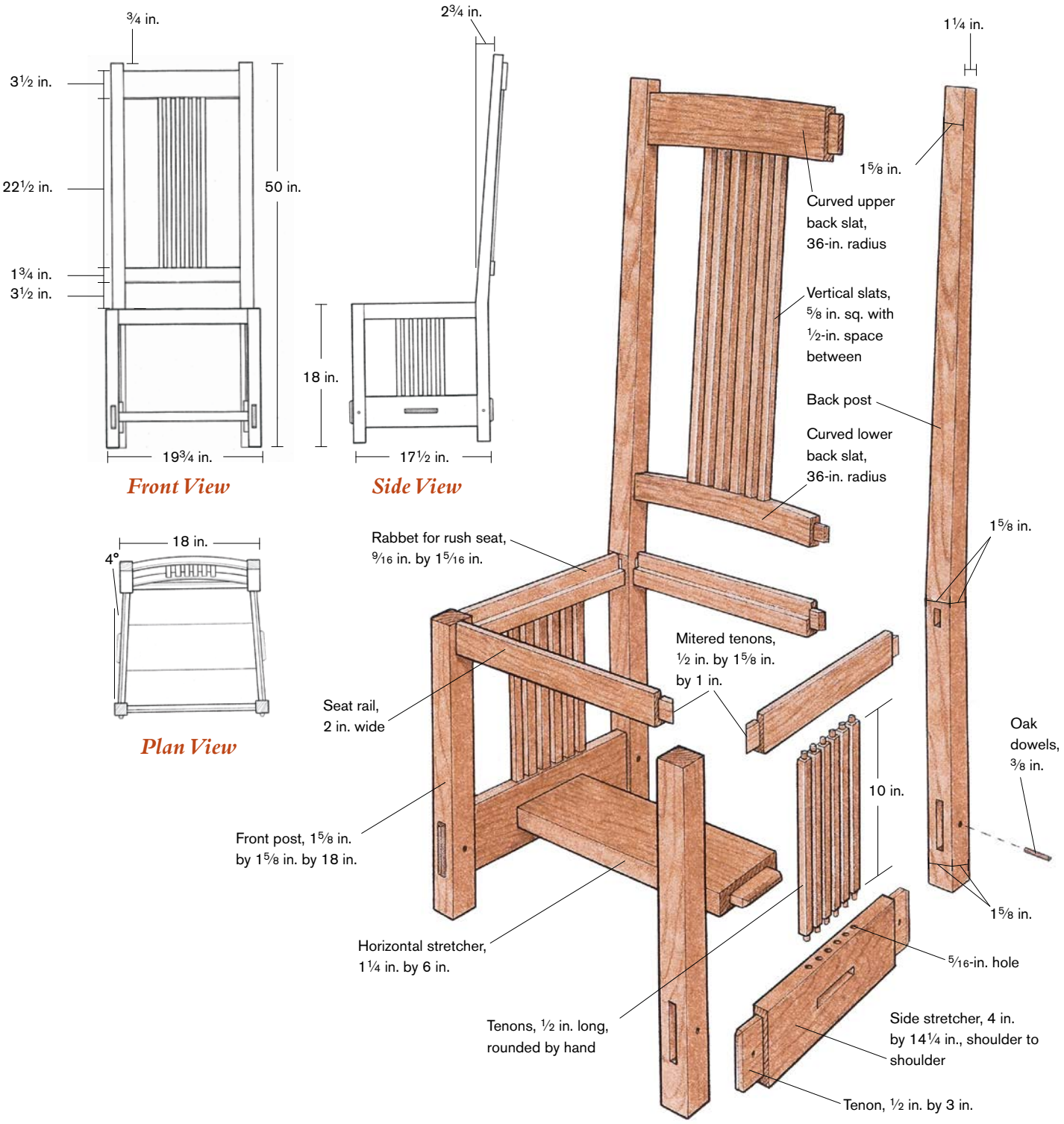
BY REX ALEXANDER

When the curator of Dennos Museum in Traverse City, Michigan asked me to design and build some Arts and Crafts-style furniture for an upcoming exhibit, I jumped at the chance. We agreed that I'd look for a customer who would buy the furniture after the exhibit. I approached Jay and Sue Wisniewski, who have been steady clients on a number of projects. They were excited by the idea.

I immediately ordered more than $100 worth of books by or about Stickley, Greene and Greene, Roycroft, and others. These books gave me a feel for designs of this period. And they told me what type of wood to use and how it should be cut and finished. I studied detailed drawings and proportions to help with the design.

A STICKLEY-STYLE DINING CHAIR

The author based the design for this chair on a Stickley original. Stickley was influenced by Frank Lloyd Wright. Mortise-and-tenon joinery makes this chair sturdy enough to withstand the stresses of daily use.



The deal with the museum didn't work out, but my clients gave me the go-ahead for a dining table and some chairs. We still had to agree on a final design, and it had to be compatible with a reproduction Frank Lloyd Wright chandelier they had already bought for the dining room.

I learned that Gustav Stickley, in designing his No. 384 chair, was influenced by Wright's work. I knew I had found the inspiration to my design problems. It was this chair (first built in 1905), with its rush seat and vertical slats on both the sides and the back, that I drew upon to arrive at the final design for these chairs. The chairs are shown in the photo on p. 53.

Solve Problems by Building a Prototype

I developed a scale drawing of the chair to help determine a materials list (see the drawing on the facing page). For several reasons, I also decided to build a prototype: the joinery is complicated, I had to buy tooling and make jigs, and I wanted to be sure my clients were satisfied with the comfort of this chair. Also, I could use the prototype to verify the proportions and to resolve some of the details of the frame and the fit of the inset rush seat.

Building six chairs is a small production run. A prototype helped me to organize each step and avoid many construction problems. I made the prototype with poplar scraps accumulated from other jobs and assembled it without glue so it could be taken apart. A mistake with poplar at this stage would not be too costly.

Once I was happy with the prototype, I took it apart and measured each piece for a final materials list. Each chair was made from front and back posts, seat rails, side stretchers, a horizontal stretcher, curved upper and lower back slats and vertical slats. There were 35 parts in all, including four oak dowels to pin the stretchers to the front and back posts.

Machining the Parts

All the parts started out as 8/4 quartersawn white oak. I could resaw the 2-in.-thick material into ⅞-in. seat rails, stretchers, and slats and still have plenty of material for the 1⅝-in.-sq. front and back posts. For a table, six side chairs and two arm chairs, I ordered 400 bd. ft. I wanted heavily rayed pieces for the sides of the front and back posts, the bottom side stretchers and the curved upper and lower back slats. I chose lightly figured white oak for the seat rails.

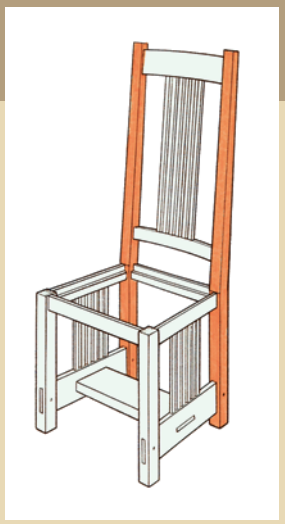
Except for the back posts, I rough-cut all the chair parts on a tablesaw and then cleaned them up with a jointer and a planer. Later, after making tenons, I cut out the curved upper and lower back slats on the bandsaw, marked with a ¼-in. plywood template made to a 36-in. radius. I cleaned up the bandsaw marks with a spokeshave and a compass plane.

I made a special jig to clean up the back posts after they had been rough-cut to size on the bandsaw (see the photo and drawing on p. 56). The jig is based on one in *Tage Frid Teaches Woodworking: Furnituremaking* (The Taunton Press, 1985).

Two legs are sandwiched between two pieces of birch plywood. One side of the jig is shaped for the outside cut and the other for the inside cut. Support blocks on each end and one in the middle of the jig register the pieces to be cut. Machine screws through one side thread into T-nuts in the other side and hold the legs firmly in place. I applied strips of self-adhesive sandpaper to the inside of each piece of the plywood jig to keep the legs from slipping.

I trimmed the legs to size with a 3-hp router equipped with a ⅝-in. template guide and a 4-in. solid carbide up-cut spiral bit. I cut the front of each leg first and then

Routing Back Posts

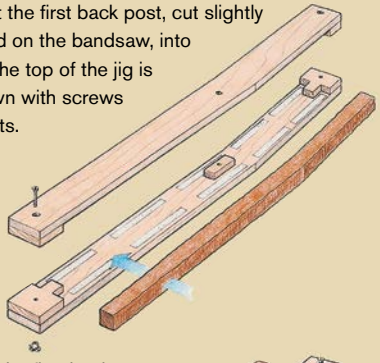


A PLYWOOD JIG FOR SHAPING the back posts. A little time invested in this jig guaranteed that all back posts would be the same size and shape. A shaper with a rub collar works as well as a router.

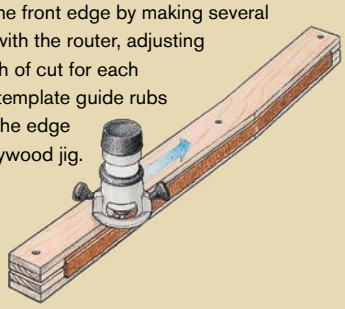
A Jig for Trimming the Back Posts to Size and Shape

This jig is sized to handle two legs at a time. After cutting the profile for the front of the leg, the author moves the leg to the back of the jig and finishes the profile.

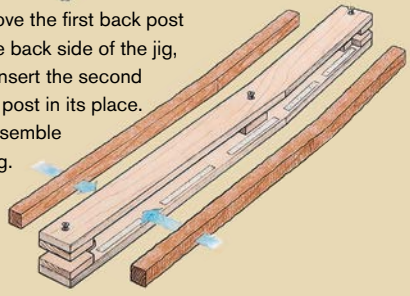
1. Mount the first back post, cut slightly oversized on the bandsaw, into the jig. The top of the jig is held down with screws and T-nuts.



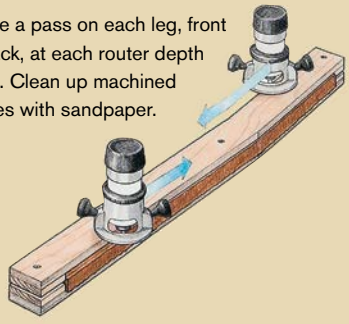
2. Trim the front edge by making several passes with the router, adjusting the depth of cut for each pass. A template guide rubs against the edge of the plywood jig.



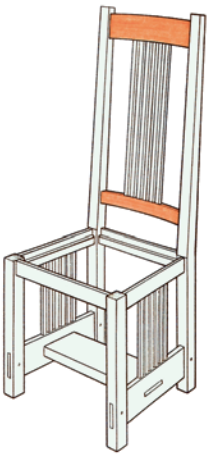
3. Move the first back post to the back side of the jig, and insert the second back post in its place. Reassemble the jig.

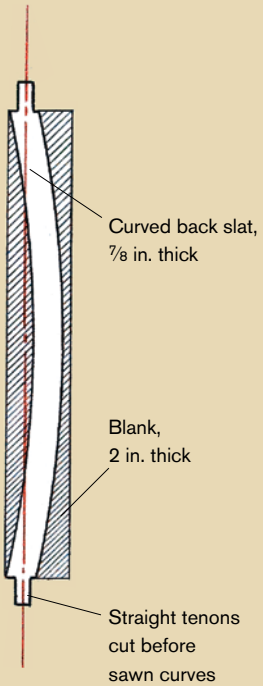


4. Make a pass on each leg, front and back, at each router depth setting. Clean up machined surfaces with sandpaper.



Cutting Curved Back Slats





CUTTING THE CURVED BACK SLATS–Convex and concave cuts from 8/4 lumber yielded 7/8-in.-thick slats, after the surfaces were scraped clean. These slats are the only curved pieces of the chair.

moved it to the other side of the jig against the registration blocks. You can avoid too much stress on the bit and prevent tearout by making several passes with the router, adjusting the depth of cut a little at a time.

Cutting the Mortises

All the chair parts except for the vertical slats are connected with ½-in. mortise-and-tenon joints. Years ago, I developed a simple jig to cut the mortises for a batch of screen doors, and I was able to use it again for this project. This jig is made of ¾-in. plywood with sides that act as a carriage for the router. A ⅝-in. slot runs down the middle of the jig, stopping 2 in. from each end. Two adjustable stop blocks sit square in the carriage and control the length of the mortise.

I held the piece to be mortised in the jig by clamping it to the underside, below the ⅝-in. slot. I used my 3-hp router with a ½-in. by 4-in. solid carbide up-cut spiral bit, adjusting the depth of cut with stops on the router. Even with the jig, this was a time-consuming process.

Router bits don't cut square-cornered mortises. Rather than cleaning out all the corners by hand, I devised a method that works really well. I chucked a Lie-Nielsen® corner chisel into my drill press (make sure it's unplugged). I clamped an adjustable fence to the drill-press table to rest the stock against and squared the chisel to the fence. The rack-and-pinion force of the drill press pared a clean, sharp corner in the mortise.

Cutting Angled Tenons

1. MOVABLE BASE SUPPORTS make adjustments easy. Built for mortising a set of doors, this jig can be adjusted to cut mortises in stock of different widths.

2. USE CHAIR PART TO SET JIG. After securing one base piece, the author snugs the other one against a side stretcher and screws it in place.

3. STOP BLOCKS FOR THE ROUTER determine the length of the mortise cuts and keep them all consistent. Pencil lines help to align the stock.

4. THE DEPTH OF THE MORTISE is controlled by the plunge mechanism on the router. The author secures stock to the jig with C-clamps.

Cut the Tenons on the Tablesaw

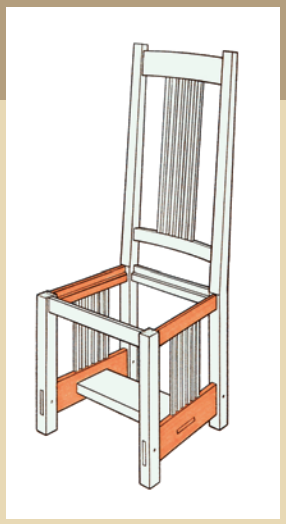
All the Stickley chairs that I've seen are wider in front than in back. The side chair in Gustav Stickley's *Making Authentic Craftsman Furniture* narrows toward the back by 1¾ in. I built these chairs to that dimension—19¾ in. wide at the front and 18 in. wide at the back, with a seat depth of 17½ in. Because of this design detail, either the mortises or the tenons have to be angled on the seat rails and the stretchers. I decided it was easier to angle the tenons.

I used the tenoning jig. By drawing the seat-plan view to full size on a scrap of plywood, I determined that the front and back of the chair related to the sides by 4 degrees off square, or 86 degrees, so I set the sawblade to that angle. To cut the cheeks of the tenons on the seat rails and bottom stretchers, I used two blades of a dado set with a ½-in. spacer between them. You can adjust the height of the blades off the table to account for tenons of different length.

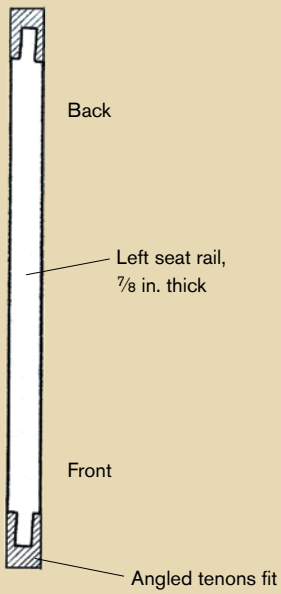
After cutting all the angled tenons, I straightened the blade mechanism back to 90 degrees to cut all the cheeks for the horizontal stretcher, front and back seat rails, and the upper and lower back slats. The tenons for all these pieces are straight—parallel to the pieces themselves.

Next, I removed one of the dado blades from the table and set the remaining blade at 4 degrees to cut half the shoulders of the angled tenons. I used a miter gauge with a positive stop. I lowered the blade, still set at 4 degrees, and moved the miter gauge

A Jig for Routing Mortises



DOUBLE-BLADE TENONING ON THE TABLESAW. With a custom-made jig, the author cut angled tenons for the side stretchers and side seat rails. Sawblades were set at a 4° pitch to the surface of the saw table and separated by a ½-in. spacer.



to the other slot to make the shoulder cuts on the other side.

Then I straightened the blade and adjusted the height for cutting the shoulders of the rest of the tenons, except the horizontal stretcher. That piece has straight tenons, but the ends of the piece are cut to 86 degrees to follow the shape of the chair seat. So the shoulder cuts for the horizontal stretcher are cut at 86 degrees with the miter gauge.

The tenons for all the ⅝-in.-sq. vertical slats were simple to make. To get ⅝-in.-sq. tenons, I cut all four sides at each end with a dado blade. A wooden backer board mounted with double-faced tape held each piece firmly against the miter gauge. I cut each piece slowly to avoid tearout on the corners of the slats. I used a sharp knife to carve the tenons down to a dowel shape to fit ⅝-in. holes drilled in the back slats, the side stretchers, and the seat rails.

Fine-Tune and Dry-Fit the Parts

Before final assembly with glue, I always like to check the joinery by dry-fitting the parts. It helps me avoid surprises when I can least afford them. I check the fit of every piece and make adjustments as necessary with a chisel or a shoulder plane.

I marked the through-dowel pins for the lower stretchers (⅜ in. dia.) with a homemade gauge at 4 in. up from the bottom of each post. I drilled halfway in from either side with a Forstner bit in the drill press. Scraping and sanding removed all the milling marks and provided a smooth surface for finishing. After a satisfactory dry-fit, I completely disassembled the chair and stained all the parts.

You have to think through the order in which the pieces of a chair go together, but it's really pretty simple. Vertical slats went in first, glued into both the back slats and the side-stretcher and seat-rail assemblies. I assembled whole sides by adding the front and back posts and clamped them to dry overnight. The next day, I put two sides together with the horizontal stretcher, the front and back seat rails, and the back-slat assembly to make a complete chair frame. I let any glue squeeze-out around the joints cure partially before removing the glue with a sharp chisel.

After the glue had cured, I removed the clamps and glued and screwed ⅞-in.-thick corner blocks to the inside bottom of the chair. These add stability to the frame and support the inset rush seat. I go over the chair completely with 400-grit wet-or-dry sandpaper and follow that with a good rubdown using #0000 steel wool.

A Finish from Sam Maloof

Oil on wood is really a beautiful finish, bringing out a depth that looks superior to any film finish. But on furniture and cabinets that come into contact with water, I had been hesitant to use such a finish until I read about Sam Maloof's three-part formula. He mixes equal parts of raw tung oil, boiled linseed oil and polyurethane. The polyurethane prevents this finish from showing water spots.

With the temperature about 50° to 60° F, I sprayed this concoction on the chairs and let it soak in for 10 to 20 minutes. After that, I wiped it off with a rag, using a circular motion. I repeated this procedure two times, letting each coat dry a few days. Then I gave all the surfaces a final buff with #0000 steel wool.

The Maloof technique also calls for another mixture: equal parts tung oil, boiled linseed oil, and beeswax. To make this, I melted some beeswax in a double boiler on the stove. While that was still in liquid form, I added the tung and linseed oils, mixing

DRY-ASSEMBLE ALL THE PIECES. **This dress rehearsal for the final assembly helps the author avoid the costly mistake of glued joints that don't fit.**

them together. When this mixture cools to a paste, it's easy to apply with a cotton cloth, rubbing in a circular motion. I applied three coats to the chairs. The beeswax gave this finish a nice, satiny glow.

The Frame and Fiber Rush Seat

Unlike most chairs made with a rush seat, this one has a separate frame screwed into place after it was woven. Fiber rush exerts a tremendous amount of pressure on a frame, so I decided to use plywood, figuring the multiple alternating layers would hold up better over time. A ¾-in. piece of plywood, cut out in the middle to make a 1½-in.-wide frame, worked best.

REX ALEXANDER builds furniture, cabinetry, and millwork in Brethren, Michigan.

Sculpting Chair Seats with a Shop-Built Duplicator

BY DAN TRIMBLE

Shaping a flat slab of wood to fit the human behind is nothing less than sculpture. Doing it 30 times the same way is production sculpture. This was one of the tasks I faced when asked to reproduce more than two dozen Yorkshire-style chairs (see the inset photo above) for a new restaurant. Although I had built lots of chairs before, these were the first with contoured solid seats. Hand-chiseling the seats was out of the question, and I wasn't ready to invest in a designated machine for one run of chairs. So I set out to find a more practical way to carve the seats.

I knew that a chainsaw could do the job and remove wood rapidly, but control was questionable. I also knew about a power-carving wheel that had chainsaw-like teeth and fit a standard angle grinder. I reasoned that a less-aggressive version of this cutter would be just the ticket. I rushed an order off to King Arthur Tool (see sources on p. 69). After receiving the 22-tooth Lancelot cutter, I mounted it on my angle grinder and experimented on a piece of wood. The wily little tool surprised me with its effortless cutting, removing stock both in line and side to side. But controlling the cut for 30 exact copies still presented a problem. Necessity being the mother of invention, I built a duplicating jig using this power carver and two pattern followers (see the photo at right).

Making a Linear Carving Duplicator

Based on three points on a line, I figured that when two outside points followed identical patterns, a center point would trace the matching contour on a blank. Allowing 3 in. between the patterns and a 17-in.-wide blank put the distance between the blank centerline and the center of each pattern at 20 in. To assemble the patterns and jig, I mounted a plywood base on a large worktable.

Frame and Cutter I made the jig's frame, which holds the followers and angle grinder, from a piece of ¾-in. cabinet-grade plywood. To straighten the frame, I added a plywood stiffener to go along its top edge. The neck on the head of my grinder fit nicely into a 1¾-in.-dia. hole drilled in the frame. To hold the grinder (with its screw-on handles removed) in place, I bolted a couple of ¾-in. plywood blocks to each side of the grinder reusing the tool's handle holes. Then I screwed on a piece of plywood to act as a guard for the cutter, as

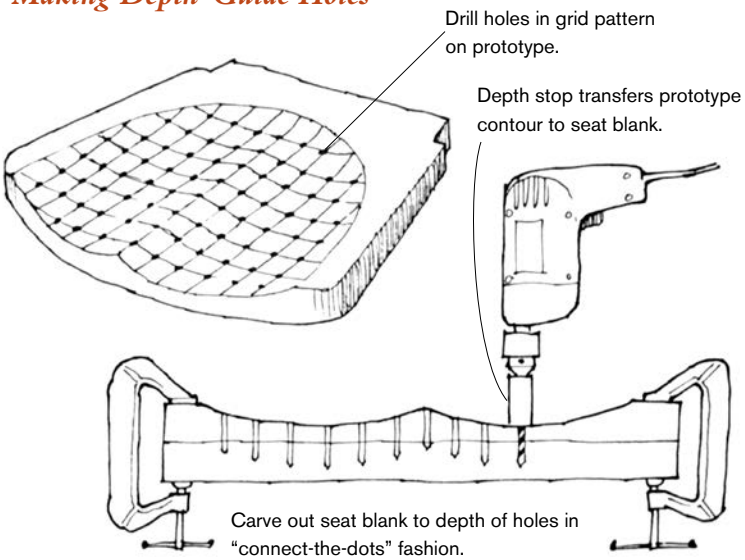
TO SIMPLIFY A PRODUCTION run of Yorkshire chairs with contoured hardwood seats (inset), Dan Trimble devised a seat duplicator. The jig's cutterhead, an angle grinder fitted with a wood-carving wheel, dishes out the central seat blank, reproducing the shape of the two seat patterns that are located left and right of the blank. When copy carving a seat (10 minutes from start to finish), Trimble wears long sleeves and an air helmet.

Depth Holes Guide Consistent Seat Carving

BY ALEC WATERS

Confronted with six time-consuming Windsor chair seats, Bill Turner of Stonington, Maine, came up with a method that transfers a seat shape from prototype to blank using depth-governed pilot holes. He first lays out and drills a 1-in. grid of holes through a prototype pattern (see the drawing below). With the prototype clamped atop a seat blank, he drills through a hollow spacer back through each hole. The resulting hole depths conform to the seat contour. To remove wood in a connect-the-dots fashion (see the photo below), both Turner and Canadian furnituremaker Mac Campbell use grinders with chainsaw-tooth cutters. (Cutters are available from Woodcarver; see sources on p. 69.)

Making Depth-Guide Holes



FREEHAND POWER CARVING:

When carving with his grinder, Campbell shifts the tool's safety guard to a 45 degree angle to its axis. After he clamps the workpiece to his bench, he power carves up to about ¼ in. away from a pencil guide line that he marked at the back of the seat. To maintain control, Campbell orients the cutting wheel at a 90 degree angle to the work while holding the tool's auxiliary handle. To deflect chips, he wears a glove and face shield. Starting at the back of a seat, Campbell moves toward the front, scooping to a 1-in. depth about 3 in. from the rear of the carved area. Unlike traditional Windsor chair makers, Campbell slightly rounds his seat's front edge to give more comfort to the back of a sitter's legs. After the seat is sanded, he also eases the bottom edge with a rasp or roundover router bit.

BOTH BILL TURNER AND Mac Campbell use depth holes to guide them when roughing out seats. Campbell modified the shape of this pattern several times by adding fiberglass auto-body compound and grinding away wood. As he's carving, he periodically checks the seat's profile with a centerline template.

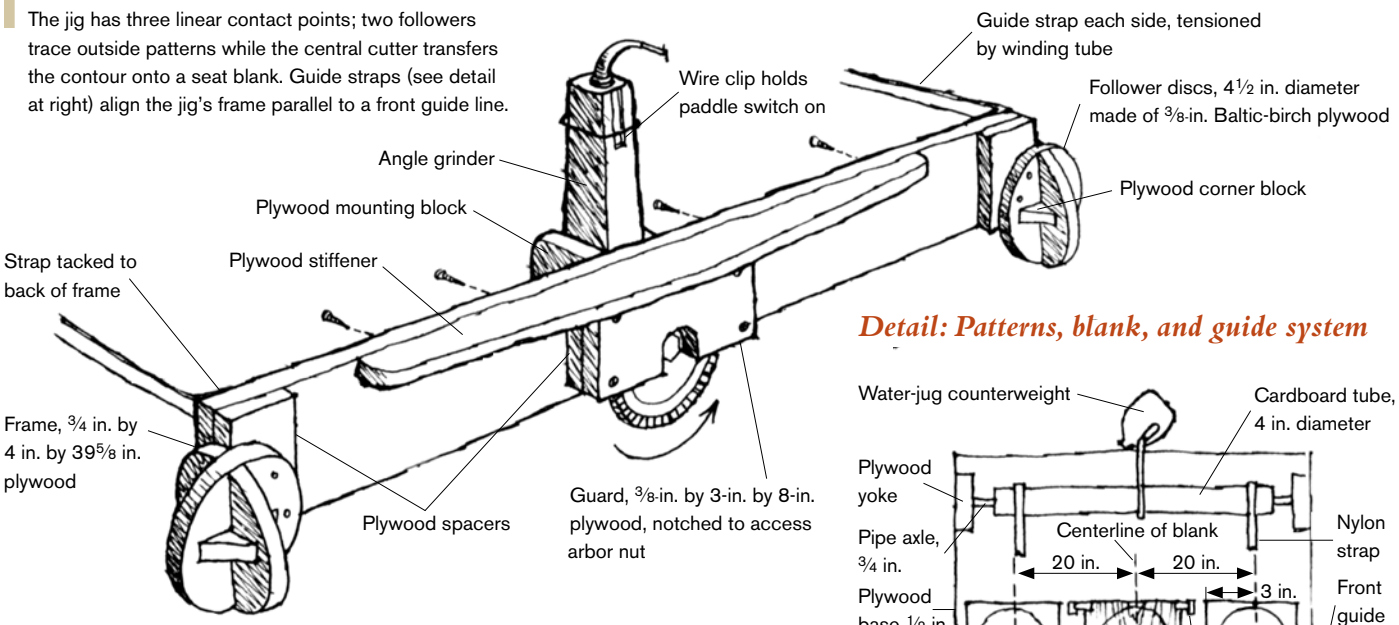
shown in the photo below. I also notched the guard so that I could access the arbor nut of the grinder.

Pattern Followers To transfer the patterns correctly, I made round followers the same diameter as the cutter wheel. I cut two 4½-in.-dia. discs of ⅜-in. Baltic-birch plywood and added pairs of 4 1/2-in.-dia. semicircles at right angles to the sides of the discs (see the drawing below). To keep the discs aligned and rigid, I glued on some corner blocks. Then I shimmed the discs in line with the cutter wheel. I screwed the sphere-like followers to the frame's ends, so the bottom of the discs were tangent with the edge of the cutter and 40 in. apart, center to center. The discs don't roll. Instead, they slide over the contour, much like the stylus of a lathe duplicator, pushing wood chips out of their way as they go.

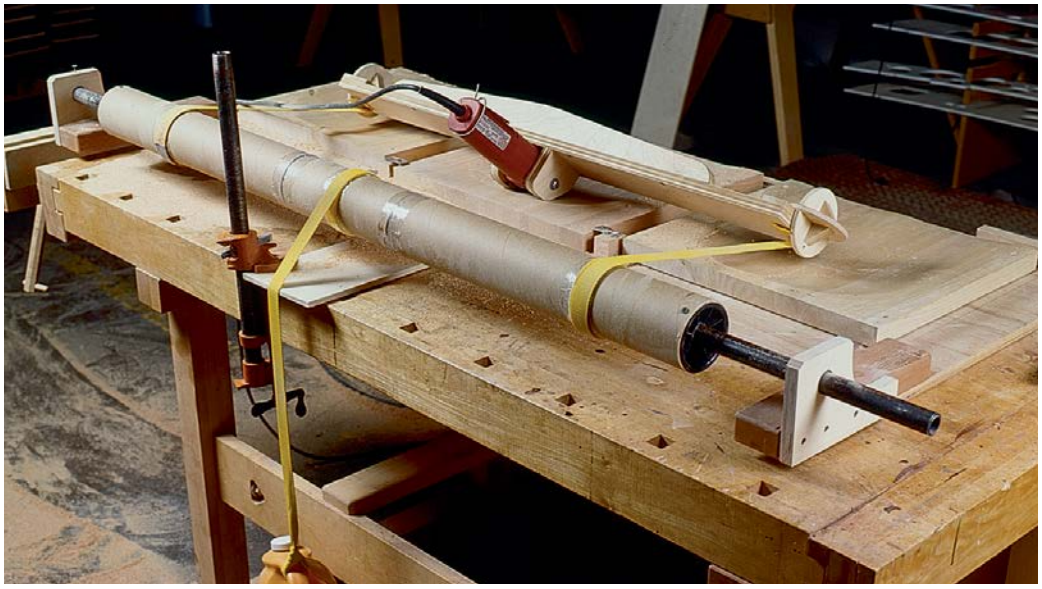
WHEN DUPLICATING A SEAT, **Trimble moves his jig with the grain, taking ¼ in. at a pass. In actuality, the carving wheel cuts across the grain. To minimize grain tearout, Trimble makes an initial L-shaped swath with the cutter, which reveals the seat's pommele. Here, part way through a seat, he adjusts the guard.**

SEAT DUPLICATOR ASSEMBLY

The jig has three linear contact points; two followers trace outside patterns while the central cutter transfers the contour onto a seat blank. Guide straps (see detail at right) align the jig's frame parallel to a front guide line.



Detail: Patterns, blank, and guide system



AT THE BACK SIDE OF THE JIG, a pair of nylon straps wrapped around a tube keep the two followers parallel to the front edge of the patterns. This alignment ensures that the cutter copies the contour on the blank. The tube spins around an axle (¾-in. iron pipe) that is supported by two yokes. A counterweight (water jug) suspended at the end of a central strap puts tension in the system.

Parallel Guide System The line between followers has to stay parallel to the front of the seat patterns and blank (see the drawing detail on p. 65); otherwise, the three-point follower/cutter principle fails. I originally thought I could hold the duplicating jig in line by hand but quickly found this very hard to do. So I came up with a system for guiding the jig using nonelastic straps attached to the ends of the frame. I used a pair of 4-ft.-long nylon straps rolled around a 5-ft.-long cardboard tube (photo above). I ran a 5½-ft. length of ¾-in. iron pipe through the 4-in.-dia. plugs on each end of the tube to act as an axle. Supported on two plywood yokes that were screwed to blocks fixed onto the base, the tube spins on its axle and winds the straps in. When the straps are adjusted tautly, the jig stays parallel to the front of the base. To tension the straps, I wrapped another strap in the opposite direction at the tube's center and weighted the other end of this strap with a plastic jug of water, letting it hang off the back of the table. To make the guide system operate more smoothly, I simply adjust the counter balance by putting more or less water in the jug.

Laminated Patterns and Topographic Prototypes In my initial attempt to make seat patterns, I built two frames for plaster-of-paris molds. The pair came out fine, but after I applied a coat of varnish to harden their surfaces, the molds were still too soft, and the followers scored them easily. (I've since found that a thick piece of Baltic-birch plywood makes an ideal prototype material; the even layers produce rings that resemble topography lines, which let you know when the two halves of the seat are symmetrical.) Luckily, my plaster molds lasted long enough for me to copy carve (duplicate) two laminated maple patterns that work superbly.

Because my blanks were thicker (1$\frac{3}{16}$ in.) than the patterns, I used the contact points of my jig as a guide and shimmed the patterns at their corners until the cutter just grazed the blank. While I was at it, I measured my cutter wheel and found that it was slightly out of round. I marked where the high spot was so that in the future, I'll always use the same reference point when leveling the patterns. Once shimmed, I just screwed the two patterns to the base. Then, to hold the blank down, I made a pair of turn clamps from blocks of scrap and some metal clips.

Hand Tools Shape a Traditional Seat

BY MARIO RODRIGUEZ

For the sake of authenticity, when I'm reproducing an 18th-century chair, I use traditional hand tools and techniques. This is especially true when I'm scooping the chair's seat. I conduct workshops on making traditional-style seats, and people are often surprised that I can hand-shape a Windsor, or any other style chair seat, in 40 minutes or less. Here's how I do it.

Most antique chairs have seats carved from a single piece of wood. For my seats, most of which are to be painted (see the photo of the Connecticut comb-back Windsor chair on page 69), I begin with a 2-in.-thick slab of pine that's sound and relatively clear, except for maybe a few small knots. First, I bandsaw the pine blank roughly to shape (use a bowsaw if you're a pure traditionalist). Then I mark out the pattern to be carved on the blank's top and an edge guide line at the circumference. I also drill holes for the legs and arm posts (stumps) at this time.

1) Adze: To begin roughing out a seat, I use a long-handled adze. I straddle the blank, so I can hold it down with my feet (clad in steel-toed boots) while I swing the adze. Using shallow cuts and fairly short strokes to break up and shorten the grain, I hollow the center of the seat (well within my outline) to about ¾ in. deep.

2) Inshave: Next, I clamp the seat to my bench and use an inshave to smooth out the seat cavity that's splintered and rough from the adze. Along the edges, I cut to within ¼ in. of my pencil line, easing the transition to the ¾ in. depth at the

STEP 1: Rough the seat hollow with an adze.

STEP 2: Sculpt concave area with an inshave.

Copy Carving and Finish-Sanding the Seats

Thinking that I should carve blanks in their grain direction, I first set up the patterns with the seats facing sideways. I plowed into a blank and got a fairly smooth cut using a to-and-fro motion while taking about ¼ in. at a pass. But after shaping a few oak blanks, I found that I couldn't keep the grain from tearing out excessively on the uphill cuts. So to make the cutterhead carve cross-grain, I removed the patterns, rotated them 90 degrees and remounted them perpendicular to a front guideline (see the drawing on p. 65). I then cut an L-shaped swath (down the left side and across the bottom), which prevents the cutter from tearing out grain on subsequent passes.

To use the jig, I hold one hand on each follower. Because this position places me near all the dust, I wear a respirator/face

Hand Tools Shape a Traditional Seat (cont.)

STEP 3: **Shape convex surfaces with a drawknife.**

STEP 4: **Remove gouges and ridges with spokeshaves.**

STEP 5: **Carve definition and**

middle. To avoid tearing out grain, I shave from the rim down to the hollow. For clean cuts, I keep my inshave sharp and my strokes light. I also keep tuned to the grain direction and restrict my shaving to the seat's concave area.

3) Drawknife: I use a drawknife to shape the seat's raised curved areas. The drawknife leaves an attractive faceted surface that needs little further work. I also use the knife to shape the seat's convex underside and back, working to the perimeter guide line.

4) Spokeshaves: I have two spokeshaves for seat-shaping work: One has a flat bottom and the other is round. I use the round-bottom shave to smooth out the curved surfaces, removing unwanted ridges and tool gouges; with the flat-bottom shave, I smooth the seat's front and back edges and its underside. Both spokeshaves leave a silky surface with slight tool marks such as those found on original Windsor chairs.

5) Carving gouges: A carving gouge is great for fine detail cutting, carving knotty areas, and getting into tight places where other tools won't. I prefer shallow gouges (#2 and #3 sweep) for carving down from the rim outline into the seat. I use ½-in.- and 1-in.-wide gouges. If a chair design calls for a rain gutter, I'll go to a ¼-in. veining gouge.

shield (available from Airstream® Dust Helmets; see sources on the facing page). I also wear a long-sleeved shirt—the chips come off the cutter at a hellish speed, giving a good sting to bare flesh.

The jig is quite forgiving when cutting cross-grain, and in less than 10 minutes, I can produce an accurate seat shape. I've found that I can smooth out any slight imperfections and give a flowing seat contour through sanding. I first rough-sand with a pneumatic orbital sander using a 24-grit disc that's mounted to a soft pad. Then it's on to finish-sanding with a sequence of 40-, 80-, 120-, and 220-grit discs. After the sanding is done, even a sharp eye (or a sensitive behind) cannot detect variation from seat to seat.

DAN TRIMBLE runs a woodworking business in Indiana, Pennsylvania.

details with gouges.

STEP 6: Smooth the seat contour with sandpaper.

6) Hand-sanding: Finally, I use sandpaper to give the seat smooth, flowing contours. I start with 60 grit to remove any grain tearout and finish up with 100 grit for a paint-ready surface. In keeping with the 18th-century chair look, I sand only the seat's top and front edge while keeping the edge crisp. On the seat's back edge and underside, I leave the tool marks showing.

MARIO RODRIGUEZ is a cabinetmaker and 18th-century woodworking consultant. He teaches toolmaking, furniture making and antique restoration in New York City.

Sources

King Arthur Tool
3225 Earl Dr.
Tallahassee, FL 32308
904-893-8550

Airstream Dust Helmets
Highway 54 S.
Elbow Lake, MN 56531
218-685-4457

Cutters are available from:

Woodcarver
c/o Ryobi America Corp.
1424 Pearman Dairy Rd.
Anderson, SC 29625
800-323-4615

A Slim, Comfortable Slip Seat

BY MICHAEL FORTUNE

AN UPHOLSTERED SLIP SEAT complements a beautiful chair. Using modern materials, it's not difficult to construct an elegant seat that will remain comfortable for decades.

In 1979 I spent five months designing and making a prototype dining chair that I hoped would be comfortable for three or four hours at a time. Part of that effort involved creating an upholstered seat that was up to this formidable task but was thin enough that it would not overpower the chair's design. Simply gluing foam to a plywood seat was not only uncomfortable but also had all the grace and style of a muffin top. What resulted was a simple upholstery detail that I have used in a wide variety of chairs ever since, in thicknesses up to 2½ in. And my original seat has held up nicely these 27 years.

Slip seats are an upholstered, padded alternative to solid wood or woven seats, offering greater comfort and a range of looks as endless as the variety of fabrics available. Another advantage is that they can be removed easily for reupholstery. In the past, slip seats were made using traditional upholstery techniques and materials, such as horsehair. I use simple techniques and commonly available, modern materials without

compromising the look and feel of a well-made traditional seat.

My slip seat consists of three different densities of foam on a thin plywood platform, which is slotted to allow it to flex and conform to the person using the chair.

Cut Slots in the Seat Platform

I use ¼-in.-thick plywood for the seat platform of dining chairs, while larger chairs that are designed to be used in a living room may have ½-in.-thick platforms. I always use Baltic-birch plywood for seat platforms because it has more laminations than other plywoods and the core is free of voids and quite strong.

Cutting a series of slots front to back on the platform makes it much more flexible and thus comfortable. The slots are 3/16 in. wide, approximately 2 in. apart and extend to within 2 in. of the perimeter (see the drawing at right). Then install T-nuts on the top side, which allow the upholstered platform to be attached and removed as needed.

For an inset slip seat like the one shown on the facing page, the platform should come up ⅛ in. short all around the inside of the seat frame. Foam and fabric added later will fill the gap.

Build Up the Foam Layers

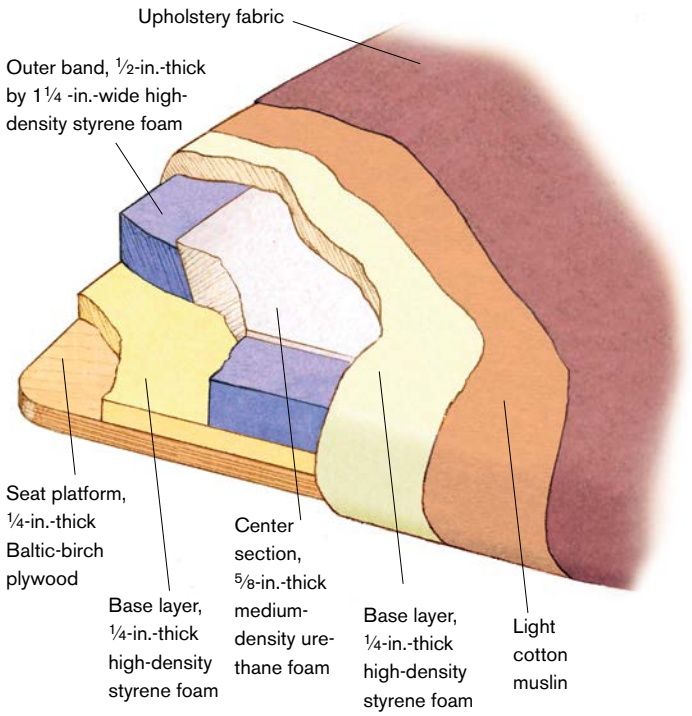
Moving from bottom to top, the foam layers go from high to low density (firm to soft). The closed-cell, high-density styrene foam used as the base layer of the seat is sold as sleeping-pad material for camping. It is available at camping-supply stores in thicknesses ranging from ¼ in. to ¾ in. To attach and laminate the foam pieces, I use spray adhesive, following the directions on the can for a permanent bond.

Put Down a Base Layer of Dense Foam Start the upholstery sequence by determining how thick (and comfortable) you want the final upholstered platform to be, then choosing the appropriate thicknesses of foam to get you there. For a dining chair, a final thickness of 1 in. to 1¼ in. is appropriate, so I start by attaching a layer of ¼-in.-thick high-density styrene foam to the plywood platform. (The fractional sizes given here are approximate because the materials I buy in Canada come in metric sizes.) Thicker seats can be made simply by increasing the thickness of this base layer and building up the outer band of firm foam that follows.

Apply the foam oversize, then trim it with a knife, scissors, or the bandsaw (fine-tooth blade) so that it is proud of the plywood by 1/16 in. The next step is easily overlooked (to the embarrassment of the person sitting down in the chair), and that

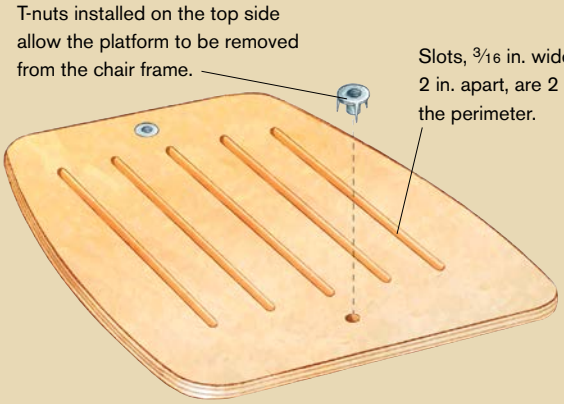
SEAT ANATOMY

This slip seat, made from plywood and a few types of foam and fabric, has a thin, flat profile, yet it's comfortable and durable.



Start with a Flexible Foundation

The seat platform starts with ¼-in.-thick Baltic-birch plywood and can be adapted to fit many types of chairs and seat configurations, from versions that overlay the seat frame to platforms that are inset into the seat frame.



SLOTS ADD SOME GIVE to the stiff material. These can be cut a number of ways, but Fortune prefers to use a template-guided router for consistent results.

is to provide some air vent holes in the foam. Locate the slots in the plywood and, using a ½-in.-dia. hole punch, create five or six vent holes around the surface for air to escape. Without the vent holes, the upholstered insert becomes a whoopee cushion.

Add an Outer Band of High-Density Foam To avoid the rounded, muffin-top look, the next step creates a firm dam around the perimeter of the seat. This is done by attaching a band of high-density foam, about ½ in. thick by roughly 1½ in. wide. If you are unable to find ½-in.-thick material, you can build up layers of thinner material.

It is important to bevel the inside edge of this outer band to ease the transition between the high-density styrene foam and the medium-density urethane foam that will fill the center. Without the bevel, the change in firmness will be too abrupt.

The high-density foam can be cut on the bandsaw with a fine-tooth blade. First, cut strips 2⅜ in. wide. Then tilt the table to 45 degrees and rip the strips into equal parts. Attach the front piece first, followed by the sides and finally the back. Bevel the ends of the pieces so that they mate nicely with each other.

Fill the Center with Urethane Foam The next step involves filling the center with medium-density urethane foam. I get low- and medium-density urethane foam from a local fabric store.

For the center section, use urethane foam that is slightly thicker than the dense foam used for the outer band. For a perimeter thickness of ½ in., for example, I recommend that the urethane foam be ⅝ in. thick.

Cut the foam about ⅜ in. bigger than the opening all the way around and leave the edge square—not at a 45 degree bevel. Spray adhesive on one side of the urethane

Build Up Layers

PUNCH FIVE HOLES for air to escape. Align these with the slots in the plywood platform below.

CUT THE OUTER BAND OF FOAM. Angle the bandsaw table to cut two beveled pieces from a single strip. Apply it flush with the outside edges of the platform, beveling the ends for neat joints.

START AT THE CORNERS. Using spray adhesive on all of the mating surfaces, attach the corners of the center section of medium-density foam to the corners of the high-density outer band.

WORK IN TOWARD THE MIDDLE of each edge. Be careful to mate each square edge of the center section as smoothly as possible with the beveled edge of the outer band.

LAST, PRESS DOWN the center section. Working from the edges toward the center, compress the softer, oversize center section as evenly as possible.

foam and on its edges. Then spray the center surface of the seat, including the 45 degree edge but not the remaining top surface. Attach the square-cut edges of the urethane foam to the 45 degree edges of the band, working in from the corners. The center of the urethane foam will form a bubble. Press down the bubble into the center area in a uniform manner. There may be small bumps around the edges, but these will be evened out in the next step.

Add One Last Layer The next step is to wrap the surface in ¼-in.-thick, low-density urethane foam. Lay the seat platform upside down on a piece of thin urethane foam cut about 2 in. larger all around. Spray the exposed 2-in. band of foam and the edges of the platform, and then lift the foam so that it bonds to the edges, avoiding large wrinkles at the corners. Lay a knife flat on the plywood and trim the excess foam flush to the surface.

Cover the Platform

The seat platform should be wrapped with thin, neutral-colored cotton muslin in preparation for the upholstery fabric. The cotton muslin can be stretched lightly with medium effort and stapled to the underside of the platform, followed by the upholstery fabric. A good hand stapler will work, but an air-powered stapler that shoots narrow staples is much easier to use, particularly if you intend to make a lot of upholstered chairs. I use a Haubold stapler with ¼-in.-long wire staples, which tend to drive in completely, holding the fabric firmly.

Care has to be taken to read the upholstery fabric. There may be a pattern that should be kept centered or stripes that should be kept straight. If the fabric has a nap, it should point toward the back of the chair so that the person using the chair is less inclined to slide out. Use only

One Last Layer

FIRST, EASE THE EDGES of the dense outer band. This material is easily machined, sliced, and sanded.

A FINAL LAYER OF FOAM smooths the bumps. Lay the seat platform upside down on ¼-in.-thick low-density urethane foam. Apply glue only along the sides of the platform and the exposed foam. Then pull up the foam evenly against the sides, being careful to avoid bumps and gathers.

Wrap it Up

THE FIRST FABRIC LAYER is cotton muslin. Stretch the fabric across the middle, from front to back, placing a few staples in the middle of the front and back edges. Then stretch it side to side and attach it the same way.

WORK TOWARD THE CORNERS, a few staples at a time. When you are near the end of an edge, skip ahead to the corner before doubling back to fill in the staples between. This should help you avoid deep wrinkles.

upholstery fabric to cover a slip seat. Fabric made for clothing or drapery will become threadbare quickly.

The fabric is attached in much the same way that an artist's canvas is stretched onto a frame: Start in the middle, stretching the fabric front to back, and tack down just the center of the front and back edges. Then stretch the fabric side to side and tack down the middle of the side edges. Now work toward the corners, adding a few staples at a time as you move outward. The tension used to stretch the fabric should be equal on all sides. When you reach the corners, pull the fabric around tightly, trying to avoid overlaps and wrinkles. Finish off this upholstery job by covering the bottom of the platform with black polyester cloth.

Wrap It Up continued

STAPLE THE UPHOLSTERY fabric the same way. The two tabs of white tape indicate the alignment of the stripes.

LAST, COVER THE BACK with black polyester. Staple it down and trim the excess.

Options for Installing the Seat

The slip seat can be supported in a number of ways, depending on the application. Most of my chairs have slip seats that are fully or at least partially set into the seat frame. To support these, I glue a plywood ring into the seat frame. It serves two purposes: supporting the seat platform and strengthening the seat frame. Like the seat platform, the thickness of the plywood seat ring is determined by the overall size of the chair. As the seat frame is assembled, the ring is set into a deep groove about ⅝ in. below the top edge. Then the upholstered platform is squeezed into the space above the ring, hiding the edges of the platform.

An alternative to insetting a slip seat into a seat frame is to let the upholstered platform hang over the front rail of the seat frame. In this case I usually attach a curved wood lip under the front edge of the platform, strengthening it and creating a plush look. If the slip seat must overlay the seat frame, it can be attached to wood blocks that are glued inside the frame.

To attach the seat platform to the wood blocks or plywood ring, you must locate the attachment holes. I cut pieces of ¼-20 threaded rod about ¾ in. long and sharpen one end of each by filing it. To mark the location of the platform T-nuts, I thread the sharp bolts into the T-nuts and press down the upholstered platform into position. Then I drill the clearance holes in the seat ring and attach the slip seat with round-head machine screws.

The result is a smooth, seamless, low-profile seat that will remain comfortable for many years.

MICHAEL FORTUNE is a studio furniture maker in Toronto, Canada.

Carve a Softwood Seat

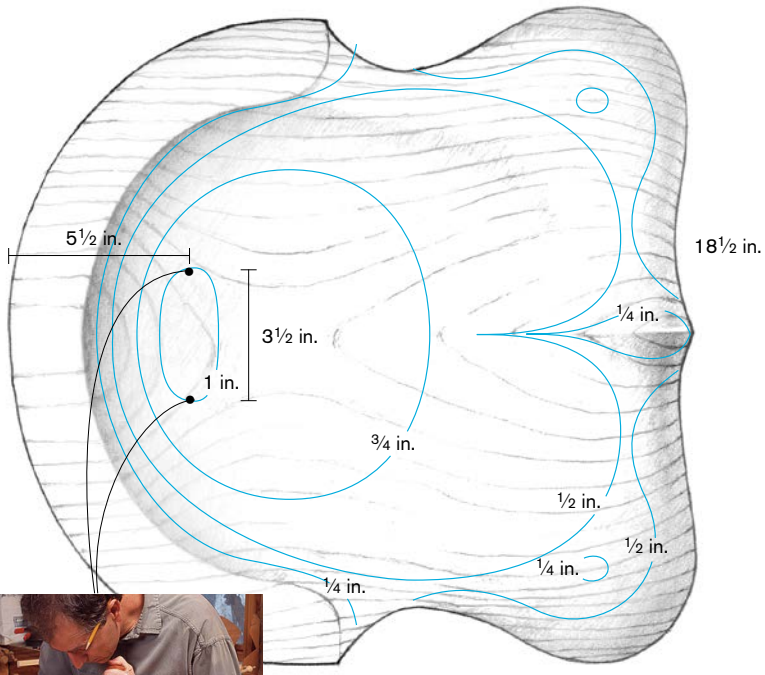
BY CURTIS BUCHANAN

I specialize in Windsor chairs because it gives me the opportunity to work almost exclusively with hand tools. It's easy to get hooked on a quiet, dust-free shop and lulled by the pace of life set by hand tools.

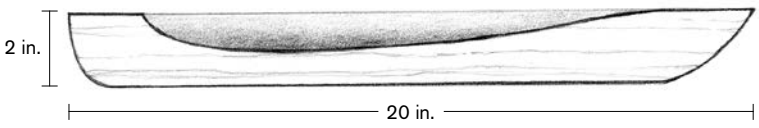
There are various challenges to making Windsors, but carving the seats is the most frustrating. Once the unfamiliar tools have been mastered, the difficulty is in creating a complex contoured shape with very few reference points. To turn a flat, square blank into a seat with a nice, deep saddle that will hold a sitter comfortably, it's useful to have a topographical map of the seat, like the one shown at right.

I begin a seat with a single piece of eastern white pine. I run the grain front to back unless the seat is extremely wide, in which case I run the grain side to side. Gluing up a seat blank is fine, but the fewer joints, the better. The more pieces you join to make the blank, the more difficult it is to get the grain alignment necessary for ease of shaping and good looks.

After planing the blank, draw the outline of the seat. Then drill two stopped holes at what will be the most deeply scooped-out parts of the seat. These holes provide a depth gauge you'll use while carving.



QUICK DEPTH GAUGE.
Two holes drilled 1 in. deep provide the main points of reference for carving out the seat.



Tools for Carving a Seat

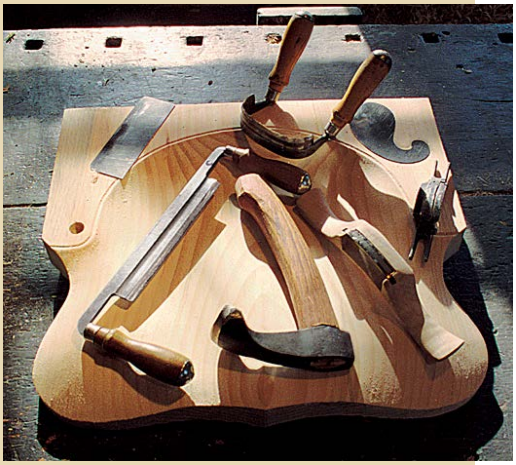
• Gutter adze–Used for the roughest initial shaping. It removes stock very quickly and leaves a deeply scalloped surface.

• Inshave–Essential for secondary shaping of the seat, it can also be used for all shaping if you lack an adze. A versatile tool that leaves a finely scalloped surface.

• Drawknife–The best tool for beveling the edges of the seat, it excels in cutting across end grain and can make a clean cut while removing a large amount of wood.

• Bottoming shave–A cross between an inshave and a spokeshave, it smooths out the marks left by the inshave and further refines the shape.

• Scrapers–Both flat and curved scrapers are used to produce the final smooth surface. After the scrapers, only a very light sanding is required.



THE TOOLS IN QUESTION. You don't have to spend a fortune on tools to get started. Clockwise from top center are inshave, gooseneck scraper, two bottoming shaves, gutter adze, drawknife, and card scraper.

Begin by excavating an oval-shaped section at the deepest part of the seat. I do this first quick removal of stock with a gutter adze. The main thing to remember when using this tool is to stand with your feet solidly planted and spread far enough apart so that an errant swing will go between your legs. Swing the adze across the grain or diagonal to it. Cutting along the grain could easily split out a chunk of wood right through the spindle deck. After you gain some depth, you can make some cuts with the grain, as long as you are cutting downhill.

When you have roughed out the oval section, use the adze to start chopping two troughs toward the front of the seat. They will divide at the front of the seat, leaving a high ridge—the pommel—between them.

This completes the rough hogging out and leads to the inshave, which will perform most of the rest of the shaping work on the top of the seat. The inshave also refines the work the adze did, replacing the adze's deep scallops with a lightly scalloped surface of its own.

Like the adze, the inshave cuts well when pulled in a path diagonal or perpendicular to the grain. A very smooth cut can be achieved by skewing the tool while pulling it straight toward you to create a slicing action. When cutting in an area where maximum control is needed, lock your elbows and shoulders and use your body to pull the knife and your wrists for fine adjustment.

The blade of a typical inshave curves in a semicircle. The cooper's inshave I use is one I had made from an old drawknife. Its blade has tightly radiused corners and a flat area between them. I use the corners to hog out material and the flat section for smoothing.

The next seat-shaping tool is the drawknife. Use it to bevel down the sides and front of the seat. Before you begin drawknifing, however, bandsaw out the front shape. Leave the back square for now so that it can be easily clamped in a vise.

To do the drawknifing, lock the seat vertically in a front vise. As you use the drawknife, skew it and use a slicing motion. This gives more control and demands less power.

After drawknifing the front edge, go back to the carving bench and use the inshave to blend in the top of the seat with the drawknifed sides. As you carve, you will begin to map out changing grain direction in your mind, developing an intuitive sense of when the path of cut needs to be altered.

At this point, the shape of the seat has been established. It's now a matter of removing the inshave marks and tweaking the shape. A bottoming shave makes quick work of this task.

Old bottoming shaves occasionally surface at flea markets for $15 to $20. These are metal tools with varying sweeps. Cut the handles off halfway, and you have a tool that will perform very well. There are some very nice wooden-bodied bottoming shaves being made today; they are rather expensive, but they work wonderfully. I use both these types, and I also modified a Record No. 151 spokeshave using files and a belt sander, producing a very satisfactory tool.

Two scrapers take over when the bottoming shave is finished: a flat one with the corners ground off and a gooseneck. By flexing the flat scraper you can smooth everything except the very back contour. The gooseneck is used for tight-radius curves like those at the back of the seat. When scraping next to the gutter, be sure to cut only in the direction of the long wood fibers or you will pull out a chip.

Finally, I use 150-grit sandpaper. If you have done your job well and not moved from one tool to the other too soon, it will take two or three minutes and only a third of a sheet of sandpaper. If the sanding reveals areas that need more scraping, then return to the scraper. Work that would take an exorbitant amount of time with sandpaper can be accomplished in seconds with the scraper.

With the top almost finished, clamp the seat upright in the front vise to bevel the seat bottom. You need a strong vise to hold

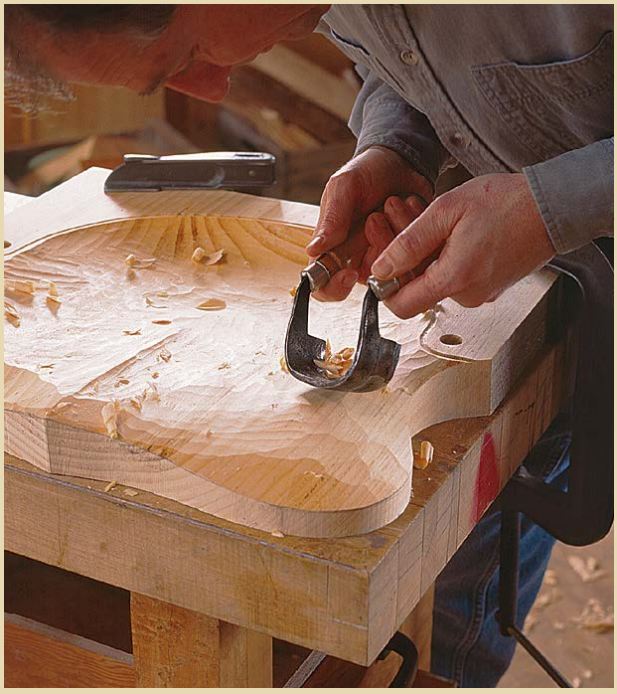
Excavate the Oval

SWING THE ADZE ONE-HANDED. **The gutter adze takes care of rough stock removal in a hurry. Start by carving an oval area at the deepest part of the seat. Keep your feet spread wide so there's no chance of hitting them if the adze glances off the workpiece.**

INSHAVE FOR SMOOTHING AND SHAPING. **An inshave refines the shape roughed out by the adze and replaces the adze's deep scallops with a pattern of smaller ones.**

Refine the Top of the Seat

SLICE THE BEVELS WITH A DRAWKNIFE. Bandsaw the front of the seat, leaving the back square to aid in clamping. Then bevel down the front of the seat. Pull the drawknife toward you with a slicing motion and work the shape in facets.



WHERE THE BEVEL MEETS THE DISH. Go back to the inshave to smooth the drawknife work and to blend the beveled areas with the dished center of the seat.

A SMOOTH SHAVE. Bottoming shaves, which can be wooden-bodied or metal, follow the inshave and create a smooth, flowing surface.

THE VERSATILE GOOSENECK. Use a gooseneck or French curve scraper to give the concave areas of the seat a final smoothing.

FLEX THE FLAT SCRAPER. A standard scraper can be flexed to clean up shallow dished areas as well as convex ones. Rounding the corners of the scraper will prevent dig-ins.

Shape the Seat Bottom

BEVELING THE BOTTOM. With the top of the seat dished and beveled, use the drawknife to bevel around the perimeter of the bottom. To simplify clamping, bore the leg mortises before the back is beveled.

DULLING THE KNIFE. At the front of the seat, where the bottom bevel meets the top bevel in a knife-edge, clean up and slightly round the juncture with a spokeshave.

BACK BEVEL. After beveling the underside of the front of the seat, bandsaw out the shape of the back. Then use the drawknife to create a steep bevel around the back of the seat.

SPOKESHAVE FAIRS THE BACK BEVEL. A spokeshave works well to clean up after the drawknife, creating a smooth, steep curve in the end grain at the back of the seat.

the seat steady. Using a drawknife, bevel back from the front edge. Cut the bevel so that it joins the top bevel in a knife edge, and then use a spokeshave to clean up the bevel and slightly round over the knife edge.

Back at the bandsaw, cut the back of the seat to shape. Then you can bevel the back with the drawknife and clean up with a spokeshave. This brings you to the sides, where the top, bottom, front, and back meet. Use the drawknife to clean up the bandsawn cove, being careful to keep the blade perpendicular to the seat. Take light cuts in from both directions to avoid digging a deep V rather than a round cove.

CURTIS BUCHANAN makes Windsor chairs in Jonesbourough, Tennesee.

Weaving a Cane Seat

TOOLS AND TECHNIQUE ARE SIMPLE. **Caning doesn't require many tools, and this octagonal pattern is easy to reproduce.**

BY JUDY WARNER

I had two reasons for wanting cane seats on the breakfast-nook stools that my husband had made. First, I love the light, airy pattern of traditionally woven cane, a pattern that's been around for more than 300 years. Second, I was tired of sitting on the hard wooden seats of the old stools. We've been very pleased with the results; the pattern blends well with the contemporary stools (see the top photo at right), and the firm yet flexible cane is more comfortable than wood and less expensive than upholstery.

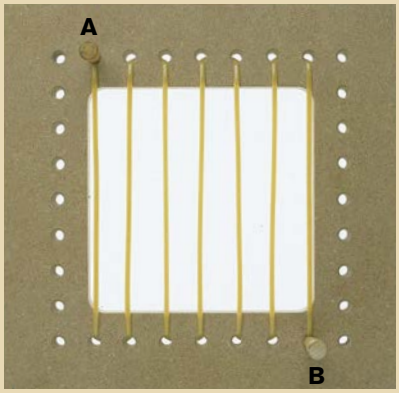
Cane and Equipment

Cane for chair seating comes from rattan, a vinelike plant that grows up to 300 ft. in the jungles of Indonesia, China, and India. The foliage and outer bark are cut away from the 1-in.-dia. main stem, which is cut into strips to make the cane.

Cane is readily available from several weaving-supply stores and is usually sold in metric widths (see sources on p. 84). Cane is supplied in hanks of 500 ft. and 1,000 ft. or in a coil of 250 ft., which is enough for one 12-in.-sq. seat. If this is your first seat, I suggest ordering at least 500 ft. of cane and weaving a practice seat. An easy way to

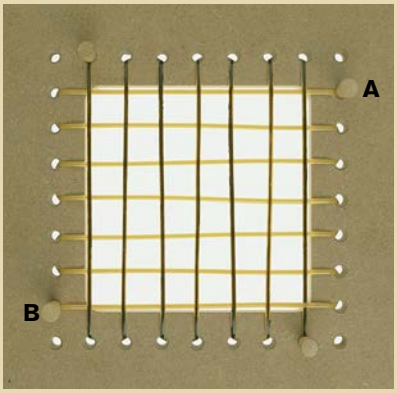
CANED SEATS ARE VERSATILE. **Although this traditional pattern is at least 300 years old, it goes well even with contemporary furniture styles.**

Weaving a Cane Seat



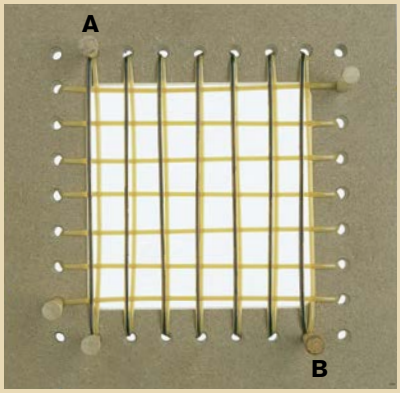
STEP 1: FIRST VERTICAL LAYER

Starting at hole A, peg the cane, pull it across the seat, and then weave it down through one hole and back up through the adjacent hole. Keep the glossy side up. Peg the last hole at B, leaving about 5 in. extra for tying off. The cane should be slightly slack because the grid tightens with continued weaving.



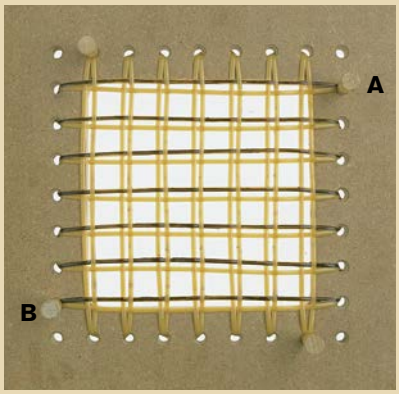
STEP 2: FIRST HORIZONTAL LAYER

This is a repeat of the first layer, except this layer fills in from side to side. Start at hole A, leaving about 5 in. of extra cane, and tap in a peg. This layer also should be slightly slack and lay on top of the first layer. Continue from side to side to the finish point at hole B. Peg the cane, leaving an extra 5 in.



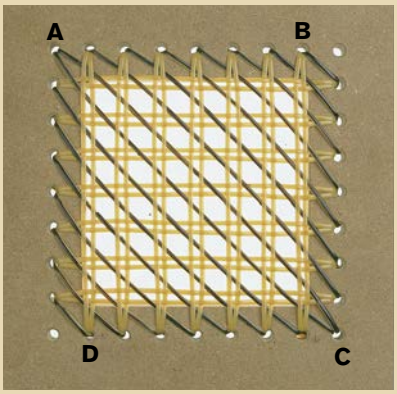
STEP 3: SECOND VERTICAL LAYER

Begin another layer in the same manner as Step 1, using the same holes, starting at A and ending at B, as in Step 1. This layer sits on top of Step 2's horizontal layer, with the cane slightly to the right of the cane in the first vertical layer. Again, leave about 5 in. at each end, and peg the ends in place. The cane still should be slightly slack.



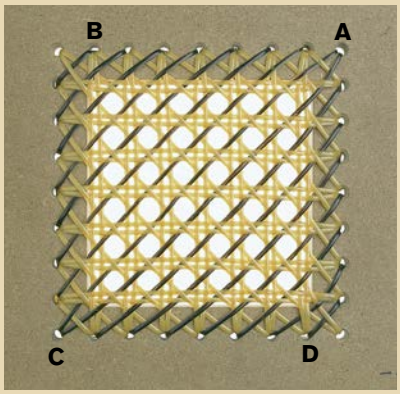
STEP 4: SECOND HORIZONTAL LAYER

Work from right to left, starting at hole A, but this time, the cane is woven under strands in layer 1, over strands in layer 3, and in front of strands in layer 2. I weave about one-third of the way across the seat and pull the strand taut before weaving the next third. The cane pulls through more easily if you keep it moist.



STEP 5: FIRST DIAGONAL LAYER

The diagonals are woven with two separate strands. The first strand starts at hole A and ends at hole B. The second starts at hole C and ends at hole D. Weave under vertical and over horizontal pairs of strands as you go. Leave an extra 5 in. of cane at the ends, and then peg the loose ends as you go.



STEP 6: SECOND DIAGONAL LAYER

This layer, which runs perpendicular to the first diagonal layer, will complete the pattern. This time, the cane is woven over the vertical pairs of strands and under the horizontal strand pairs. Complete as in Step 5. To tie off loose cane on the underside of the seat, make an overhand knot as shown in the drawing at right on p. 85.

Sources

The following companies manufacture or supply caning equipment and materials.

Cane & Basket Supply Co.
1283 S. Cochran Ave.
Los Angeles, CA
90019
800-468-3966
www.canebasket.com

Constantine
2050 Eastchester Rd.
Bronx, NY 10461
800-223-8087

Earth Guild
33 Haywood St.
Asheville, NC 28801
800-327-8448
www.earthguild.com

H.H. Perkins Co. Inc.
222 Universal Dr.
North Haven, CT
06470
800-462-6660

Rockler Woodworking and Hardware
4365 Willow Drive
Medina, MN 55340
(800) 279-4441
www.rockler.com

SELECTING CANE

Hole Diameter	Space Between Holes	Size	Width of Cane
1/8 in.	3/8 in.	Superfine	1.75 mm
3/16 in.	1/2 in.	Fine-fine	2 mm–2.5 mm
7/32 in.	5/8 in.	Fine	2.5 mm
1/4 in.	3/4 in.	Medium	3 mm
5/16 in.	7/8 in.	Common	3.5 mm
		Binder	4 mm–6 mm

make a practice frame that requires no joinery is to cut it from ¾-in.-thick plywood.

Tools needed for the caning job are minimal, and they usually can be obtained from the same source as the cane. You'll need caning pegs (golf tees also work), a n awl, scissors, clothespins, and a dish pan to soak and soften the cane. If you're a beginner, you might want to consider plastic cane. Plastic cane is easier to weave, doesn't require soaking, and holds up to heavy use. Another option is to use prewoven cane panels held in a groove around the seat opening with a reed spline.

Preparing the Seat

For a new seat, I lay out and drill holes for the cane based on the look I want. For example, for a light, delicate look, I'll use narrower, 2-mm- to 2.5-mm-wide cane (roughly 3/32 in. wide) and size and space holes according to the chart above. I chamfer the top and bottom of each hole to ease the stress on the cane as it wraps around the frame. I also lightly chamfer the top inside edge of the seat frame, so the cane doesn't wear at that point. A rabbet routed around the bottom side of the seat frame helps hide the knots that hold the cane in place, as shown in the photo on the facing page.

To prepare an old seat that I'm repairing, I cut the caning away just inside the frame and save this piece for a pattern reference when weaving the new seat. After cleaning out all the old cane and any other residue left in the holes, I make any necessary repairs to the chair. Now's the time to clean up and refinish the chair, if necessary. It's much harder later.

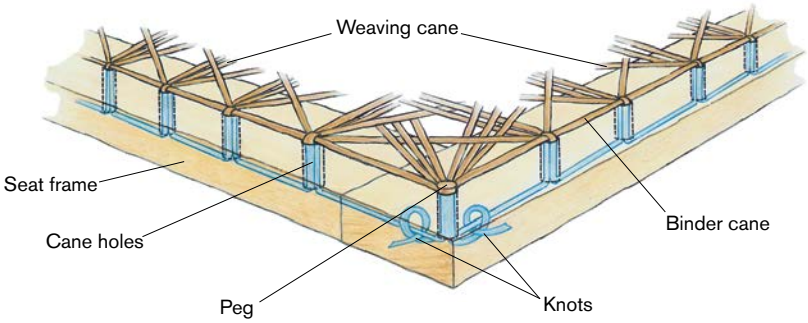
Caning a Seat

I use the seven-step approach, a standard caning technique, as shown in the photos on p. 83 and in the drawing at left on the facing page. This method is suited to the simple, square seats that my husband makes for his stools (see the top photo on p. 82). It's a technique that has been around for more than 300 years and is a good starting point for learning more advanced designs later. Whether weaving a new seat or replacing the broken cane in an existing seat, the first step is to determine the appropriate cane size from the chart above. I used medium cane (about 1/8 in. wide) in 10-ft. to 15-ft. lengths on this seat.

Before weaving, the cane must be soaked in water for at least 10 minutes to make it pliable. If the cane dries out while weaving, a quick dab with a damp sponge will help the cane slide a little more smoothly. Another thing to keep in mind while weaving is that the top side of the cane is smooth and shiny and somewhat convex and the bottom is flat and rough. Be sure to keep the shiny side up. Use a continuous pattern of down through one hole and up through the adjacent hole. Hands should be positioned one above, one below, as shown in the bottom photo

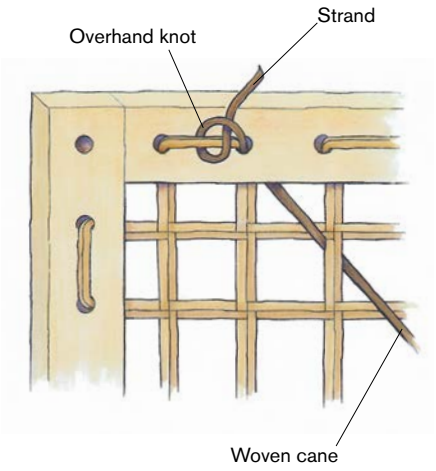
STEP 7: BINDER CANE

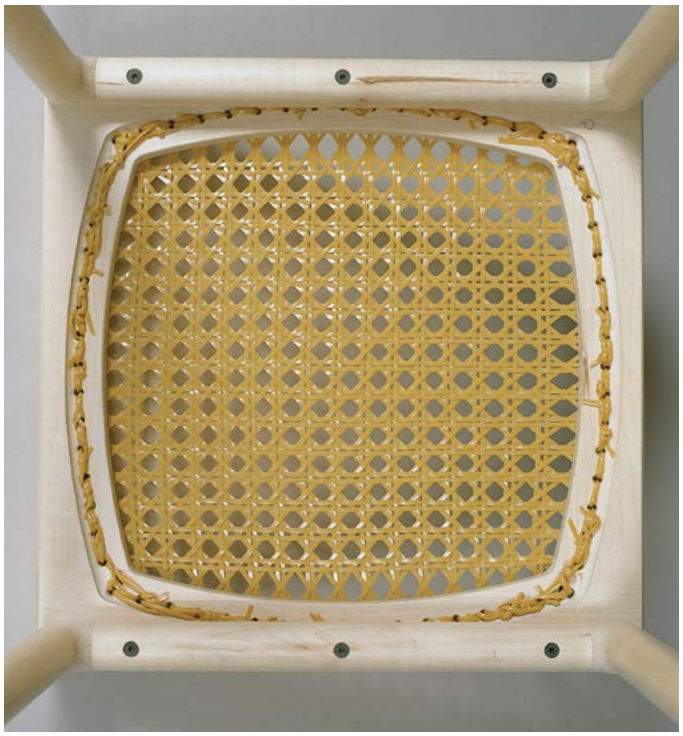
For a finished look, install a binder cane. Cut a length of binder to fit one side of the seat, leaving about 5 in. extra on each end for tying off. Pull the binder through corners and peg in place. Secure the binder with regular cane by pulling the cane up through the first hole, over the binder, and down through the same hole, continuing to the next corner.



TYING OFF LOOSE ENDS

(Bottom view of seat frame)





KEEPING THE KNOTS NEAT.
A rabbet routed into the underside of the seat frame helps hide the mass of knots and cane endings. Chamfering the top and bottom of each hole and the top, inside edge of the frame helps prevent undue wear on the cane.

on p. 82. Note that no actual weaving takes place until the fourth step.

Finish the seat by tying off all the loose ends with overhand knots, as shown in the drawing at right above, cutting away any extra fringe and trimming the ends to leave about 1 in. Try to keep the knots equally spaced around the underside of the seat frame.

I like the natural, glossy look of cane, but it can be stained or finished with shellac or varnish if you prefer.

JUDY WARNER is a weaver in Escondido, California.

Coopering a Chair Seat

BY CHARLES ARGO

Coopering is the barrel-maker's art, the technique of joining beveled staves into curved surfaces. I learned it from James Krenov at the College of the Redwoods, not a place known for its wooden barrels and buckets. Krenov taught me how to use this technique for making a variety of curved furniture parts like cabinet doors and case sides. But it was Jeremy Singley, a woodworker I've never met, who got me thinking about coopering solid wood to form curved chair seats.

Singley had tackled the problem of making a curved chair seat by cutting sawkerfs in the bottom of the chair blank and then driving wedges into the slots to force the seat into a curve. After reading about his approach, I remember thinking that coopering would be a lot easier. Because I wasn't making chairs with solid seats at the time, I filed the thought away.

Eight years later, when I began to consider a chair with a solid seat and spindle-turned parts, it was only a short leap back to the idea of a coopered seat. Unlike the traditional method of sculpting a seat from a thick plank of wood, coopering produces a seat that is curved across both top and bottom. I think of chairs essentially as functional sculpture, so a coopered seat promised to add to the chair's visual appeal (see the photo on the facing page).

At first I was just going to use a simple, curved panel as the seat—something like a section from a barrel. But I soon realized that with a little planning and some judicious cutting, I could form a pommel at the front of the seat before the staves were glued up. It seemed easy enough on paper. In reality, it wasn't, and I did several seats before I was happy with the result. Coopering a chair seat is still a lot of work. Staves must be cut and fitted with great precision and gluing them together correctly takes planning as well as practice. Unlike a seat made from flat lumber, a curved seat provides no flat reference points. There's no doubt that making a coopered seat for a chair like this rocker is more involved than shaping a solid seat. But is it worth it? Absolutely. Coopered seats are extremely comfortable, and they look simply but elegantly sculptural.

Mock Up a Seat before Cutting Seat Patterns

There are two curves in these seats: the basic curve of the seat (the profile you see if you look at the chair from the back) and a double curve in the front that forms

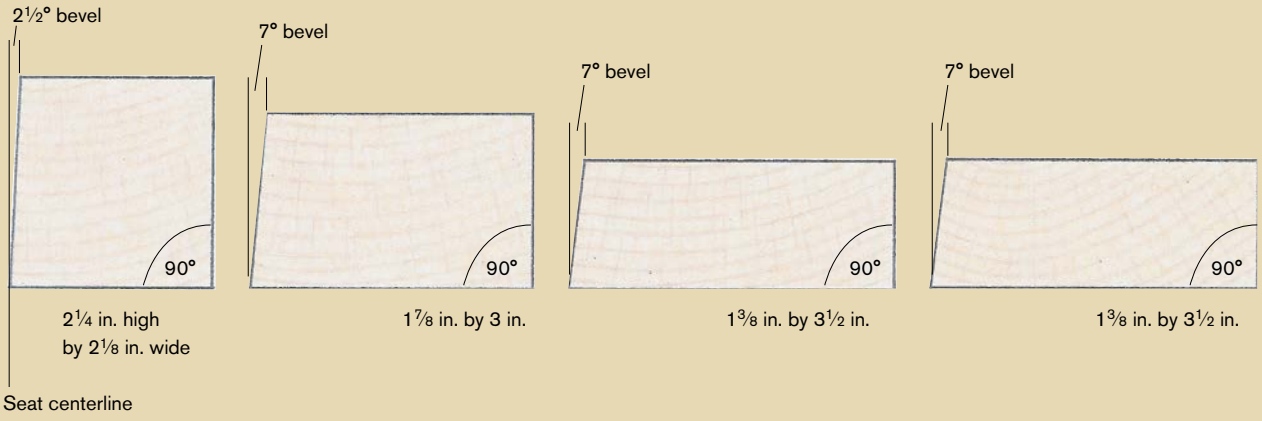
the pommel. My first step is to make a mock-up seat. Then I establish the finished size of the seat (19 in. deep by 21 in. wide for this rocker) and find the right radius for the basic curve. I want as much curve as possible. But I don't want the seat to pinch my legs together when I'm seated. So I settled on a radius of 27 in. and a seat thickness of 1¼ in.

With the width, curve and thickness established, making a template that corresponds with the back edge of the seat is a simple matter with a set of trammel points. The front template is more complicated because it has the pommel meeting in the center. I start with the template for the

LAY OUT THE CURVES BEFORE CUTTING STAVES. Templates of front and rear seat curves are traced onto a piece of scrap. Staves will be cut in order, beginning at the seat centerline.

Rough Dimensions for Seat Staves

This seat is made of eight staves, four on each side of the seat centerline. Because the seat's pommel will be cut from the two staves on either side of the seat's centerline, these pieces are thicker and narrower. Staves are beveled on their inside faces.



basic curve that I've just made and then lay out the pommel over it. The height and width of the pommel is up to you, but my seats have a ridge that rises 1 in. above the basic curve at the center and fairs into the seat at a point about 5½ in. on either side of the centerline (see the bottom photo on p. 87). It's important to get a smooth transition between the basic curve and the double curve of the pommel. Once you have the front edge laid out, you can make a template of it. The templates can be traced onto a piece of scrap, and each stave is marked and cut directly from this drawing.

Pay Attention to Grain When Selecting Staves

Generally, I use eight staves to glue up a seat blank. Because I do the bulk of the shaping on the finished seat with planes and spokeshaves, I look for wood that will cut cleanly. For the same reason, I like to arrange the staves with the grain running in the same direction along the top surface. And because the pommel ridge is so prominent, I always cut the two staves that form the ridge from the same piece of wood. That reduces the chance of seeing the glueline.

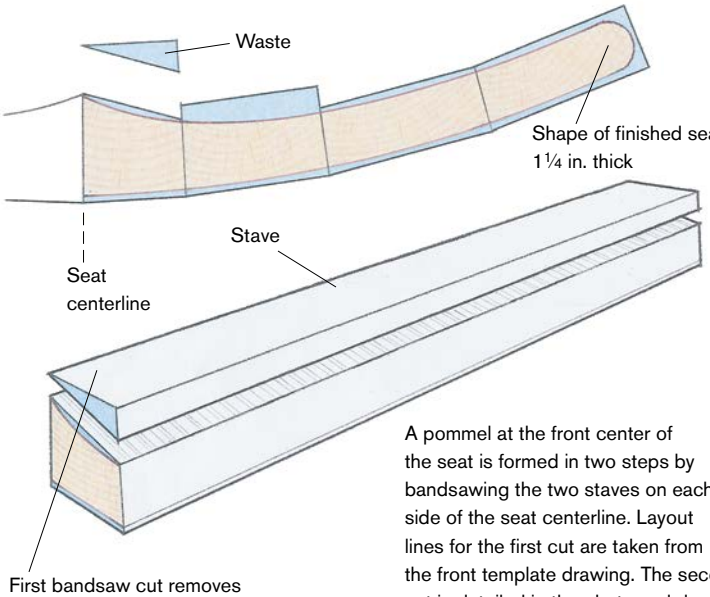
The pommel begins at the center of the seat and falls away to either side, so I need thicker material at the center than I do at the outer edges. The drawing above shows the dimensions I use for the eight staves. So to save time later, I make the innermost staves narrower than the ones on the outside. The more of a curve you span with a stave, the more material there is to remove by hand after the seat is glued up. I always cut an even number of staves and make identical left and right pieces as I go.

Laying Out the Staves on the Drawing

With the staves roughed out and the templates traced onto a piece of scrap, I'm ready to mark and cut each stave in order. I start in the middle and work out. The series of photos on the facing page shows how the staves are marked. The outer edge and bottom of each stave is left square as I work outward along the curve. The bevels are cut

Fitting Staves to the Template

WORK FROM THE CENTER OUT. The author has marked this first stave so it will conform to the centerline of the drawing.



A pommel at the front center of the seat is formed in two steps by bandsawing the two staves on each side of the seat centerline. Layout lines for the first cut are taken from the front template drawing. The second cut is detailed in the photo and drawing on p. 90.

MARK THE CUT FOR THE POMMEL. After the bevel has been cut on the tablesaw, the stave can be marked for the first of two bandsaw cuts that will define the pommel at the front of the seat.

ADJUST THE BANDSAW BY EYE. The first angled cut for the pommel is made freehand on the bandsaw. The angle is found by marking the end of the stave on the front template drawing.

STAVE NOW FITS THE DRAWING. The inside edge of this stave has been beveled on the tablesaw and the top cut end to end on a bandsaw. The stave should line up with the template drawing.

MARK THE DRAWING FOR THE NEXT STAVE. The author marks the drawing where the outside edge of the first stave stops. The edge of the next stave, beveled at a slightly steeper angle, starts here.

on the inside faces of the staves, and the angles vary.

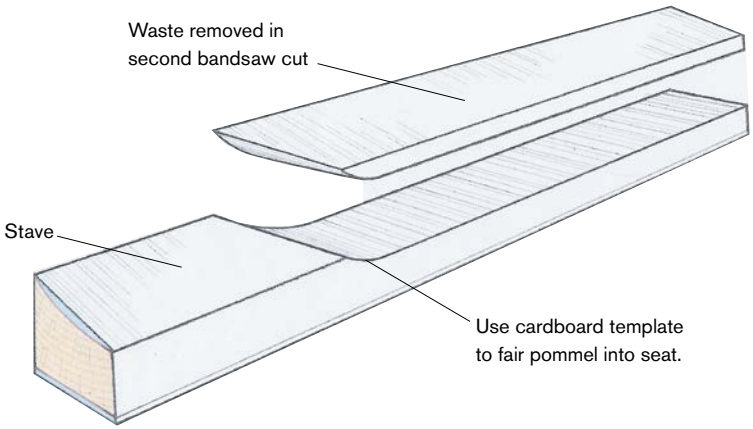
The first stave is cut on the tablesaw so its inside face (the one along the chair's centerline) is about 2½ degrees. The inside edge of the second stave has a bevel of about 5 degrees, and the two outside staves are beveled at about 7 degrees. These angles will vary with the seat, and you'll just have to experiment as you go along. Just make sure the staves conform to the drawing you've made from the template. And remember to cut the stave's mirror image—the stave for the other side of the chair—as you go along.

Forming the Pommel with the Bandsaw

The pommel is like a small hill that rises out from the center of the seat in the front. It fairs into the basic curve of the seat to the sides and to the rear. Only the two staves to either side of the centerline have to be cut for the pommel—the two outer staves on each side are simply beveled to fit the basic seat curve.

The side-to-side profile of the pommel is formed stave by stave using the front template and the bandsaw. To cut the second pommel curve, the one from front to back, I start by deciding how far back from the front edge of the seat the pommel ridge will extend. I find that about 5 in. works well on my finished seat. Because I've allowed an extra inch in the length of the staves for the rough seat blank, I make a mark 6 in. in from the front on the top inside edge of the two center staves.

At the back of the stave, I mark the point where the stave intersects the back template. With the help of a straightedge and a cardboard template for the pommel curve, I draw a line on the inside edge of the stave parallel with the bottom that sweeps up into the pommel (see the photo below). The sweep of the second pair of staves is marked after I've cut the first ones on the bandsaw.



There's a Trick to Gluing Up

Now that all the staves are cut, how do you glue this thing together? Well, it's not like gluing up straight stock. I glue up staves in pairs: the two outside staves on each side, the two inside staves on each side, then the two halves of each side and, finally, the

LAY OUT THE SECOND POMMEL CUT. The template drawing of the back of the seat, a straightedge, and a curved cardboard template are used to lay out the second cut that will finish up the rough pommel shape.

EIGHT STAVES MAKE A SEAT.
Once the contours of the pommel have been cut on the four center staves, seat parts are now ready for glue-up.

A JIG FOR FINAL GLUE-UP.
By the time the author is ready to glue the two halves of the seat together, the clamp line is well below the two outside edges of the seat, making clamping tough. The solution is a jig that is screwed to the seat blank.

whole seat. Gluing the whole thing up at once would be nearly impossible. The most important part of glue-up in any coopered panel or seat is getting clamp pressure at exactly 90 degrees to the face of the joint. I use my template drawings to determine the correct line of clamp pressure and make angled glue blocks. Keeping clamp pressure on the centerline is crucial to a tight joint. Even small deviations will result in open gluelines.

The final glue-up—in which the two halves of the seat are joined—is the most complicated. Because of the amount of curve involved, the line of pressure for the clamp falls below the outer edge of the seat. I make a heavy jig that fits against the bottom and outside edge of each half and screw it directly to the seat blank in areas that will be cut away later (see the photo above).

If glue-up has gone well, shaping the seat should be relaxing and fun. I have a variety of round-bottomed planes I've made, some specifically for this chair seat, as well as spokeshaves and scrapers that accommodate the various curves. For me, this is fun. But if it sounds like too much trouble, you could get away with abrasives and curved scrapers alone for final shaping.

CHARLES ARGO is a partner in Sierra Craftsmen, a custom furniture making studio in Visalia, California.

Weaving Shaker Tape Seats

BY GLENN A. CARLSON

I make Shaker chairs for a living. I also serve as the resident chairmaker at Hancock Shaker Village in Pittsfield, Massachusetts, where I periodically teach people to weave chair seats. My students are often surprised to discover how easy the technique is to master.

The early Shakers made their chair tape from wool. Later, they switched to cotton. I prefer cotton tape to other woven seat material because it's durable, comfortable, easy to apply, and available in a variety of colors. (For cotton tape, see sources on p. 97.) This is the same material that the military uses for belts and backpack straps, so it's durable.

The Tools Are Basic

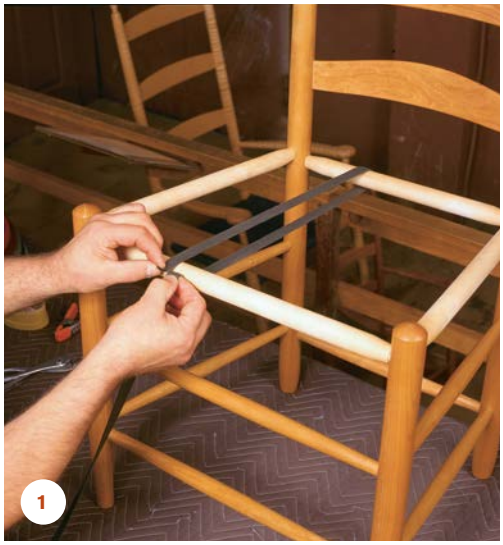
You can weave a seat with only a few basic tools (see the bottom photo on the facing page). You may already have most of them in your shop. There are likely to be two exceptions: a steel surgical clamp and a wooden weaving needle. You could weave a seat without either of these tools, but they'll make the job a lot easier.

The surgical clamp, also called a hemostat, is a cross between a pair of scissors and a Vise-Grip®. You can use it to grab and pull the cotton tape, or you can double the tape over the nose of the tool and push it through a tight space. You should be able to buy one at a surgical-supply or a fish-tackle shop for $5 to $10. A wooden needle also can be used to thread the tape. I fabricated mine from a discarded chair slat.

Wrap the Warp First

Applying Shaker tape is relatively simple. First you wrap one piece of tape around the seat rungs from front to back. This is called the warp. On an average-size chair, the warp is approximately 20 yd. long. The second piece of tape, called the weft, is woven through the warp from side to side.

EVERYTHING YOU NEED TO WEAVE A SEAT. **Most of what you see at left are basic shop tools, except the wooden weaving needle and the surgical clamp. With these tools, the author wove the new chair seats above; the older chairs behind them are from the collection at the Hancock Shaker Village in Massachusetts.**



MEASURING TAPE LENGTH. The author first wraps a piece of the cloth tape one full revolution, front to back. Then he measures the distance between the back posts to calculate the number of rows that will fit over the back rung.

THE WARP IS ONE CONTINUOUS PIECE OF CLOTH TAPE stretched over the front and back rungs of the chair seat.

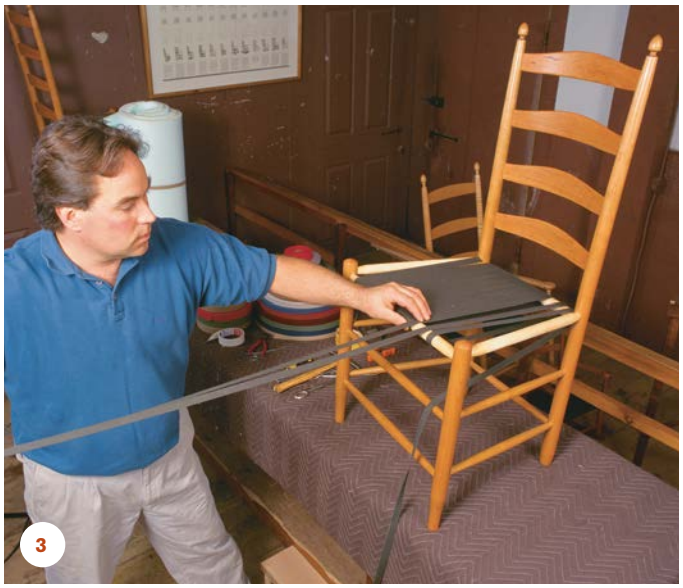
When weaving two colors of tape, always use the darker color for the warp because it covers the front rung where the seat will soil the most.

To calculate length, wrap the tape around the seat frame, front to back, one full revolution, and mark that length on the bench. Measure the distance between the back posts, or legs. If you're using ⅝-in.-wide tape, every 5 in. of rung will need eight rows of tape to cover it. For 1-in. tape, every inch of rung equals one row of tape. Pull the required amount of tape from a roll, adding an extra row or two to be safe.

Tack one end to the seat frame at the back of the left side rung, using no. 3 upholstery tacks, ⅜ in. long (see photo 2). I always drive tacks into the rungs on the inside edge so the metal heads won't wear through the cloth tape over time. Bring the tape around the front rung, under the bottom, and back up over the top of the back rung.

Repeat this process a few times, wrapping loosely. Then pull all the excess through. Keep wrapping this way until you use up most of the material. Before wrapping the last row or two, clamp the tape to the front rung, and then go back to the first row and pull each row tightly enough to take up the slack (see photo 4). Later, the weaving process will tighten the warp more. Use your fingernails and a tack puller (with sharp edges filed dull so they won't tear the cloth) to compress each row slightly between the back posts. Add an extra row or two if you have the room, but don't overlap the material. Turn the chair over, and tack the material to the side rung near the back post (see photo 5). Cut off any excess.

Because the chair seat is wider at the front, you'll have to fill in the triangular gaps at the front corners of the frame (see photo at 6). Use short pieces, 1 ft. or 2 ft. long, and tack each piece to the side rungs, top and bottom. Start each piece at the top, and finish it on the bottom, as much toward the back as possible. It makes no difference if the number of filler strips is the same on each side. What counts is that the wood rungs are covered with the cloth tape. Be sure to compress the tape to fit in as many rows as possible.



ROWS DO NOT OVERLAP. **Each row of tape should butt firmly to the one next to it. No wood should show through when the seat is done.**

GETTING RID OF SLACK. **The author clamps the end of the warp in place. Then he goes back to the first row to pull the tape securely. After that, he pulls the rows tightly to one another and adds another row or two to cover the back rung.**

TACK THE END OF THE WARP TO THE UNDERSIDE **of the side rung, near the back. The goal is to hide all the tacks from view when the seat is finished.**

FILL IN THE CORNERS WITH SHORT PIECES. **The chair seat is wider at the front, so the triangular gaps on either side must be filled in with separate pieces of tape.**

THE FOAM SERVES A DUAL PURPOSE. **It cushions the seat for a softer feel, and it strengthens the two layers of tape so that they stretch as one when weighted down.**

Fill the Center with Foam

Cut a 1-in.-thick, high-density foam pad slightly smaller than the seat frame, and push it into the space between the top and bottom layers of the warp (see photo 7). Choose an opening roughly one-third of the way across the seat. Use one hand to push the foam into place and the other hand (on the underside of the seat) to help pull it along. The foam acts as a cushion and helps the top and bottom layers of tape work together to support a load.

THE WEFT IS NEXT. **After weaving the tape front to back, the author adds the weft–the side-to-side rows. He starts at the back of the chair.**

SURGICAL CLAMP REACHES INTO TIGHT SPACES. **It can be used to push or pull the tape. Doctors use this tool, as do fly fishermen. A clamp costs less than $10.**

END THE WEFT ON THE BOTTOM. **One tack to the underside of the front rung, after all the rows have been pulled tightly and adjusted for neatness, finishes the job.**

Weave the Weft Last

Start the weaving with one long piece of tape, called the weft, that stretches between the left and right rungs of the chair frame (see photo 8). Calculate the yardage you'll need using the method of wrapping and measuring described for the warp piece. Always add an extra row or two for good measure. Because the seat frame is larger at the front, the test wrap should be measured a little front of center so the calculated length will not be too short.

To weave in the weft, start at the back of the chair and work forward. But before beginning the weaving process, place a piece of cloth-backed, double-faced tape along the back two-thirds of each side rung. This will prevent the Shaker tape, over time and use, from sliding backward on the trapezoid-shaped seat frame. Pull the backing paper off gradually as you weave toward the front of the seat to expose more adhesive. The Shakers solved this problem by gluing cloth to the side rungs. The cloth was part of a packet filled with straw or wood shavings designed as a cushion. I don't think they'd object to using foam and double-faced tape instead.

With the chair upside down on the working surface, feed one end of the tape in from the right side, under two widths of cotton tape in the warp and then over two. You'll end at the left rear corner. Tack the new length of tape under the existing warp piece to the back rung in the left rear corner.

Turn the chair upright. Thread all the material through your hands to find the top and bottom of the tape so that you don't get it twisted. Weave the first row on the top of the chair seat, under two, over two. Flip the chair, and weave through the bottom layer.

Turn the chair upright again. Be sure to tuck the end of the tape into the seat to make it ready for the next layer of weaving. Then pull the long length of tape all the way through. The waxed paper backing on the double-faced tape will make the Shaker tape slide more easily.

Using the tack puller and your fingers, straighten the row, and push it toward the back of the chair seat. Pull the Shaker tape tightly, removing any slack, and secure it to the double-faced tape.

Continue weaving the seat toward the chair front. Weave over the tacks holding the warp filler strips in place. Weave under the filler strips as soon as you can because that will help to strengthen the weave.

If you need to fit one more row when you reach the front of the seat and it appears there's not enough room for a width of tape, simply compress the last six or eight rows with your fingers. Turn the chair upside down, pull the final length of weft through at the front corner, and tack it to the front rung, under the warp (see photo 10).

GLENN A. CARLSON makes Shaker chairs and lives in Norfolk, Connecticut.

Sources

Connecticut Cane and Reed
Box 762
Manchester, CT
06045
www.caneandreed.com

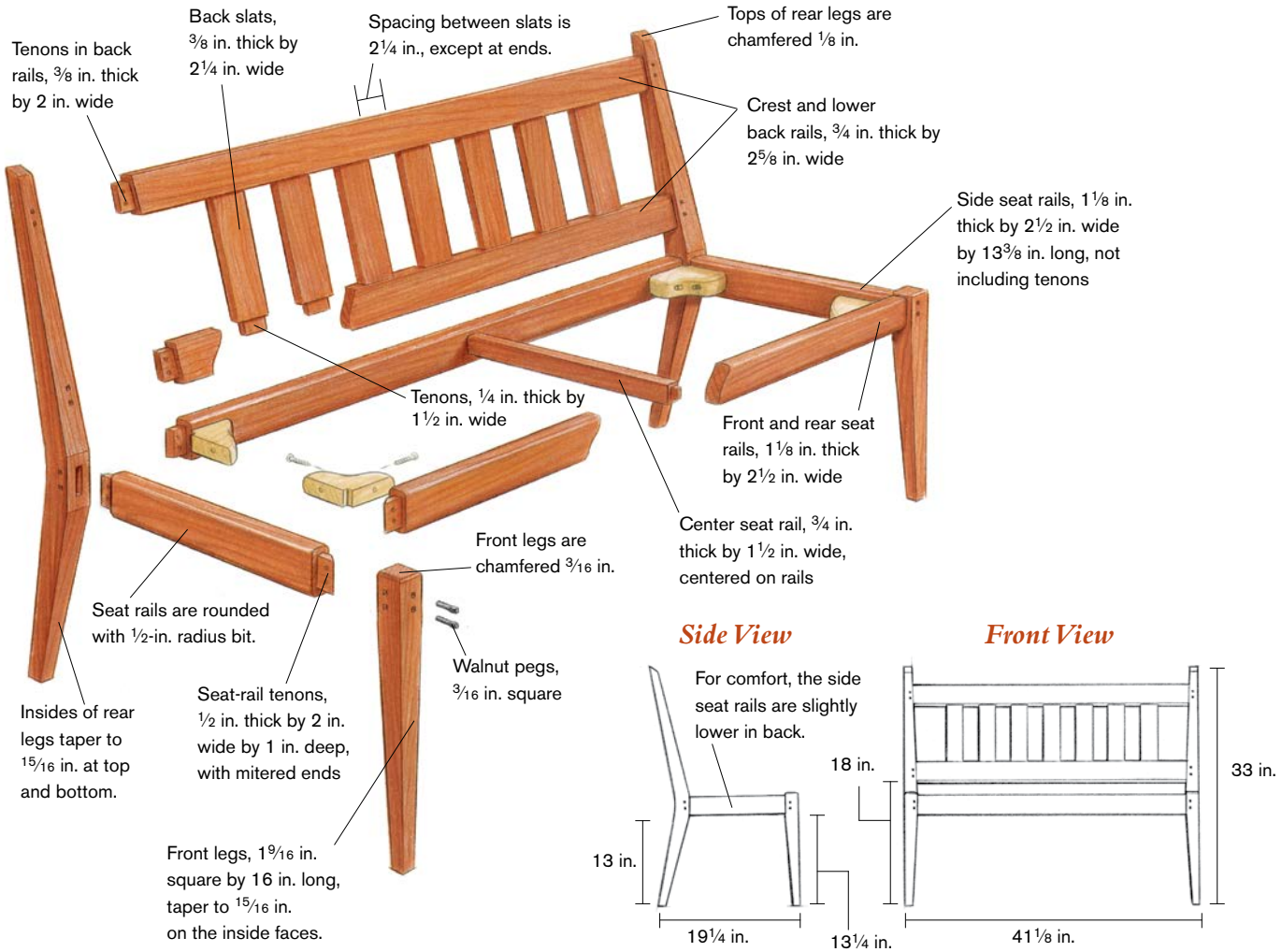
H.H. Perkins
222 Universal Dr.
North Haven, CT
06470
800-462-6660
www.hhperkins.com

A Light Settee in Cherry

BY MATTHEW TEAGUE

A BENCH FOR TWO

This design uses mortise-and-tenon joinery throughout, with square walnut pegs to accent the light cherry. Seat rails are rounded over to accommodate a woven seat.



I can't draw well, but it's never kept me from trying—on newspapers, leases, whatever happens to be in front of me. And when I needed a coffee table, I was drawing them everywhere. One design began on a Post-it® note while I was on the phone—which may explain, in retrospect, its odd transformation. When one table leg turned out a little canted, I drew another line off the back, making it a chair. Then when I tried to turn the chairlike doodle into a perspective drawing, the lines were too long—yet further proof that I can't draw. But when I looked back down, my coffee table had turned into a vaguely elegant settee. I drew little cross-hatched lines across the seat and was rather pleased.

I spent a bit more time on later drawings: I designed a stretcher system, tried two dozen shapes for the back and various seat treatments, but in the end I kept returning to the Post-it note sketch of my coffee table. I liked its lightness and the simplicity of its straight lines. I bumped up the size of the seat rails to avoid using stretchers and to give the undercarriage a more delicate look. And I chose to use a woven seat for its light appearance.

My settee appears rooted in the Shaker and Arts and Crafts traditions, but the woven seat and walnut accents lend the piece a contemporary look, which suits my tastes. It's a small, low bench, perfect for an entryway or along a short wall.

Building this settee calls for only about 15 bd. ft. of wood—8/4 for the legs, 5/4 for the seat rails, and 4/4 for the back. I chose cherry because it is easily worked with hand tools and because its light color lends the unimposing look that I wanted the piece to have. But the design would work just as well using other woods.

Shape and Mortise the Legs

I always make templates for the rear legs of chairs and benches. I mark out all of the mortises and write down construction notes on the template itself. This way, if I ever want to make the piece again, I have a reliable story stick. For this piece, I made a template for the rear legs by bandsawing the profile out of plywood and cleaning it up with files, planes, and a spokeshave.

To make both the front and rear legs of this piece, you need only a single 8/4 board about 40 in. long and 10 in. wide. Mill the stock down to 15⁄16 in. and then lay out the rear legs, one nested against the other. The offcuts will provide enough stock to mill the front legs.

Rough out the profiles of the rear legs on the bandsaw, then clean up the front surfaces with a handplane. Because the fronts of the two rear legs are the reference surfaces for locating the mortises, they must line up perfectly. Clamping the two legs together while handplaning is an easy way to ensure matching legs.

After the flats of the legs have been handplaned, shape the curve at the back of the legs using a spokeshave. Take light cuts and work with the grain, and as soon as the wood begins to tear out, try shaving from the other direction. Light tearout can be cleaned up with a card scraper.

Before laying out the mortises, check the grain direction of the legs and mark which surfaces will get tapered later—you don't want the tapers to fight against the grain. Also, label the tops of the legs as front, rear, left, and right.

Before tapering either the front or rear legs, mark out and cut the mortises for the seat rails as well as those for the crest and lower rails on the back. This way you can rout to a flat-bottomed mortise, even though the shoulders on the back-rail tenons will be angled later to match the taper of the legs. The mortises for the seat rails are 2 in. wide and ½ in. from the outside of the legs. The mortises for the back are 2 in. wide and 5⁄16 in. from the front of the leg.

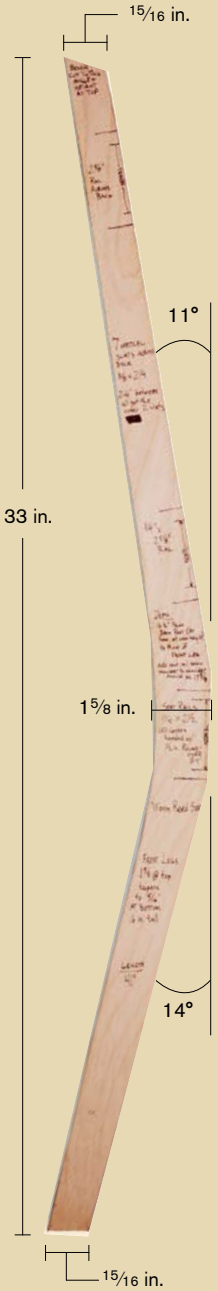
I cut the seat-rail mortises using a ½-in. straight bit and an edge guide mounted on my plunge router. Clamping two legs together provides a wider flat surface for the router to bear against as you cut. Be sure to stop the router exactly at the mortise line. Work the router back and forth in the mortise, dropping down only about ⅛ in. with each pass, until the mortise is a hair over 1 in. deep. The mortises for the back are cut using the same method, but with a ⅜-in. straight bit and slightly deeper. I square up the ends of the mortise with a chisel, but you can just as easily round over the corners of the tenon.

Tapering the Legs Although the settee has a rectangular seat, tapering the inside of the legs makes it appear as though the back flares outward. The back legs taper from full width ¾ in. above and below the seat-rail mortises to 15⁄16 in. at the top and bottom. Leaving a flat surface where the seat rail joins the leg allows you to use simple, right-angle joinery.

Place the handplaned surfaces on the bandsaw table and cut the tapers on the inside of the legs. While at the bandsaw, go ahead and taper the front legs. The bandsawn surfaces are smoothed with a

Leg Template Serves as a Story Stick

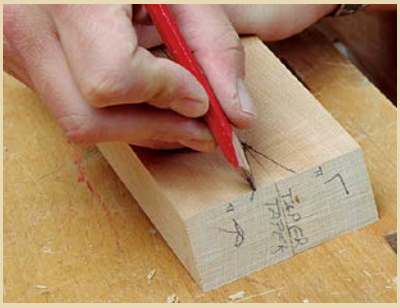
All mortises can be marked directly from a story stick, which is simply the rear-leg template marked with mortise locations and notes on construction. Should you ever want to build the bench again, the layout information is in one handy place.



ONE BOARD, FOUR LEGS. Nesting the two rear legs allows you to cut all of the legs from one 10-in.-wide 8/4 board. The legs are bandsawn to shape after layout.

A PERFECT MATCH. Clamp the two rear legs side by side, then handplane them smooth. Do not plane an angle into the flat surfaces where the seat rails join the legs.

FAIR THE TRANSITION CURVE. The curve at the back of the leg is smoothed with a spokeshave. Any slight tearout can be cleaned up with a card scraper.



MARK OUT THE LEGS. Tick marks on the front of the legs indicate which faces will be tapered after the mortises are cut.

A STORY STICK SAVES TIME. Layout is simplified by marking out all mortises directly off the rear-leg template.

CUT THE MORTISES for both legs at the same time. Use a router and edge guide, and clamp the legs together to provide a larger bearing surface for the baseplate.

SQUARE UP THE MORTISES. When cutting mortises with a router, you either have to chisel the mortises square or round over the tenons.

MARK TENON SHOULDERS FROM the assembled back. With the rear seat rail clamped in place, make sure the assembly is square, then clamp the crest and lower back rails into place. The tenon shoulders, which are angled slightly to match the leg tapers, can be marked directly off the leg.

CUTTING ANGLED SHOULDERS. After the bulk of the tenon has been cut on the router table, backsaw to the angled shoulder line. Quick work with a chisel trims away the excess.

handplane. To ease joinery, be sure you don't change the angles of the flat areas where the seat rails join the legs.

Cut and Tenon the Seat Rails

Because this piece has no stretcher system, the seat rails must be meaty and the joinery tight. Mill the seat rails to 1⅛ in. thick and cut them 2½ in. wide. After the rails have been cut to length, tenon them. I used a horizontal router table, but you can cut the tenons using a handsaw, bandsaw, tablesaw or whatever method you're accustomed to. I cut tenons to the full depth of the mortise, then trimmed the tenons at 45 degrees on the ends. Mitered tenons provide more glue surface.

A center rail reinforces the woven seat. Locate the center of the front and rear seat rails and cut mortises ½ in. deep by ½ in. wide by 1 in. long to accept the center rail. The rail, made of ¾-in. stock, is positioned ½ in. below the height of the seat rails. If the seat ever sags with age, it will sag into a handsome two-seater with clearly delineated bucket seats—a look I've wanted to emulate since seeing it on an old English Arts and Crafts settee.

All of the edges of the seat rails have to be rounded because the reed lengths will break if you try to bend them around the sharp corners. Round the edges of the rails using a ½-in.-radius roundover bit at the router table.

Join the Back to the Legs

Once the seat rails have been tenoned, dry-fit the back and clamp it up to make sure that the joints close up and that the assembly goes together squarely. Then lay out the crest and lower back rails and clamp them into place on the legs. Working from the clamped-up back, mark out the angled shoulders of the tenons.

Tenon the back rails slightly short of full depth, then backsaw to the line at the

shoulders. A little cleanup with a chisel and shoulder plane helps the joint close up tightly.

The crest and lower back rails are mortised to accept the back slats. To lay out these ¼-in.-wide by 1½-in.-long mortises, find the centers of the two back rails, then clamp the two pieces together with their centers aligned. Use a square to mark out both sets of mortises at once. Cut the mortises about 1 in. deep.

To get a quartersawn look on the back slats, I resawed them from 8/4 stock I had left over from the legs. After tenoning the slats, hit the surfaces with a handplane and dry-fit them to the back rails.

Glue Up One Section at a Time

To make sure there won't be any surprises during the glue-up, dry-fit the entire piece. With clamps in place, check to see that all of the joints close up, and fix any trouble spots.

After a successful dry-fitting, start gluing the back slats into the crest and lower back rails. You'll need only a few clamps to pull the joints closed. Glue the back and rear seat rail to the rear legs and set the assembly aside. Then glue the long front seat rail to the front legs.

Once the front and back assemblies have dried, make sure that the side rails still fit easily into place (excess glue can dry in the bottoms of the mortises). Brush glue onto the ends of the tenons and into the mortises, and don't forget the center seat rail as you join the front to the back. Clamp up the assembly and let it dry.

When the glue has cured, glue and screw thick corner blocks into place. Although the corner blocks are set about ½ in. below the top of the seat rails, it's a good idea to round over their edges. This way, should the seat ever sag, the reeding won't rub against sharp edges, possibly cutting into it.

Add Decorative Pegs and Apply a Quick Finish

After the corner blocks have been glued and screwed into place, I pegged the structurally important tenons using square walnut pegs, which accentuate this design nicely. Use a brad-point bit to drill 3/16-in.-dia. holes through the legs and into the tenons, then square up the front third of the hole using a chisel.

To make the pegs, rip a scrap of walnut just shy of 3/16 in. deep on adjacent sides, leaving a sliver of wood to hold the strip in place. Then cut the 3/16-in.-square strips away from the stock and cut them to 2-in. lengths. Round over the end and lower half of each peg with a small carving knife. Put a drop of glue on the ends of the whittled pegs, and use a metal hammer to tap them into place. Stop hammering when the peg bottoms out (you'll hear a difference in tone), or you risk splitting the leg. Cut off the ends of the pegs with a small saw, then use a chisel or low-angle block plane to trim them flush to the legs.

I've tried countless combinations of varnish and oil on cherry, and all of them seem to work fine, though recently I've been using Minwax® Antique Oil Finish. A mix of varnish and oil, this finish goes on quickly and easily and seems foolproof to me. Wipe on the first coat with a rag, give it 10 minutes to dry, then buff it off with a dry rag before the surface gums up. After the first coat dries, sand it with 400-grit paper, apply a second coat using 600-grit paper instead of a rag, then buff the coat dry. The finish is buttery soft but still pretty dull after two coats, so wipe on another coat with a rag, give it 10 minutes, then buff the surfaces dry. As you add coats in the same manner, the finish begins to build—the more coats, the glossier the finish.

If the seat ever sags with age, it will sag into a handsome two-seater with clearly delineated bucket seats.

Square Pegs in Round Holes

The dark walnut pegs lend a subtle accent to this cherry settee. Driven through the tenons, the pegs also ensure that the joints stay tight.

SQUARING A DRILLED HOLE. **Begin by drilling through the leg and tenon with a bit just smaller than the width of the peg. Make sure you don't drill through the other side of the leg. Use a ⅛-in. chisel to square up the first third of the hole.**

MAKING PEG STOCK. **Rip adjacent sides on a small strip of walnut–3⁄16 in. wide and just under 3⁄16 in. deep. Leave a sliver of wood at the corner to keep the strip from shooting out of the tablesaw. The sliver also makes it easier to pull away the square peg material from the stock.**

WHITTLING PEGS. **With the pegs cut into 2-in. lengths, round over the first third with a small knife. Rounding the ends of the pegs prevents them from splitting the legs.**

DRIVING IT HOME. **After applying a small amount of glue to both the peg and the hole, tap the peg in place with a hammer. Keep the peg aligned and stop hammering when the peg bottoms out (you'll hear a change in tone); otherwise, you risk splitting the leg.**

Weave the Reed Seat

Perhaps it's because I remember gathering oak splints with my grandfather, who wove baskets on slow Sunday afternoons, but I've always loved the look of woven seats; they're inviting, comfortable, and clearly handmade.

Because the seat is rectangular, the weaving for the settee is pretty straightforward. But weaving is slow work, so wear comfortable shoes and be ready to stand for a while. For this seat I used ⅝-in.-wide reeds (the material is actually the inner core of the climbing rattan vine), but oak or ash splints can be woven the same way. Reeds, and splints for that matter, are bought by the coil. I used about four coils of reeds to weave the seat for this settee. You should buy more reeds than necessary because, especially on a long seat like this, you'll want to use only the longest lengths so that you won't have to join the lengths of reed too often. You can buy reeds at many hobby and craft stores and through Connecticut Cane & Reed Co.

Before weaving, the reeds are first soaked in warm water (those who know suggest 140°F, but I've never put a thermometer to mine) for 45 minutes or so. After soaking, start with a long length of reed and orient it so that the correct side will be facing out on the weave. By bending the reed to a tight curve, you'll notice that short fibers fray loose on one side but not on the other. The side where the fibers break loose should go to the inside of the seat. Begin by using a #3 or so upholsterer's tack to secure the reed to the seat rail at the left rear side of the bench, then begin wrapping the warp (the reeds that run front to back). Start by going under the front rail and then over the back rail and continue in this fashion, keeping the weave tight.

When you reach the end of the length of reed, you'll have to join that piece to another. Make sure all joining is done on the bottom of the seat. There are numerous ways to join reeds, but the method I've used successfully is to notch the end of both lengths and tie them together with string or copper wire. The other method I use is simply to staple the two reeds together. Many weavers balk at this method, but when pressed they admit to using it almost every day. No matter how you join the reeds, once the seat is woven, they can't go anywhere. If you do use staples, you can even remove those left visible after the weaving is complete.

Continue weaving tightly across to the right end of the bench. When the warp is complete, work an upholsterer's hammer into the warp and tack the end of the reed to the seat rail, which should keep the warp tight. As you work, remember that reed shrinks slightly in length as it dries, so use a spray bottle of water to keep the seat damp.

Before you start the weft, or mainweave, add a fill-in strip at the back of this bench on the top only. A fill-in strip runs between the two rear legs but is not attached to the bottom of the seat. Drop a length of reed into the warp, and fold it over, leaving about 6 in. inside the seat. Go under two, over three, as shown in the drawing on p. 107. Simply continue the pattern as you weave the strip into the warp. At the end, stuff about 6 in. of the strip inside the seat. The fully woven seat will be so tight that there will be no risk of the fill-in strip going anywhere.

The weavers (the lengths of reed that run left to right) create a three-over, three-under herringbone pattern. Start by tucking a weaver under the bottom left corner, weave it through the warp, going over three, under three all the way across, and then carry it over the side rail. The first weaver on the top of the seat (row 2 in the drawing on p. 107) goes under the first reed in the warp, then over the next three. Continue the three-over, three-under

Woven Seat Finishes the Settee

RIGHT-SIDE UP. By bending the reed to a tight curve, one side will fray while the other won't. Orient the frayed side so that it can't be seen.

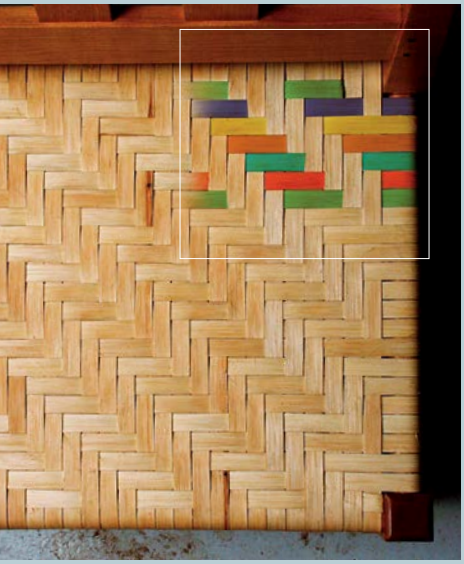
SECURING THE REED. Begin by tacking a length of reed to the seat rail at the rear left corner of the seat.

WEAVING BEGINS UNDERNEATH the seat at the rear left corner. Instead of tacking the reed into place, simply fold under the first 6 in. or 8 in.

WEAVING A HERRINGBONE pattern. As you continue weaving the pattern into the seat, the weave gets tighter. You'll need to guide the last few rows using a dull knife.

BEGINNING THE WARP. **The first length of reed goes under the front seat rail and over the back and continues in this way to the end of the seat.**

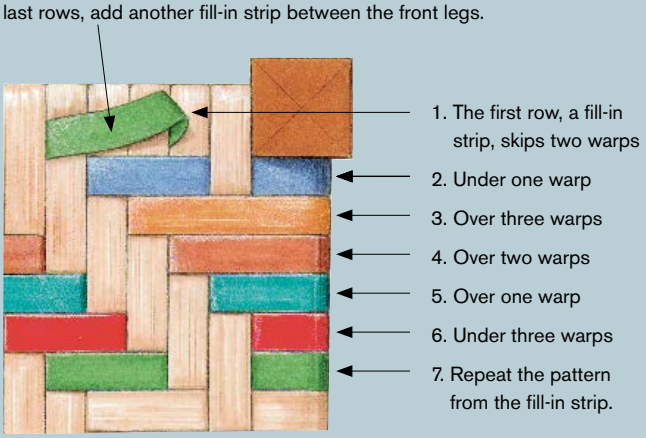
ENDING THE WARP. **When you reach the side rail, pull the reed underneath the seat and use a #3 upholsterer's tack to secure it to the seat rail.**



HERRINGBONE WEAVE

Woven of 5/16-in. reeds, this herringbone pattern makes an attractive and comfortable seat. Although the weave may appear complicated at first glance, it is nothing more than a repeating pattern weave of over three, under three. After the first six rows, the pattern repeats itself to the front of the seat. To ensure that the seat stays tight, the same pattern is repeated on the bottom of the seat.

The first and last weavers are fill-in strips. Instead of wrapping around the seat rails, 6 in. to 8 in. of extra length is simply tucked inside the seat–the tightness of the weave will hold the fill-in strips in place. Before weaving the last rows, add another fill-in strip between the front legs.



Joining Reeds

When you reach the end of a length of reed, join another piece on the bottom side of the bench. Cut two notches on each piece, then line up the notches and bind them with a heavy thread. Another option is to staple the two pieces together.

pattern all the way to the right seat rail, where the reed continues around the seat rail and under the seat.

Flip over the settee and weave the bottom in the same pattern: But begin by going over two, under three, over three, under three, until you reach the left seat rail. Wrap the weaver around the seat rail and continue with your second row across the top. But when you start the second weaver (row 3) across the top, begin by going under two and over three, then continue the three-over, three-under pattern to the end of the rail. The pattern continues this way throughout the seat.

When adding weavers along the bottom of the seat, it is no longer necessary to join them. Simply overlap the old weaver and the new weaver for about 6 in. and continue weaving. The tightness of the weave will keep the seat from coming loose. The more weavers you add, the tighter the weave gets. Everything should proceed smoothly until you reach the last third of the seat. At this point, it becomes increasingly difficult to fit the weavers through the warp. To help make the weaving easier on the last few rows, cut the leading end of the weaver into an arrow, and use a dull table knife to help open up the warp and guide the weaver through. I've also used locking pliers, hemostats, and needle-nosed pliers to grasp the end of the weaver and work it through the warp.

Once you reach the front of the seat, you can add a fill-in strip, as you did at the back, or leave it as it is. All that's left is to pull staples, trim string, and burn off any frayed strands of reed. Woven seats are typically treated with a few coats of linseed oil, cut two-thirds with thinner or turpentine, and recoated every year or so. For convenience, I used the same Minwax finish I used elsewhere on the settee.

The settee is as simple to make as the feeble drawing I first made, but I like its character—especially the lightness of the piece and the walnut accents. I think the verticality of the reeds across the wide seat rails works well with the vertical slats in the back. I've built a couple of these pieces now. But I still don't have a coffee table—so I guess it's back to the drawing board.

MATTHEW TEAGUE is the author of *Projects for Your Shop* (Taunton, 2005).

Post-and-Rung Stool

BY BRIAN BOGGS

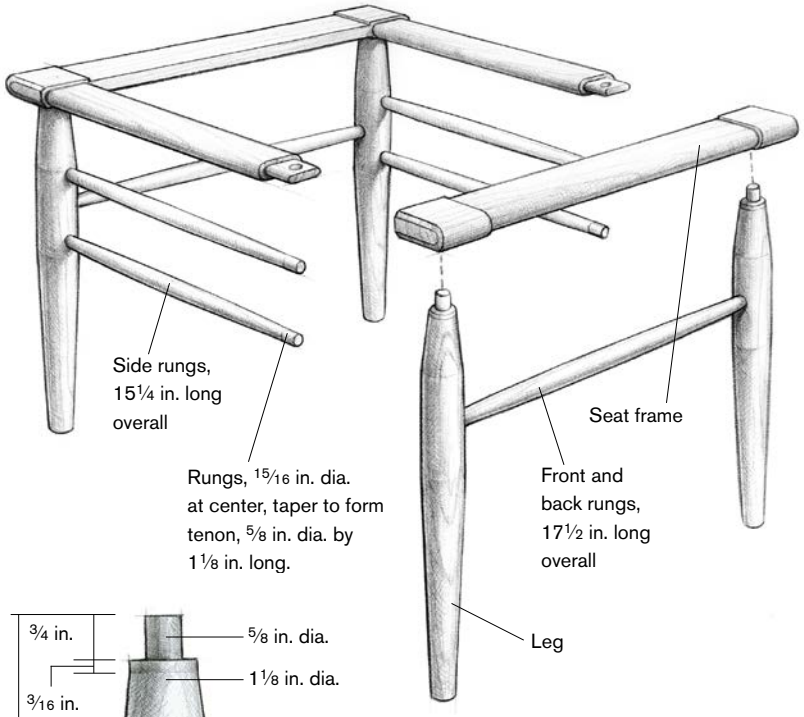
I suspect that for many readers the idea of building a simple stool seems rather mundane. But when taken as an exercise in perfecting your round joinery, there is more challenge here than meets the eye. Even after building 1,500 chairs, making a perfect round joint keeps me on my toes.

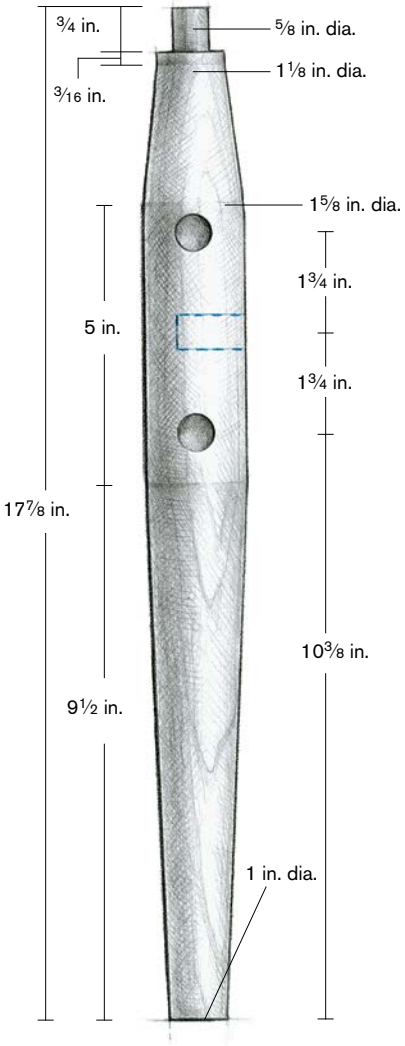
And there are lots of other reasons to get into stool making. Apart from providing compact, inexpensive seating, stools can serve as steady footrests and portable desks. Also, they can be adapted to serve as benches or bar stools or even as end tables or coffee tables. Finally, if you've never made a chair, a stool is a great first step. All of the joints in this stool are at 90 degrees.

While there are lots of ways to construct a stool, I prefer the post-and-rung frame. It's very lightweight, which is important because the stool will be moved around. Also, the round rungs can withstand a lot of racking and twisting without damaging the joint. And the parts, including the tenons, can be turned fairly quickly, and the mortises are simply drilled.

WET-DRY JOINERY REDUX

The author's post-and-rung joint does not rely on green wood. The rungs are dried to 4% moisture content in a simple kiln before assembly. But the legs are at 10% to 12% moisture content, a normal shop level. The leg-to-seat-frame joint relies on the same principle.





Round Joints Built to Last

Round joints are often seen as a cheap, inferior way to join wood parts. After all, this is the joint in ladderback chairs that has kept many repair shops busy and many chair owners frustrated. But there are very old chairs with round joints that have held up for generations of use. My mother-in-law has a fine example of a post-and-rung chair that's more than 200 years old. The joints are in great shape, and there is no evidence of repairs. So, how can we make our chairs do that? There are at least two ways, and I have used them both.

The Traditional Method The old locking joint is the most interesting. There are three requirements for success. First, the rung should be made of a very tough wood, such as oak or hickory, and the leg should be a slightly more elastic wood, such as maple.

Drying the Tenons

SUPER-DRY TENONS are critical to the author's locking joint. The rung stock is placed inside a shop-made kiln, and the legs are inserted in holes at the top, to expose just their tenoned ends to the dry heat. The kiln is simply a plywood box lined with insulation board. A light bulb provides the heat.

Second, the tenon is left slightly oversized, and a small notch is cut into it. Finally, the leg needs to have a high moisture content at the time of assembly—between 15 percent and 20 percent—with the rung dried to 4 percent or less. As the leg dries and shrinks, the mortise deforms to the shape of the notched tenon, locking the joint. Glue is not necessary and may even weaken the joint by filling the locking notch.

My Hybrid Version The traditional locking joint works fine in this stool. However, I now prefer a hybrid version of this joint—one that doesn't require the locking notch or extra moisture in the legs. It also allows me to build chairs out of a single species of wood, even a softer species such as cherry or walnut.

The joint works by combining the super-dry rung with a near-perfect fit between the mortise and tenon. Glue is added for strength. I use the same method for the leg tenons that fit into the seat frame.

The wood for the legs is at about 10 percent moisture content after sitting around my shop. I wouldn't want anything wetter than 15 percent. Then I super-dry the rungs and just the tenon portion of the legs in a simple light-bulb kiln (see the photo on the facing page).

Once dry, I cut the tenons to within a few thousandths of the mortise diameter. Because drills vary, you should drill the hole first and then carefully measure it. I use a dial caliper for measurements like this (I think every woodworker should own a pair). Torn fibers in the hole can weaken the joint, so use a very sharp bit, ideally a good brad-point.

After assembly, the tenons swell and tighten the joints as they approach equilibrium moisture content. However, without a good glue bond, the chair would depend only on the wood's resistance to compression to prevent racking. Hickory and oak can take this, but I want the support of a good glue joint for cherry or walnut. Make several test joints and check them after a few days.

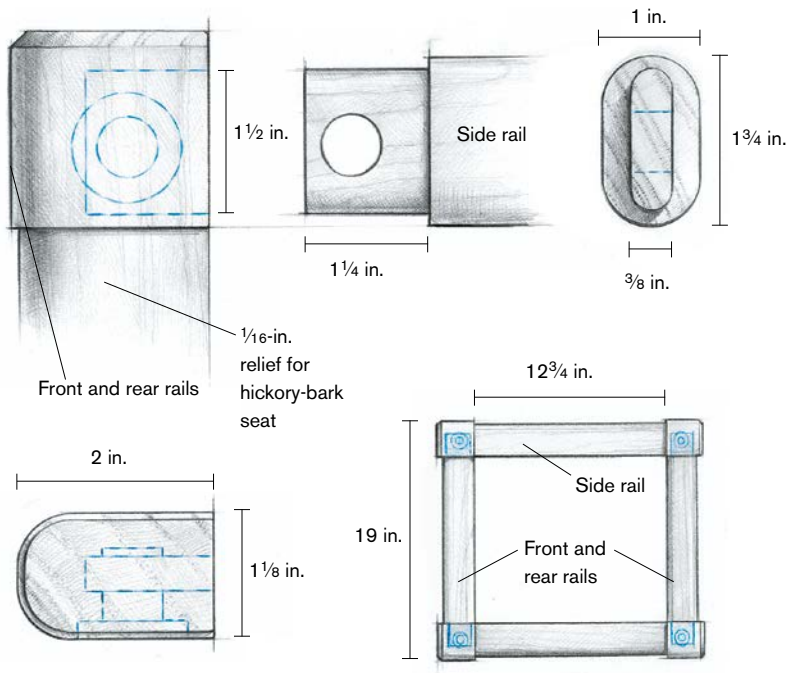
Start with the Right Materials

Any time you need strength without a lot of bulk in a wooden product, the quality of your material is paramount. Without clear, straight-grained material, you just can't make a very good post-and-rung stool. The ultimate material is riven from a straight log section. However, the parts of this stool are thick enough that—as long as the wood is straight-grained—sawing out the parts will do just fine.

I prefer making the rungs with green wood for cost reasons and because I can follow the grain better when resawing an entire log section. But you can use kiln-

BUILDING THE SEAT FRAME

The author uses round-cornered mortises and tenons to join the seat frame, but square tenons also would work.



MAKE THE SEAT FRAME while you wait for the other parts to dry. After routing the ½-in. roundover on the edges of the front and rear rails, create the relieved section for the hickory-bark seat. Cut the shoulders of this section first by setting stop blocks 1/16 in. behind the front edge of the bandsaw blade. Rotate the rail against the blade direction.

THEN BANDSAW AWAY the three sides of the relieved area. Set the rip fence 1/16 in. away from the outside edge of the blade, and start the cut just past the shoulder. Reverse the workpiece to finish each cut. Use a 7/16-in.-radius router bit to round over the edges of the relieved section.

dried wood for all of the parts, especially if you don't have time to wait for green wood to season. You can resaw 8/4 kiln-dried stock to get the quartersawn seat-frame parts you need.

To speed the drying process and to prevent checking, bandsaw the rung stock into 1⅛-in. octagons and turn the straight and tapered sections and stepped tenons on the legs to about ⅛ in. oversized before placing them in the kiln. I made my simple kiln with plywood and insulation board, but I have had success with an even simpler cardboard kiln with sticks driven through it to support the stock. Just keep the heat source away from direct contact with the wood or cardboard. A 150-watt bulb brings the temperature inside the kiln to 160°F to 180°F, and two or three days should be enough to get the rungs and leg tenons down to a moisture content of 4 percent.

I generally make one or two extra rungs per chair to cover drying and turning mishaps—not that I've ever had any.

Make the Seat Frame

While you're waiting for the rungs and leg tenons to dry, you can get the seat frame out of the way. The frame is constructed with round-cornered mortise-and-tenon joints, all at 90 degrees. Use dry, quartersawn material to minimize movement. The only hard part on this frame is making the relieved sections on the front and rear rails. This 1/16-in. relief keeps the exposed corners at the same height as the finished bark weave and helps keep the bark from shifting outward.

First, dress all of the parts and cut them to their final lengths. Round over the side rails with a 7/16-in.-radius router bit, then set them aside. Then, with a ½-in.-radius bit, round over the full length of the front and rear rails.

For the relieved section, use the bandsaw to cut the shoulders first. Set the rip

Turning Precise Tenons

SQUARE TOOL, SQUARE PLUNGE. To create the uniform tenons so critical to the post-and-rung joinery, the edge of the ⅜-in. beading/parting tool must be ground to 90 degrees, and the tool must be fed in squarely.

EACH ADJACENT PLUNGE CUT is made until a ⅝-in. wrench (acting as a caliper) just slips over the spinning tenon. To finish the rung, use a gouge and skew chisel to blend each tapered section from its 15⁄16-in. peak down to its tenon.

fence at 2 in. and clamp a stop block 1⁄16 in. behind the teeth. With the round end down against the table, cut the first shoulder. Then carefully roll the rail backward and up, exposing the round edge to the teeth. Keeping the teeth engaged in the cut, continue to rotate the workpiece until the shoulder is complete. Rotate the workpiece against the cutting direction of the blade. Going the other way will get your fingers slammed against the table. Don't ask me how I know this.

To saw out the relieved area on the bandsaw, set the rip fence 1⁄16 in. away from the outside of the teeth to control the depth of cut. You will probably need a fence extension because both ends of the piece should ride on the fence once the cut is under way. Start just past the shoulder, letting the blade slowly work its way to full cutting depth. Cut to the opposite shoulder, then flip the part and cut the other way to finish the relief. After relieving three sides, round over the edges of the relieved area with a 7⁄16-in.-radius router bit, working as close to the end sections as you dare. Finish up with a rasp and a file.

Cut the mortise-and-tenon joints and glue up the frame, being careful to keep it square. This is a good time to apply finish to the seat frame. I use Minwax Antique Oil on my chairs and stools because it's easy to pad on with a rag, builds to a thin film and gives cherry a warm, natural glow.

Turn the Rungs and Legs

When the rungs and legs are out of the kiln, it's time to turn them. I do the rungs first. The thicker legs will not have warped as much, so they can be remounted between centers the same way they came off them. For the thinner rung stock, the usual method of centering the ends won't work. I center each one by eye, lightly cranking in the tailstock and adjusting the part until its center runs true. The ends get tapered only, so they can run out a bit. Before turning, I drive the centers home firmly.

It's always a good idea to create full-size plans. I used full-scale drawings of this

Turning the Legs to Finished Size

AFTER REMOVING THEIR tenoned ends from the kiln, turn the rough legs to size. Define the straight section by making plunge cuts to final depth at both ends. A strip of masking tape on the tool rest acts as a story stick.

THEN TURN THE TENONS and connect all of the cuts. Bring the stepped tenon down to size, and complete the straight and tapered sections using the previous cuts as a reference.

stool's parts to create story sticks and guides for drilling and turning. To lay out the tenons and tapers on the legs, for example, I transferred lines directly from the plans to a strip of masking tape along my lathe's tool rest.

The Trick to Good Tenons First, for each rung, rough out a cylinder with a gouge. Then, with a ⅜-in. beading tool, carefully cut the tenons, using a wrench as a caliper. The wrench allows you to check the work while it is spinning. From the back of the workpiece, hold the wrench firmly against the tenon as you make the cut. When it slips over the tenon, stop cutting.

It is very important that the ⅝-in. wrench you use exactly match the size of the hole your drill bit actually cuts. When a tenon fits just right, I can barely push it all the way into the hole, and it pops like a cork when I pull it out. To adjust the fit, you can hammer the wrench to close it up a bit or file it to make a bigger tenon. Mark this wrench and keep it by the lathe. This is a caliper now, not a wrench, and you don't want to mar it just to loosen a bolt.

When the tenons are done, turn the tapers, moving from the widest diameter at the middle of the rung down to the ⅝-in. tenon. I use a skew chisel for the final pass. The holes in the legs will be ⅛ in. deeper than the tenons, allowing the tapered shoulder of the tenon to be driven slightly into the mortise, hiding the glueline and the slight shoulder.

Legs Need a Straight Midsection and a Stepped Tenon Next, finish turning the roughed-in legs. The tapers and tenons are different. The midsection needs to be very straight because the barrel will be used as a reference for drilling.

When turning the tenons, use the same ⅝-in. wrench to gauge the top portion and a regular caliper for the larger shoulder. To

Drilling the Mortises

A SHARP DRILL PRODUCES a clean hole and uniform chips. Pay a little extra for a good brad-point bit, and adjust it in the chuck until it runs true.

DRILL THE MORTISES for the front and back rungs first. The author's drilling jig is a block with two V-grooves and a simple hold-down.

ASSEMBLE THE FRONT and rear frames, and drill for the side rungs. Lay the frames flat on a wide drill-press table.

set your caliper for the shoulder, you need to know the exact size of your counterbore. Drill some test holes first and measure the counterbored portion carefully. Set your caliper to this exact dimension.

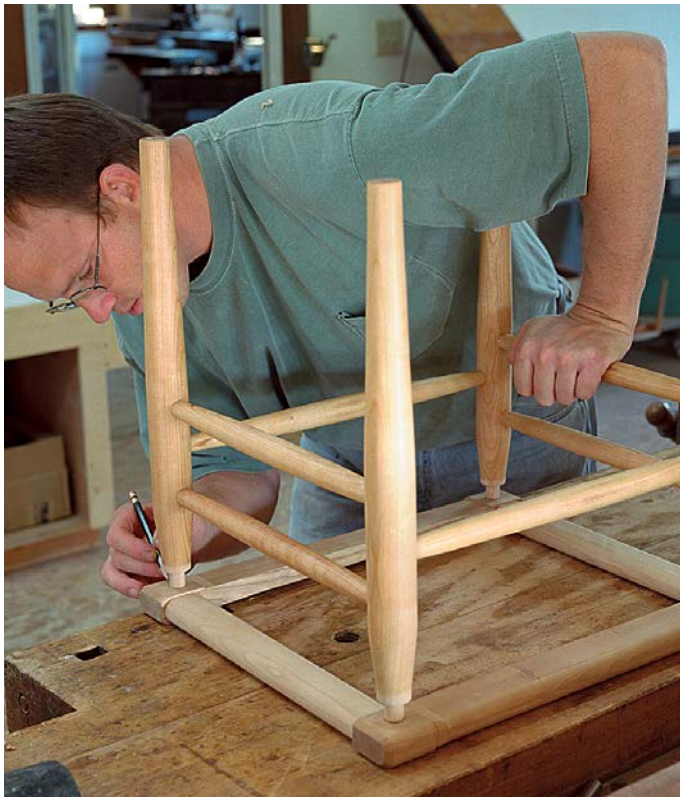
The rungs and legs are most easily sanded and finished before they are removed from the lathe. Just be careful not to get finish on the tenons.

Drill the Legs and Assemble the Undercarriage

Before drilling the holes in the legs, make up a story stick with all of the rung locations marked—the single front and back rungs and the double side rungs.

It doesn't matter which side of the legs you drill first, but I drill and assemble the front and rear frames first (each with a single rung). Place two legs in a drilling jig, which is simply a block with two V-grooves and a hold-down (see the center photo above). Orienting the grain at 45 degrees keeps shrinking and swelling of the leg equal on all rungs, and it keeps the elliptical grain pattern on the outside corners of the legs. Clamp the legs in the jig and mark the elevation of the rung. You might want to mark the center as well, but I just center the hole as I drill, sighting down the leg.

The accuracy of your holes depends on a number of factors. Assuming you have a



DRILL THE STEPPED MORTISES **in the seat frame. Center the undercarriage on the seat frame and mark the mortise locations (left). The author uses a commercial counterbore bit (above) to machine the two-stage mortise accurately, in one shot.**

Sources

BARK SOURCES

The Unfinished Universe
525 W. Short St.
Lexington, KY 40507
859-252-3289

The Caning Shop
926 Gilman St.
Berkeley, CA 94710
510-527-5010 or
800-544-3373
www.caningshop.com

Brian Boggs, chair maker
118 Lester St.
Berea, KY 40403
(bark occasionally available May to July); 859-986-4638, ask for Pat

Antique Refinishers
3815 Utah St.
San Diego, CA 92104
619-298-0864

good bit and a decent drill press, tighten the bit in the chuck with just hand pressure. Turn on the machine and watch the center of the drill to see if it runs true. If you see any vibration, loosen the bit, rotate it slightly, and try again. Start the plunge slowly for a clean entry into the legs. Fine chips indicate a smooth hole. Also, if you raise the bit to clear the chips, don't bring it all the way out of the hole or it may tear the edge of the hole upon reentry.

Once you have drilled the front and back frames, assemble these parts. I use liquid hide glue for these frames because it gives me more time to get the whole thing assembled. I prefer Old Brown Glue from Antique Refinishers (see sources at left). Coat both the mortise and tenon thoroughly. To align these parts, use the legs as winding sticks by sighting across one leg to the other. I use a deadblow hammer to drive the parts together. Drive every tenon as deeply as possible. You will hear the tone change when the tenon bottoms out.

To drill the mortises for the side rungs, mark the holes from the story stick and lay each two-leg frame flat on the drill-press table. If your table is too small, clamp a piece of plywood to it as an auxiliary table. After drilling, assemble the undercarriage by driving all of the rungs into one frame first. A bear hug will get the other side started, and the hammer finishes the job.

Attach the Seat Frame

With the undercarriage assembled, it's time to lay out and drill the stepped holes in the seat frame. Instead of laying out these according to measurements, I prefer to go by what the lower frame actually came out to be. Depending on how deep you drove the rungs, the distance between the tops of the legs can vary. With the seat frame upside-down on the table, center the leg tenons

Weaving a Bark Seat

If you've ever woven a chair seat in any material, you'll find weaving a bark seat a very manageable task. The hardest part could be finding the material (see sources on the facing page). If you are ambitious, follow the chapter on harvesting bark in John D. Alexander's book, *Make a Chair from a Tree* (Astragal Press, 1994).

I cut the bark that I harvest into ⅞-in.-wide, 1/16-in.-thick strips and soak them in hot water for about 45 minutes to make them pliable. Thicker material will need more time. Try to weave the seat in one day; otherwise, you'll have to wet the seat and wrap it in plastic to stop it from drying overnight.

Bark tends to cup toward the inside of the tree, and you want these cupped edges down for comfort. The innermost bark has a darker, smoother surface. But this is a two-over/two-under twill pattern instead of a three-over/three-under pattern. Also, no brads or nails are necessary. Tie the first strip on the back rail to start. Once you finish the seat, just tuck the last splint in on the bottom. As the bark dries, it becomes fixed in place.

Rub in a light coat of thinned linseed oil (equal parts oil and solvent) to bring out the color, then burnish with burlap. Wait a few days to sit on it. By then the weave should be dry enough that it won't sag. (For a more extensive guide to weaving a bark seat, visit www.finewoodworking.com.)

AS EACH STRIP ENDS, knot it onto the next one. This won't be possible without first whittling down the ends. All knots should end up underneath the seat.

on the corner blocks of the seat frame and mark their locations.

To drill the stepped mortises I used to use a Forstner first, followed with a counterbore I made by gluing a plug over a spade bit. Now I prefer to use a commercial combination counterbore bit, which makes the job as easy as drilling a single hole.

If the counterbored hole is drilled to the right depth, attaching the undercarriage to the seat frame is pretty simple. Use plenty of glue and drive the leg tenons into the mortises evenly.

All that's left now is weaving the seat. I prefer to use hickory bark, but you could also use splint or Shaker tape.

BRIAN BOGGS is a chair maker in Berea, Kentucky, and teaches seminars on ladderback chair making.

Shaker Rocker

BY ERNIE CONOVER

The Shaker rocker is one of the most recognized rocking-chair designs and rightfully so. It has simple and attractive lines, it is economical to build, and, if designed properly, it can be very comfortable.

This chair also is a wonderful project in my woodworking classes because it introduces students to spindle turning, steam-bending, and a few important hand-tool techniques. The plans I use in class are an amalgamation of an early brethren's rocker, which is detailed in John Kassay's *The Book of Shaker Furniture*, and the rocking chairs made later at the famous Shaker production shop at Mount Lebanon in New York state.

I made a number of modifications to improve the strength of the chair, taking into account modern-day physiques. The original 1⅜-in.-thick back posts are beefed up to 1⅞6 in. thick, and all of the seat rails and stretchers are about ⅛ in. larger in diameter than those on classic examples of the chair.

I also took some historical liberties with its design, incorporating features from various chairs produced by different Shaker communities. The arms and rockers are ½ in. thick and book-matched from the same figured maple board. The front arm posts have a ginger-jar profile and attach to the arms with a through-tenon and a

Turning Tips

All of the parts for this chair, except for the arms, rockers, and the curved back slat, are turned on the lathe. The back posts require a steady rest and a lathe that accommodates a 43-in.-long turning.

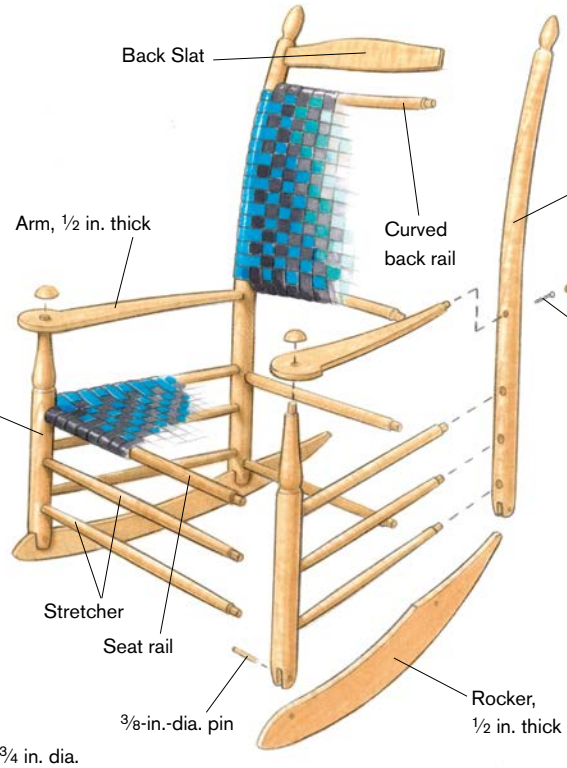
USE A STEADY REST to turn the long back posts. Conover used a bed extension on his Nova DVR 3000 lathe to accommodate the 43-in.-long posts. At this length, a steady rest is required to prevent the turning from chattering when working the center region.

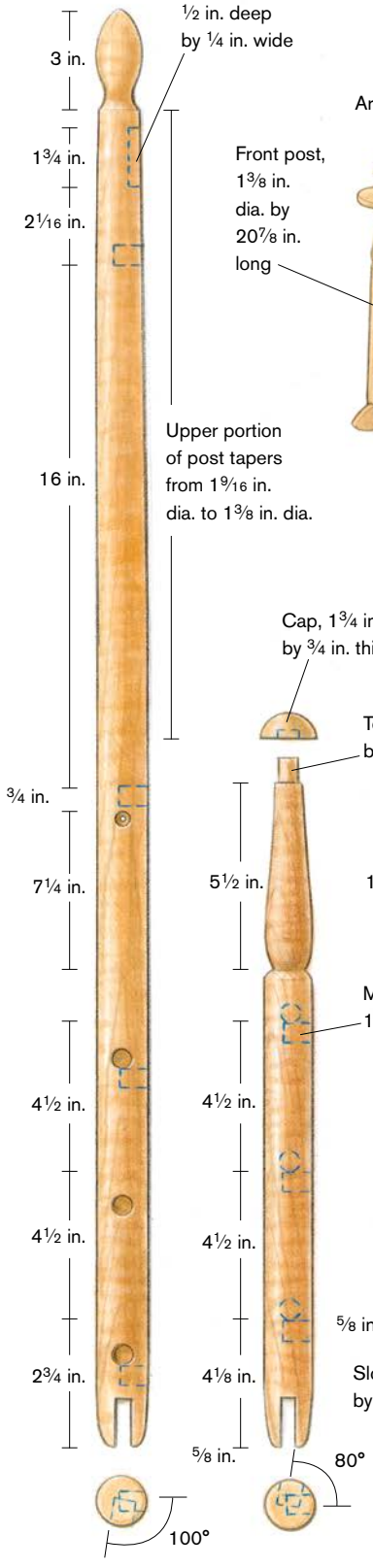
SIZE THE RAIL TENONS precisely with a wrench. Turn the tenons with a wide parting tool until the open-ended wrench slides over the tenon.

A SIMPLE METHOD to hold the mushroom caps for turning. Turn a tenon on scrap stock, then jam the cap blank over the tenon.

SHAKER ROCKER

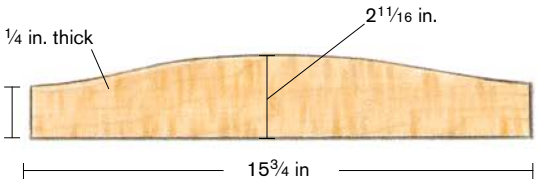
The chair is made from roughly 8 bd. ft. of hard maple. Conover used curly or figured wood as much as possible, except for the seat rails and stretchers, where straight-grain stock is necessary for strength. All of the finished dimensions include tenons.





Front and Top Views of Back and Front Posts

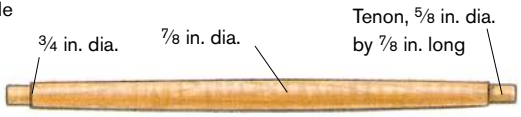
Back Slat



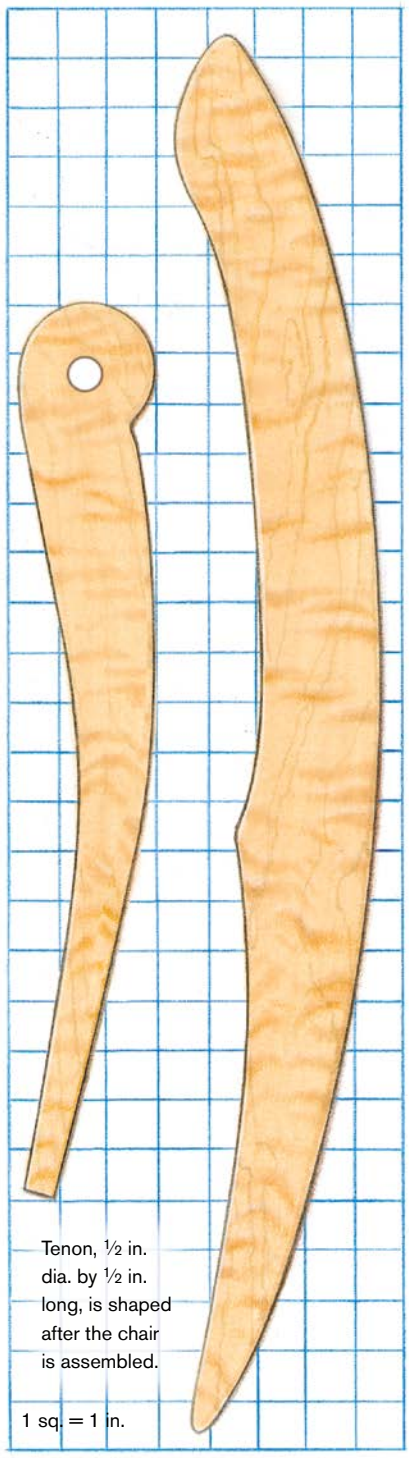
Back and Seat Rails

Upper curved back rail, 16⅜ in. long
Lower curved back rail, 16¼ in. long
Back seat rail, 16 in. long
Front seat rail, 21⅛ in. long
Side seat rails, 16½ in. long

Stretchers



Back stretcher, 16 in. long
Front stretchers, 21⅛ in. long
Side stretchers, 16½ in. long



Arm and Rocker

mushroom cap. Finally, the back is woven with one curved back splat above.

Turn All of the Spindles

Turning the various chair parts is fairly straightforward, but there are a few tips and tricks that will make it go easier. To begin, mill all of the stock for the rails, stretchers, and posts to length but just oversize in thickness so that you have some room for error when turning the delicate stretchers and rails to their final diameters.

This project requires you to be diligent and organized in the way that you mill and dimension the turning billets. Because there are so many parts that are nearly identical, varying only slightly in length and diameter, it's wise to mark each piece as it's made.

Steady Rest Prevents Chatter The long back posts require a lathe with 43 in. between centers. To accommodate that distance, I attached a bed extension to my Nova DVR 3000 lathe. A turning of this length also requires the use of a steady rest, which supports the post at the center to keep it from chattering.

Size Tenons with a Wrench Another turning trick helps produce consistent and perfectly sized round tenons, which will ensure a good glue bond when they are joined to the round mortises. First, mark the length of the tenon with a set of dividers, measuring from the end of the turning. Then, as you approach the final diameter of the tenon, fit an open-ended wrench of the finished diameter over the area. It will slide over the tenon when it's turned to the correct diameter. Ease into the fit, because if you turn the tenons undersize, you increase the chance of the joinery failing.

Finish Parts on the Lathe You can sand and finish nearly all of the round parts on the lathe. The exceptions are the back posts, the seat rails, and the curved back rails. The back posts are steam-bent before finishing, and the seat rails and curved back rails are left unfinished to provide traction so the Shaker-tape weave doesn't slide around.

The Shakers generally finished their chairs with varnish. I favor either Minwax or Olympic Antique Oil.

Jigs Align Parts for Accurate Joinery

After steam-bending the back posts, you can begin drilling the round mortises for the rail and stretcher joinery. This requires two jigs to hold the posts steady at the drill press. I also make four story sticks to locate the center points of the seat rail and stretcher mortises. The measurements for the seat-back mortises aren't included on the story sticks and instead are located with a tape measure, measuring from the bottom of each back post.

It doesn't matter in what order you cut the mortises, but I begin with the front posts. Using the story stick, lay out and mark the center point on the mortises for the two front stretchers and the front seat rail. With the post clamped in the jig, drill ⅝-in.-dia. mortises, 1 in. deep, using a drill press. Then insert a spare spindle into the mortise and rotate the front post 80 degrees, using the guide block for alignment. Clamp the front post in the jig in its new orientation and mark the mortises for the side stretchers and seat rail. Drill those mortises with the same setup. The process is the same for the back posts, but the mortises are 100 degrees apart.

The most important detail to keep in mind is to drill adjacent mortises on the correct side of each post. I mark the inside edges of the front and back posts to keep things straight. Once all of the mortises have been drilled, you will notice that some adjacent holes intersect (you can see daylight when you look into the mortises). This is intentional: The intersecting holes will help strengthen the glue joints when all of the parts are brought together.

Ease into the fit, because if you turn the tenons undersize, you increase the chance of the joinery failing.

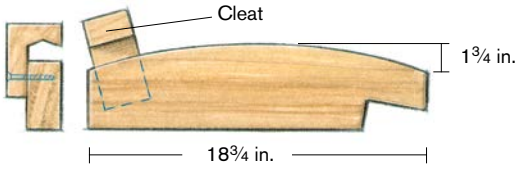
Steam-Bending Made Simple

The bending of the back posts, the back slat, and the back rails is done by heating the parts in a steambox and then clamping them to a form.

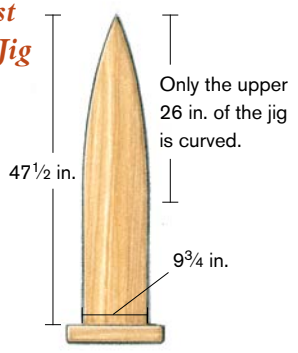
To do the job, I use a shopmade steambox composed of a propane outdoor stove that boils water in a 5-gal. gas tank and then sends steam through a radiator hose into a 4-in.-dia. Schedule-80 drainpipe. The back posts should steam in the box for about an hour at a temperature around 200°F to become flexible enough to bend. The back slat and rails need to steam for only about 15 to 20 minutes. Once a part is removed from the steambox, you have about 30 to 60 seconds to clamp it to a form.

Just like a teapot, the steambox must leak steam to prevent it from exploding under pressure. Also, it must be positioned on a slope so that condensation inside the box can drain into the water tank. Always wear heavy gloves and eye protection when operating the steambox and shuttling parts to the bending jigs. An extra pair of hands is a big help.

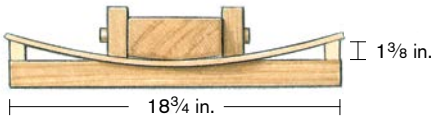
Back-Rail Bending Jig



Back-Post Bending Jig



Back-Slat Bending Jig



Use a Jig to Drill the Rail and Stretcher Mortises

The adjacent mortises on each post must be drilled at precise angles. Begin with the mortises for the front and back rails and stretchers. Then use a tenoned stick to set the angle for the side rail and stretcher mortises.

POSITION THE BACK POSTS in a drilling jig. V-blocks attached to a plywood base help to hold the posts in place for drilling. Use a center punch and a story stick to locate and align the drill bit. Then drill the mortises 1 in. deep.

SET THE ANGLE for the side mortises. Make a shorter jig to allow clearance for the bend in the back posts. Insert a tenoned stick into the mortise and use a guide block angled at 10 degrees to align the post in the jig (left). Then transfer the mortise locations from the story stick to the post (center).

DRILL HOLES FOR THE SIDE rails and stretchers. The adjacent holes should intersect with the front and back rail and stretcher mortises.

Drill and Chisel Mortises by Hand

Mortising the back posts for the curved back slat is best done by hand. Use a handheld drill to bore the round mortises for the curved back rails. First, dry-fit the chair with two band clamps. Measure from the bottom of each back post to mark the location of the back slat and rails, then use the bent parts to eyeball the approximate angle of each mortise. Hold the chisel to this angle during mortising, and do the same thing with a handheld drill to bore the round mortises for the rails.

Dry-Fit the Chair, and Align the Other Mortises by Eye

Rather than calculate the angles of the mortises, Conover dry-assembles the chair using band clamps and holds the curved part in place to determine the mortising angle.

DRILL FOR THE CURVED back rails. With the chair temporarily assembled, Conover uses the curved back rail to align the drill at the correct angle.

DETERMINE THE ANGLE of the mortise. Conover uses a mortising chisel to chop the mortises for the curved back slat. He rests the slat in place to set the proper angle for chopping (center). A piece of tape on the chisel marks the desired depth of the mortise (right) so that it can engage ⅜ in. of the tenon.

Long Open Time Aids Assembly

I use 90-minute clear epoxy to assemble the chair, taking advantage of the glue's long open time and its ability to prevent squeaky joints. Apply well-mixed epoxy to the mortises and tenons with a solder brush. Be sure to wear disposable gloves; epoxy is difficult to get off your skin.

Assemble the back posts first, then add the side stretchers and finish up with the front-post assembly. Two band clamps generally are adequate to hold the chair together while the glue sets. However, during assembly a bar clamp can be helpful to drive some of the tenons home. Once the chair is clamped, set it on a flat floor and muscle it into proper alignment by step-

ping on the front rail to hold it steady; then shake the back posts side to side and front to back.

Attach Rockers after Glue-Up

I choose highly figured material for the arms and rockers. The arms are book-matched and the rockers mirror-matched, so only one of each needs to be shaped. Trace the patterns onto planed 5/4 material, bandsaw to the lines, and handplane or sand away all saw and planer marks. Resaw the shaped pieces, then plane them to ½ in. thick. Finally, round over the top and bottom edges of the arms with a ¼-in. roundover bit.

Each rocker is attached with a pinned bridle joint, a process best done by hand. Scribe the rockers to the bottom of the posts, then lay out the bridle joint 1¾ in. deep. Backsaw the shoulders of the joint and remove the waste with a chisel. Undercut the joint with the chisel from both directions to prevent tearout, much like cutting a through-mortise. Then test-fit the rocker and refine any tight spots with a chisel and rasp.

After a slide fit has been achieved, trace the outline of the bridle joint on the rocker to facilitate positioning it in the same place on subsequent trials. The fit is refined on the front by flattening the edge of the rocker between the pencil marks. You also will have to chisel the back edge of the bridle joint on the back post so that the rocker sets fully in the joint. Glue the rocker into place once you're satisfied with its fit, then drill a through-hole and pin the rocker to both posts with a maple dowel.

Arms Go on Last

The arms are attached after the woven seat and back are completed. First, measure the distance from the back post to the center of the front-post tenon. That measurement, plus 1/16 in., is the distance from the arm's tenon shoulder to the center of the round mortise at the front of the arm. The extra 1/16 in. puts the joint under tension.

Next, raise a ½-in. tenon on the end of the arm to go into a stepped hole drilled into the back post. Although I use an antique tenon maker, modern versions can be used in an electric drill. Alternatively, the job could be done by careful carving.

Mark the location of the mortise on the back post at the same distance above the seat as on the front post. Drill through the

Assemble the Chair

All of the parts of the chair, except for the arms and rockers, go together in one glue-up. Conover prefers to use 90-minute epoxy for its long open time. Join the back parts first, then insert the side stretchers, and wrap up with the front-post assembly, clamping it with two band clamps. Once all of the parts are assembled and clamped, rest the chair on the floor to check for alignment.

Cut Bridle Joints for the Rockers

The adjacent mortises on each post must be drilled at precise angles. Begin with the mortises for the front and back rails and stretchers. Then use a tenoned stick to set the angle for the side rail and stretcher mortises.

MARK THE LOCATION of the rockers. With the chair clamped upside down in a vise, the rockers are positioned where they will join the front and back posts. Scribe a line down both sides of the post to the correct depth.

CUT THE BRIDLE JOINTS by hand. Use a backsaw to cut along the scribe lines. Then clean out the waste with a chisel.

MEASURE THE GAP. The rocker initially won't sit flat in the groove. Use dividers to measure the gap on one side when the other is set.

CHISEL THE MORTISE until the rocker is fully set. Then the rockers can be glued and pinned to the front and back posts.

back post with a 1/16-in. bit to locate the center point of the mortise. Now, drill a ½-in.-dia. by ½-in.-deep mortise to accept the arm tenon. Finally, from the opposite side, countersink the 1/16-in. through-hole for a #8 by 2-in. flat-head wood screw. I drill deep enough to bury the screw under a plug, but not too deep that it breaks into the ½-in. mortise on the opposite side.

The arms are glued and secured with a faceplate-turned mushroom cap on each front post and a wood screw covered by a plug from the rear.

ERNIE CONOVER is a regular contributor to *Fine Woodworking* who teaches woodworking at his workshop in Parkman, Ohio.

Attach the Arms

Make the arms longer than necessary, then cut them to length and tenon the ends after the chair has been assembled. The joint is reinforced with a screw inserted from the rear of the back post. Weave the seat and back before attaching the arms.

LOCATE THE ARM MORTISE. **Hold the arm in place to determine the mortise angle. Drill through the post using a 1/16-in.-dia. drill bit, then drill a 1/2-in.-deep mortise using a 1/2-in.-dia. bit.**

MEASURE FOR THE ARM JOINERY. **Determine the distance from the back post to the center of the front-post tenon on the assembled chair. Add 1/16 in. to determine the distance from the tenon shoulder to the mortise center to ensure the joint stays under tension after assembly.**

COUNTERSINK THE BACK OF THE POST. **After weaving the seat and back, glue the arm in place and secure it with a screw. Cover the screw hole with a maple plug.**

Shaker Weave

My wife, Susan, who is a fiber artist, weaves the Shaker-tape seats and backs on my chairs. However, most of my students find that weaving is part of the fun of making a Shaker rocking chair. You'll need about 80 yd. of 1-in.-wide tape to complete this chair.

Oval Chippendale Stool

BY RANDALL O'DONNELL

It's real easy to get excited about making a stool like this. Compressed into this little gem are the chief hallmarks of the Colonial Philadelphia chair makers: finely carved feet on graceful legs tenoned into a thin curved frame, topped off with an upholstered slip seat. Less than a handful of original oval stools exist today. To my eye, this Chippendale-style stool commands a presence far beyond the small amount of material needed to build it.

With its curves, carving, and fine proportions, 18th-century-style furniture is hard to ignore. Over the years, I've built all kinds of things from wood, but making furniture in this style continues to offer the most satisfying challenge. That challenge lies not just in the cutting and carving but in researching the history and construction details of the piece.

In my part of the country, there are not a lot of original examples of this type of furniture to examine, so to capture the essence of a particular piece, I have to do a lot of homework. First I read all of the related books and magazine articles I can find. Then I travel to check out similar pieces in museums or, if possible, in private collections. The research is far more time-consuming than actually making the piece.

This stool is an outstanding example of the Philadelphia Chippendale school of chair making. For chairs with curved seats, Colonial Philadelphia chair makers tenoned the legs up into a stout frame. In most other areas, chair makers tenoned the frame members into the leg the same way a table's aprons are tenoned into its legs; that resulted in a strong joint but a wide frame. The Philadelphia approach sacrificed just a little bit of strength for an elegantly thin frame.

Although making a curved frame and attaching curved legs may appear daunting, the joinery is dirt simple. In this article, I'll describe how to construct the frame and

make and carve the legs. I'll also show you a foolproof assembly process and touch on applying the finish.

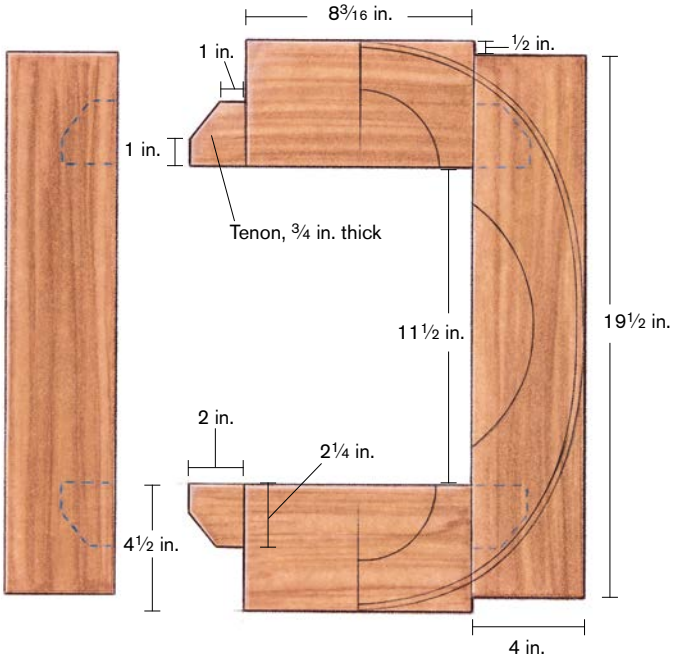
Make Full-Size Patterns and a Rabbeting Template

Start by making full-size plywood patterns of the seat frame, leg and knee block (for dimensions, see the drawings to the right and on p. 130). Additionally, you'll need to make a template to guide the router for wasting away material to form the rabbet for the slip seat.

The frame pattern provides the curve of the oval and the mortise location for the leg tenon. To avoid cutting errors, enlarge this quarter-segment pattern to full size and use it to make a complete oval pattern. Mark out one quarter of the oval, and then, using the centerlines as reference marks, flip

MASSIVE TIMBERS AND SIMPLE JOINERY

This handsome little stool starts as a hefty rectangular frame.



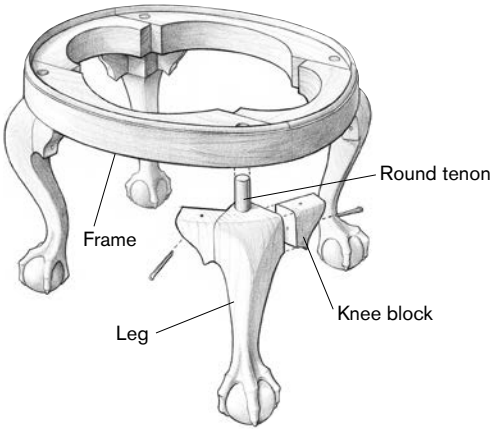
ASSEMBLE THE FRAME. **The bulk of the frame has been reduced by bandsawing arc-shaped segments prior to assembly.**

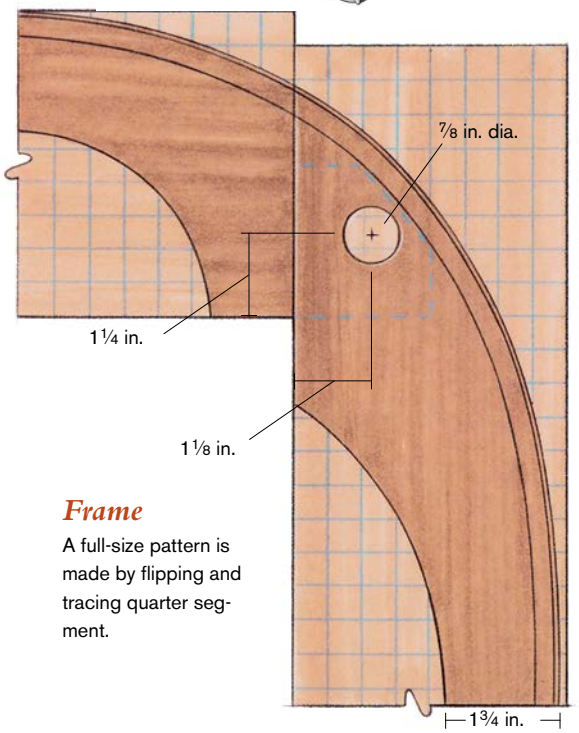
A ROUTER MAKES FAST WORK of the seat rabbet. Use a full-size oval pattern to establish the layout line.

THIS GOUGE IS GOOD. To hog away stock the router couldn't reach, the author used a gouge.

Oval Chippendale Stool

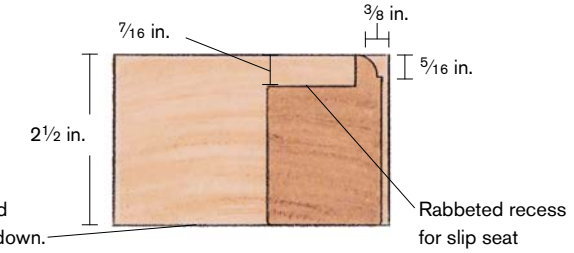
Full-sized patterns help avoid errors and simplify layout. These patterns are 40 percent scale. Use a copying machine to enlarge them to full size, or use the grid to develop the full-size patterns.

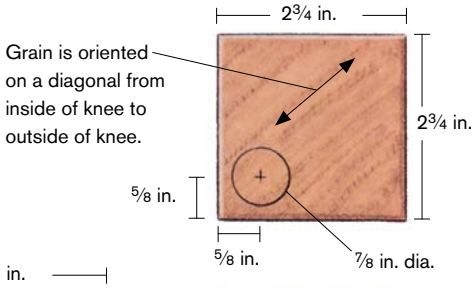


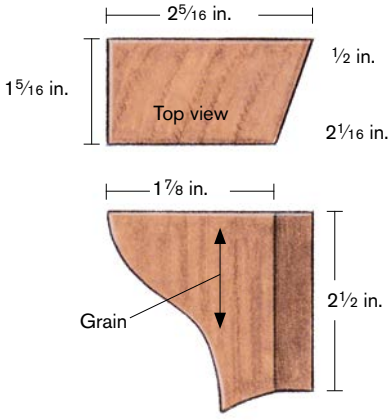


Frame

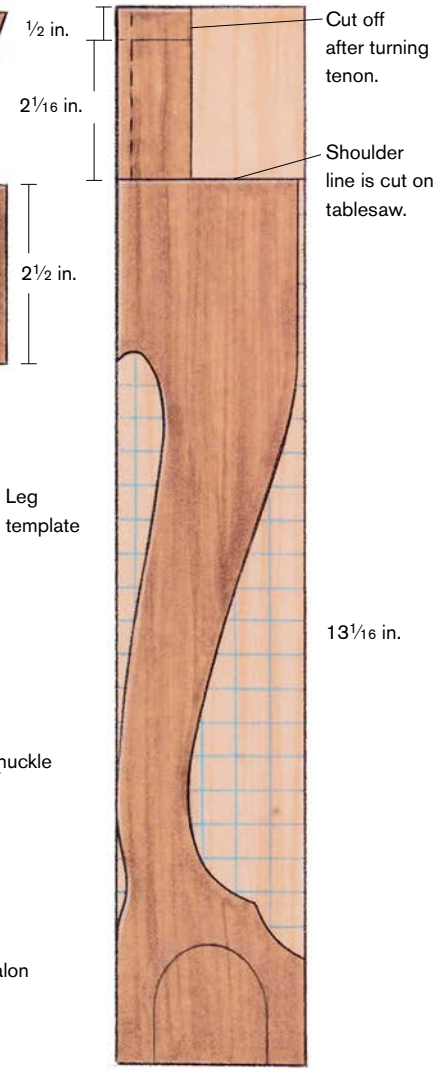
A full-size pattern is made by flipping and tracing quarter segment.

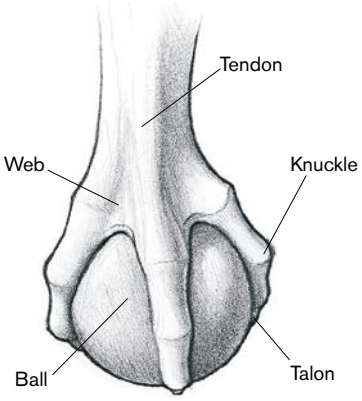




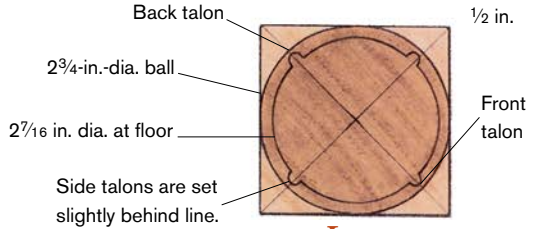


Knee Block





Ball-and-Claw Foot



Leg

the pattern over to mark out the remaining quadrants.

I make a plywood router template for rabbeting the frame for the slip seat. When sizing the oval opening in the template, figure in the offset between the router bit and the guide bushing you will use to cut the rabbet. Be sure to save the interior offcut from the rabbeting jig. It will be used as a router platform for cutting the bead on the top edge of the frame.

Join a Rectangular Frame, then Shape the Oval

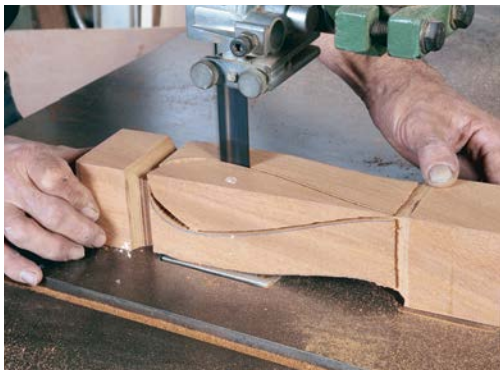
It's astonishing that this small stool starts out with timber-frame-size members. To build the frame, start by milling the stock to 2½ in. thick and cutting the four frame members to size. It helps to orient the frame stock so that the heart side faces down. This orientation results in an arc-shaped grain pattern that rises toward the middle of the frame, which looks much better than a slumping grain pattern.

Referring to the full-size pattern, mark out and cut the mortises and tenons. For mortising, I use a plunge router to remove most of the waste and hand-chisel the corners and sloping transition in the mortise. A bandsaw makes fast work of the tenons. Again, I carefully pare to the layout line with a chisel.

Many original Philadelphia pieces simply left the inside of the beefy frame rectangular, but I prefer to cut away a lot of the excess bulk to reduce the mass. Prior to assembly, I bandsaw large arc-shaped hunks from the frame interior.

Now, glue up the frame. Don't worry about clamp marks on the frame edges because they will be cut away when you saw the oval. After the glue dries, use the pattern to mark out the ⅞-in.-dia. mortises and then drill them.

Some Philadelphia chair makers used a separate, applied lip to house the slip seat



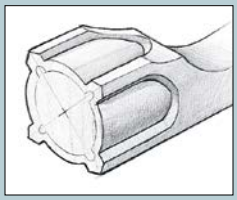
LIGHTEN THE LOAD, then turn the tenon. Rough bandsaw the leg, leaving a bridge of material to hold the first cutoff in place. When turning the tenon, use a short tool rest for best support.

because it was more economical. For me, it's easier to make the lip by rabbeting the frame, using a router to waste away the excess stock quickly. Using an exterior template and router guide bushing prevents cutting into the lip. Because the router base is too small to provide adequate support while cutting the area toward the middle of the frame, I use a gouge to pare away the waste. After rabbeting the frame, saw it to the oval shape on the bandsaw. I use an oscillating edge belt sander to clean up the profile to the scribe line.

An edge bead on the seat rim forms a neat transition from the frame to the slip seat. The rabbeting template offcut, placed where the slip seat goes, provides the platform for supporting the router. You could use a standard beading bit for this edge bead, but I prefer to end up with a less-machined-looking result.

I first make a 1/16-in. rabbet around the perimeter of the frame and then round over

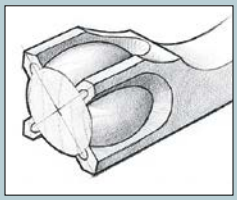
Carving a Ball-and-Claw Foot



OUTLINE THE TOES WITH a V-parting tool. Cut to the depth of the larger circle marked on the bottom of the foot.

SHAPE BETWEEN THE TOES. Use a #2 gouge and cut to a cylindrical form between the toes.

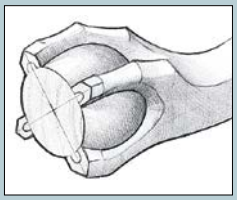
1. ESTABLISH A CYLINDER



ROUND THE TOP, then the bottom. Carve from the equator toward the ankle with a #2 gouge. Work around the ball to develop a sphere. Then carve down from the equator to shape the bottom of the ball.

2. SHAPE THE BALL

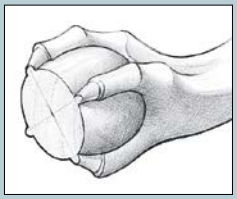
3. LOCATE AND CARVE THE KNUCKLES



MARK THE KNUCKLES. The front and side toes have three knuckles; the back toe has two.

SHAPE THE TOES. Round over and slightly undercut the toes. The areas between the knuckles are scalloped and thinner than the joints.

4. CUT THE TALONS AND TENDONS



CARVE THE TALONS. Taper the talons to about ⅛ in. at the bottom of the foot. Note that the side talons taper to a point slightly behind the line.

PROMINENT TENDONS PRODUCE A strong-looking grip. Define the tendons and web using a #8 bent gouge. Work up from the ball to the knee.

GLUE THE LEGS IN the frame. The knee blocks temporarily screwed to the frame ensure that the legs go back in the same position. The knee blocks are glued in place after the leg glue joint has started to set.

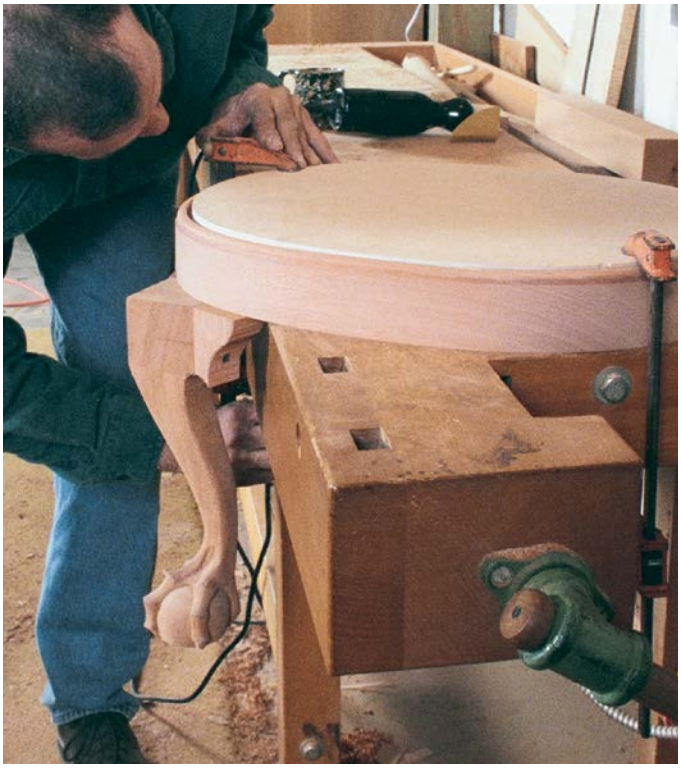
the top edge with a cabinetmaker's file. Develop the bead by making a series of small parallel chamfers, with the grain, along the perimeter of the frame. I think the slight irregularities resulting from this process give an authentic handworked look to the piece.

Bandsaw the Cabriole Legs, then Turn the Tenon

The leg material should be sound, straight-grained stock. Cut the 2 ¾-in. square leg billets to size. Allow an extra ½ in. of length on the tenon end for the lathe's spur center. It will be cut off after the tenon has been turned. Use a full-size pattern to mark out two faces of each leg. Orient the pattern on the leg billet so that the resulting leg profiles are knee to knee. Mark the center point of the round tenon on both ends. To define the start of the tenon, cut the shoulder lines at the top of the knee on the tablesaw.

Before turning the leg, cut the cabriole shape on the bandsaw to reduce the leg mass and lathe vibration during the tenon turning. When cutting cabriole legs, I use the bridge method to eliminate the need for reattaching the offcut stock. Briefly, when bandsawing the first cabriole profile, don't saw off the waste completely. Instead, leave a small bridge between the leg and the waste. This allows you to cut the other side of the leg profile without having to reattach the sawn-away stock. Cut through the bridge after the second profile has been cut.

Once the leg has been rough-cut, turn the tenon. Mount the leg on the lathe with the tenon nearest the headstock. The spinning blur of a leg may look a little scary, but it's quite safe because all of the work is confined to the tenon. Use a short tool rest so there's no chance of getting pinched between the leg and the tool rest.



TEMPORARY FIXING. With the ball and claw complete, prepare to carve the knee by dry-fitting the leg to the frame. Use screws through the knee blocks to hold the leg in place .

Carve the Feet

By about 1755, the ball-and-claw foot had become firmly identified with the American Chippendale style. The motif is thought to have originated in China as a dragon's claw clutching a pearl. To make the feet for this stool, draw two concentric circles on the bottom of each foot. A 2 ¾-in.-dia. circle is the full diameter of the ball. A 2 7/16-in.-dia. circle is the ball diameter at the floor. Mark the equator—the horizontal centerline of the ball—⅝ in. from the bottom of each foot. Now, mark the toe outline from the drawing.

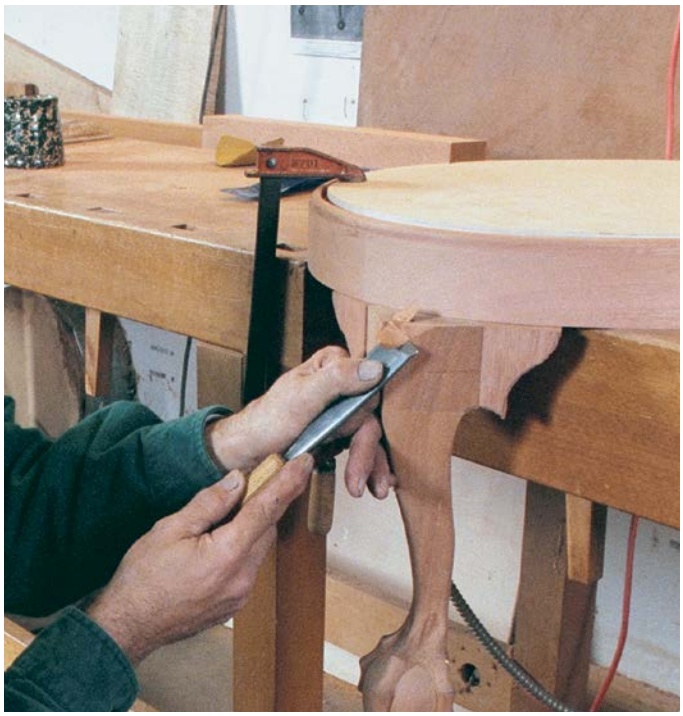
To achieve uniformity, carve the four legs together, advancing all four from one stage to the next. I use only a few carving tools to make the feet: a V-parting tool, a #2 gouge, a #8 long-bent or #8 spoon gouge, a rasp, and a riffler. The tool

numbers refer to the gouge's cutting-edge radius, or sweep.

Start by outlining the toes on the ball using a V-parting tool. Using the #2 gouge and the V-parting tool to refine the outline, cut the ball area to a cylinder by working to the layout line marked on the bottom of the foot. Then smooth this area with a rasp to produce a nice, uniform surface. With the #2 gouge, round the top area of the ball, working from the equator and deepening the toe-to-ball junction with the V-parting tool. Be careful not to remove any stock from the center point of the equator—this is the basic reference for the ball diameter. Round the lower half of the ball, working down to the inner circle. Keep referring to the other three surfaces between the toes to maintain the spherical shape. Once you have the ball rounded, smooth it with a riffler.

Now, mark out the toe joints: three on the front toes and two on the back. Round over the toes, slightly undercutting them at the ball surface. Scallop and thin the toes between the knuckles, making the knuckles more prominent. Once the toes have been defined and rounded, mark out the talons ½ in. from the bottom of the foot—Philadelphia-style ball-and-claw feet tend to have rather stubby talons. Note that even though the side toes are forward at the centerline for most of their length, their talons taper to a point slightly behind the centerline. The front and back talons are aligned on the centerline. Taper the talons to about ⅛ in. dia.

Now comes the part that really gives a feeling of tension in the foot: cutting the web and defining the tendons. Use a #8 long-bent gouge and start defining the extent of the tendons. Work from the ball up toward the knee, leaving the web proud of the ball by about 1/16 in. Smooth the carving with rifflers and small pieces of sandpaper. Shape the leg from the ankle to the knee with a rasp and rough-sand the lower leg and foot. The upper leg will be shaped and faired to the frame in the next step.



KNEE WORK. WITH THE LEG dry-fitted, rough-shape the upper leg, blending the knee to the frame. Final fairing with a rasp is done after glue-up.

Fit the Knee Blocks and Fair the Upper Legs

The knee blocks make the visual transition from the legs to the frame and buttress the joint. Fitting knee blocks to a curved frame is somewhat different from the usual rectangular frame because the blocks flare away from the leg to meet the frame.

Dry-fit the legs into the frame, aligning the flat knee-block surface of the leg parallel to the frame's joint line. Now, screw the knee blocks in place to hold the leg in this position for rough shaping the upper leg. Be sure to mark the legs and knee blocks so that you can return them to the same positions on the frame. Carefully remove the legs without disturbing the knee blocks.

FOUR-LEGGED UNIFORMITY. **Complete each stage on all legs before moving on to the next stage. Use rifflers and sandpaper for a refined foot.**

Finish Up

With the knee blocks still screwed in place, glue the legs to the frame. Once the glue has started to set (about 10 minutes), remove the knee blocks, one at a time, apply glue, and screw them back in place. After the glue-up, replace the screws in the knee blocks with hand-forged nails for authenticity.

After the glue dries, use a #2 gouge and a pattern maker's rasp to blend the curves of the upper legs and knee blocks into the frame. The final smoothing is done with sandpaper, starting at 100 grit and ending with 180 grit. Sponge with water, then give the surfaces a quick hit with 400-grit paper to remove any raised wood fibers.

Susy, my patient wife, does the finishing and really gets the wood's figure to pop. She colors the wood with red mahogany aniline dye, followed by a washcoat of shellac. Two separate applications of paste filler with a black tint, spaced a day apart, follow. Finally, several coats of buttonlac shellac topped off with Behlen's violin varnish make the stool glow.

Crowning this regal little stool with a silk damask-covered slip seat completes the project. I make the frame, and an upholsterer does the webbing, padding, and fitting of the fabric. To make the frame, I simply join a rectangular assembly of poplar, bandsaw it to the oval shape ⅛ in. smaller all around than the seat recess, and cut a heavy chamfer around the top outside edge.

RANDALL O'DONNELL makes period-style furniture at his shop in the countryside near Bloomington, Indiana.

Bowback Windsor Step by Step

BY HARRIET HODGES

The rewards of building Windsor chairs are sweet indeed. From logs, I create objects of beauty and utility, strong but graceful, steeped in tradition and destined to last generations (see the photo above). The process isn't difficult as long as you take it step by step.

Preparation

Before you start to make a bowback (or any other style) Windsor, you have to get green wood, preferably in whole log form. Split out, square, and then round blanks for the back-bow, spindles, legs, and stretchers. I use sugar maple for legs and spindles, pine or basswood for the seat, and hickory for the back-bow.

You'll need to make a crude kiln to dry the tenons that go into wet mortises: Wet-dry joinery gives Windsors their characteristic strength. A cube of folded foil-faced insulation with a light bulb inside and plywood ends works well for me. Shape your spindles (see the bottom drawing on p. 144 for dimensions), and dry them for at least 24 hours. If you don't want to build a kiln, you can put the spindles in a gas oven with a pilot for 48 hours.

Drilling and Shaping the Seat

Using the seat pattern from the drawing on p. 139, scale the pattern onto a piece of cardboard or heavy paper. Now set the blank on the bench, heart side down, and trace the pattern on it. Mark the centers of spindle, back-bow and depth holes. Mark leg centers on the top for reference in carving. You want to leave a lot of material around the legs for strength. Mark spindle sight lines. They will be used later to help drill the spindle mortises at the correct angles.

Cut the front profile of the seat, but leave the back waste intact so you'll have corners to clamp. Then set the pattern on

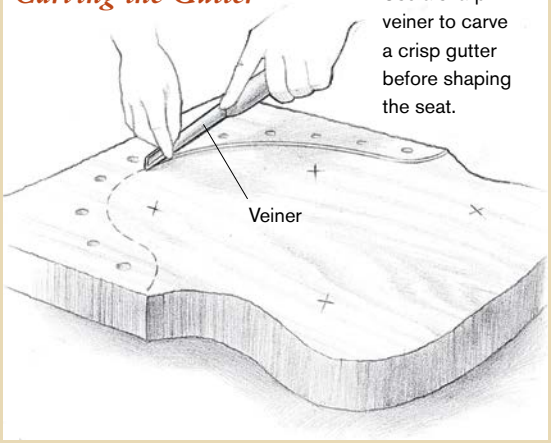
STRENGTH BELYING ITS DELICACY is the hallmark of a Windsor chair, a trait it derives from the wet-dry joinery and the long, unbroken grain of the drawknifed, not sawn, pieces. The Windsor's classic good looks fit in almost anywhere.

Drilling and Shaping the Seat

ALIGNING BRACE AND BIT IN TWO PLANES ISN'T DIFFICULT, but it takes practice. Hodges positions a bevel gauge, set at 8 degrees off perpendicular, along the sight line she'd marked previously for each spindle mortise. By keeping her bit in line with the bevel gauge in front of it and checking the mirror to make sure the bit remains parallel to the gauge, she can bore all the spindle mortises in about 10 minutes.

Carving the Gutter

Use a sharp veiner to carve a crisp gutter before shaping the seat.



the bottom, lining it up at the front and marking leg centers for drilling. Also, transfer the sight marks for the legs from the pattern (marks FL and RL in the drawing on the facing page), and then draw sight lines, as shown. Next mark the centerline of the gutter, which defines where the seat carving begins and the plateau for the back ends.

Start drilling with the center spindle mortise. Set a bevel gauge to 8 degrees back from perpendicular, and center its blade on the sight line. Use a ½-in. auger bit, and set a depth stop for 1½ in. Drill with a mirror set to the side of the bit and bevel gauge, so you can sight both angles at once (see the photo at left). After the center spindle, drill in pairs, one mortise to each side of center. Change the bevel gauge's angle setting for each pair. Use a ⅜-in. bit to drill the back-bow mortises.

Turn test tapers now to match your reamer (see the drawing on p. 143). The reamer tapers leg and back-bow mortises. Ream the back-bow holes from the top until the test taper protrudes below. Check angles repeatedly, aligning the center of the test taper, the blade of a try square, and the sight line to get one angle right in one plane. Use the bevel gauge to check the angle in the other plane (see the bottom photo on the facing page).

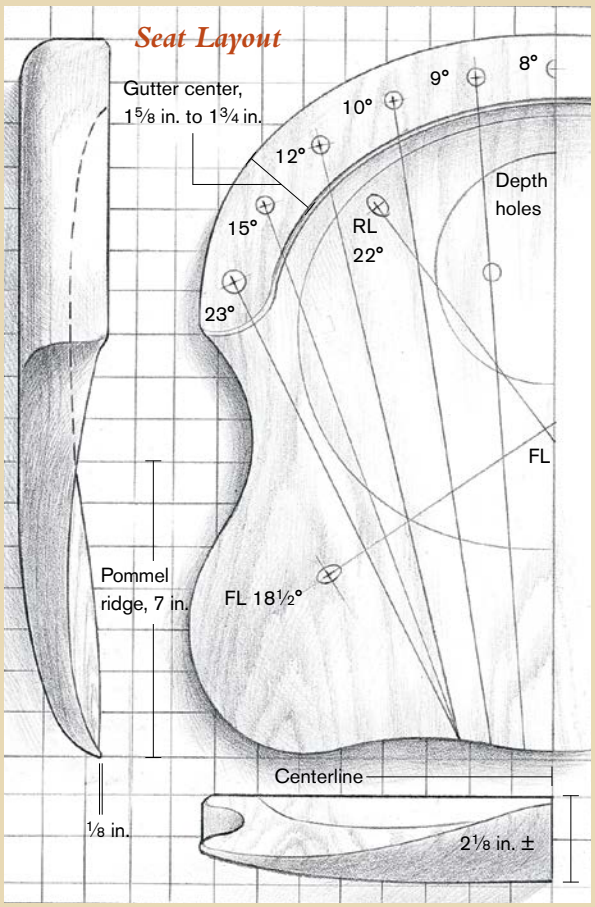
The first step in shaping the seat is to carve the gutter. Carving a crisp gutter requires a scalpel-sharp veiner (a carving tool that cuts a V-groove); see the drawing at left. Before you start removing more seat material, draw contour lines along the front of the seat and the forward part of the sides (see the drawing on the facing page). Bore depth holes to ⅞ in. with a Forstner bit. Then have at it with an adze, inshave, or large gouge. Proceed evenly, from the middle of the inner circle, aiming for a shallow bowl that gradually deepens

and widens. Bring in area A. Drawknife the front, spokeshaving when close to the line. Round the seat over slightly below the gutter. Undercut the underside at the front deeply, tapering into the areas under the gutter edge. Finish up with scrapers on the top, leaving the bottom spokeshaved. Saw the waste off the back.

The side S-curves are difficult, undulating in two planes, perpendicular to the floor at the back and twisting subtly. Use rasps and files as necessary. Look for symmetry between the two sides and for fluidity (see the top photo below).

Once you've shaped the seat, turn it over and bore leg holes, using the same mirror technique as the spindle holes. Ream them from the bottom until the test taper protrudes slightly all the way around, testing frequently for angles with the test taper.

Seat Layout and Carving



MUCH OF A WINDSOR'S ALLURING GRACE IS FOUND IN THE SEAT, particularly in the S-curve on the side. The transition from a horizontal to nearly vertical surface over just a few inches requires a good eye and sharp tools to make it feel natural. Hodges uses a drawknife for starters, followed by a rasp, file, and spokeshave.

A REAMER (TO THE LEFT, ON THE SEAT) is used to taper the chair-leg mortises. Bore the mortises for the chair legs, using a mirror to get the angles right. Then use a bevel gauge, protractor, square, and test taper to check the angles and mortise depth as you ream. A reamer in a tap wrench can be used to pare selectively within the mortise to get the angles just right.

Preparing Legs and Stretchers

I chose simple bamboo-style turnings for this chair. Bamboo turnings can be done with a gouge and just the tip of a skew, which is good news if you haven't done much turning. Note the positions of the bamboo nodes in the drawing on p. 142. Be sure to sand the legs while they're still on the lathe.

Once you've turned the legs, lap them to mate with their mortises. Mark a heavy line down the reamed hole with a soft pencil. Twist the leg in the hole, rechuck it, and remove high spots. The end of the tenon should protrude slightly all around. Mark and match legs and holes for a permanent match; they're not interchangeable. I use stick-on colored dots.

Insert all four legs in the seat with light mallet taps. You'll need to get the seat up on blocks, so the leg tenons will go to depth in their mortises. Orient the legs properly, turn the assembly upright, and mark the top of the leg tenons for the direction of the sawkerf (note the orientation of legs and stretchers the drawing on the facing page). Kerfs must be perpendicular to seat grain.

Now flip the assembly back over, so the seat is back on blocks on your bench. Measure for stretchers at the centerline of the bottom node of the bamboo. To do this, choose a front-back pair, and mark the center of the mortise in one with an awl as you sight "through" its mate. Flip the assembly around and repeat. Now measure the distance between the two marks, add 2⅛ in. (for the tenons and chamfered shoulders) and you have the length of your stretcher. Repeat for the other side. It doesn't matter if the two stretchers are different lengths.

To get the length of the medial stretcher, first measure the distance between the front legs and the distance between the back legs. Use the same awl marks you made to drill for the side-stretcher mortises. Add those two lengths, divide by two, and add ⅝ in. That's the length of your medial stretcher.

Cut stretcher stock to exact lengths and turn, making tenons exactly 1 in., chamfers ⅛ in., but leave the tenons slightly thick. Center the nodes on the side stretchers; space two equidistant from each other and the chamfers for the medial stretcher. Sand them on the lathe, and make sure to turn a couple of extras for test-fitting. Now wrap legs and stretchers tightly in aluminum foil, leaving just the tenons exposed, and dry them in your kiln for 48 hours—no more. Then rechuck all legs and stretchers, and sand lightly to take down the grain raised by heating them in the kiln.

Assembling the Undercarriage

Boring and assembly require concentration and speed. Assemble the chair upside down on the bench on blocks, orienting each leg properly in the correct mortise. Scribe around each leg at the seat.

To check the leg-stretcher angles, set a rule along each side pair of legs. Then set a bevel gauge against the rule, and adjust it so the blade is in line with the center of a leg, rear first, then front (see the top photo on the facing page). Record these angles for boring the side-stretcher mortises.

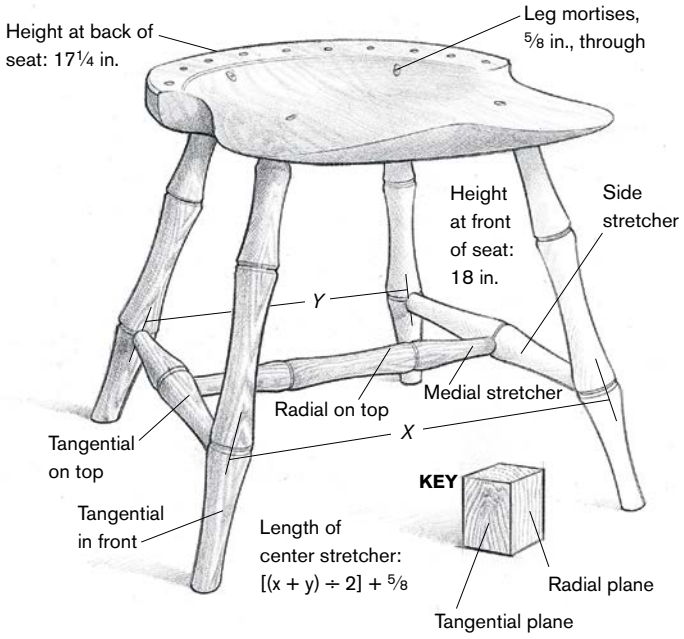
Lay another rule across the first, snugging it against either both back or both front legs. With the bevel gauge, record the acute angle where the two rules meet. This is the medial-stretcher angle.

Place side stretchers on the seat with their tangential planes up. Put the medial stretcher between them, radial plane up. Pick up side stretchers with your thumb and middle finger opposing, each in the middle of an "ellipse," right at the center of the tangential face of the stretcher. Now prick a mark with an awl on the node ring

Making the Undercarriage

USING A STRAIGHTEDGE TO ESTABLISH A PLANE between the front and back legs, the author checks the leg-to-seat angles to make sure that the stretchers will be parallel to the seat.

Seat and Undercarriage Assembly

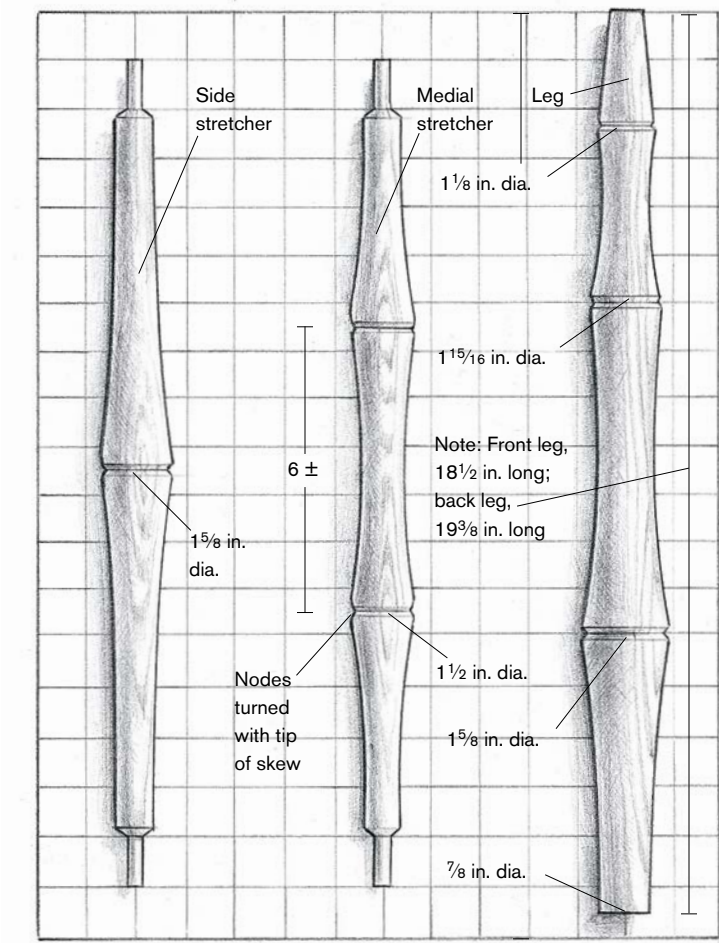


Note: Correct grain orientation is critical to the strength of Windsor chairs.

HOLDING PARTS SECURELY IS MORE THAN HALF THE BATTLE. Hodges uses three pegs and a wedge in her shaving horse, but a shoulder vise with wooden jaws also could be used. Either way, blocks should be used to keep the workpiece from rocking while you're drilling.

WORK QUICKLY ONCE YOU'VE started attaching the legs to the stretcher assembly because glue in the leg joint will cause it to swell in no time, freezing the joint in place. Once you've adjusted the stretcher assembly so that it's parallel with the bottom of the chair, pound the tenon home.

LEG AND STRETCHER LAYOUT



halfway between your fingers, or right in the middle of the radial face, to locate the mortise for the medial stretcher.

The next step is to size tenons. Accuracy is a must. Use test pieces until you get a perfect fit, and then go for the real thing. File a test tenon very slightly in the radial planes, exaggerating the oval. Chamfer ends slightly, so they won't bind just as your tenon enters a test board. Use a piece of scrap maple with a ⅝-in. hole in it to test the fit. If the tenon slips right in, try a smaller bit. If it won't penetrate with moderate blows, it's too wide. A drive plate is wonderful for sizing tenons because it removes such a small amount at a time. Failing that, either file or rechuck in your lathe. When you have a tenon that fits well, record its diameter with dial or vernier calipers. Then file flats on its radial planes, swab glue in the ⅝-in. hole in the maple test board and on the end of the tenon, and pound it home in the test mortise. Wait a minute. Try to pull it out or twist it. If you can't—and the mortise didn't split—that's your tenon dimension. Now size all tenons for real.

To avoid confusion in drilling, point the leg tenons toward you. For the two stretchers you'll mortise, draw arrows that will point toward you as you drill at an acute angle. You don't need jigs: Hands and eyes are capable of more than enough accuracy. Set the seat on blocks upside down on the bench for test fits. Do the stretcher assembly first. Pick up a side stretcher, note the angle you wrote down for the medial stretcher, set your bevel gauge, and place the stretcher in a vise to hold it without rocking while you drill. I use a three-peg vise, which works well and takes only minutes to make. Place the bevel gauge alongside the stretcher, the acute angle pointing toward you. Set a mirror to the side, so you can see both bit and bevel gauge simultaneously while drilling. Don't worry about being a little off. This step is forgiving, too.

Bore the mortise so it's at least 1⅛ in. deep. Relieve the acute-angle side of the mortise, so the chamfer on the medial stretcher doesn't get hung up. Clean any chips or sawdust out of the mortise. Orient the medial stretcher correctly, and coat its tenon thinly with glue, particularly the end. White glue's a good idea until you're confident you can deal with the quicker set-up time of yellow glue. Pound the tenon home with a mallet. Now bore the other stretcher, and pound in the other tenon in the same plane. If it needs correction, twist as you pound.

Take up a rear leg, bore the side-stretcher mortise, glue its tenon, and pound it into the leg mortise a little. Seat the leg (dry)

in its hole with the stretcher assembly attached. The medial stretcher should be parallel with the seat. It probably won't be, so correct it by pounding at the other end of the stretcher assembly while twisting it (see the photo at right on p. 141). Check again. Remove the leg from the seat, and pound the stretcher home. Be quick because the kiln-dried tenon is swelling from the moisture reintroduced by the glue. Bore the other rear leg, and keeping both legs in the same plane, pound the glued stretcher tenon home.

Reset the bevel gauge for a front leg, bore the mortise, glue its tenon, and insert it in a little way. The top of the front leg should fall slightly to the outside of the line described by the back leg as you look across the pair. Treat the last leg in the same way—except now you can use its mate for alignment.

Kerf the leg tenons almost to the scribe line you marked showing their depth in the seat. Turn the seat upside down on blocks, swab the mortises with glue, and work glue into the sawkerfs. Set the lower assembly in place, each leg tenon in its mortise. Pound legs down alternately, listening for the thunk that says it's done. Turn what is now half a chair over. Hammer in glue-smeared wedges.

Back Assembly

The next step is to bend the back-bow. I steam the piece for about 45 minutes in a length of 4-in., schedule 40 PVC pipe with a cap glued on one end and a couple of rags in the other end. My steam generator is a tea kettle on a hot plate. The steamed back-bow goes into a plywood bending form the shape of the interior of the bow.

After drying the back-bow in the bending form for about a week, stick its tenons into hot sand or under a light bulb in an aluminum reflector for at least four hours. Sand can be heated easily in a cake pan or skillet on an electric range top. After four (or five or six) hours, test-fit the back-bow tenons in the seat mortises. Pare the tenons until they protrude below the seat at least 3/16 in. Mark tenons left and right, scribe around them at seat level, and mark kerf lines, perpendicular to the seat grain. Chamfer the tenon ends.

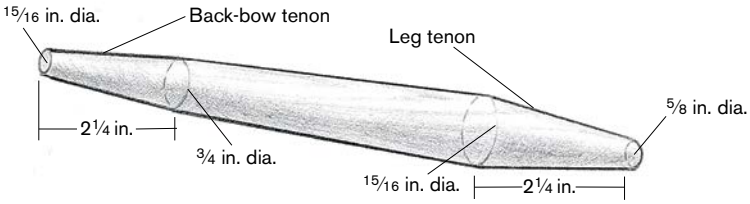
While the tenons are drying, make a simple support fixture to steady the back while you drill for spindles (see the top drawing on p. 144), but wait to notch the top until after you've fitted the bow. Set the back-support fixture in place 90 degrees to the seat in the center-spindle mortise. If the top of the back's arc doesn't coincide with the center of the seat, mark the true center. The center spindle must be perpendicular. Mark off spindle locations with dividers and pencil using the measurements in the drawing on p. 139. Fix each line with your eye over its respective spindle mortise in the seat, and without moving your head or your gaze, use an awl to mark on the line at its center on the bow.

This center is important because there's not much wood to spare. Bore the spindle

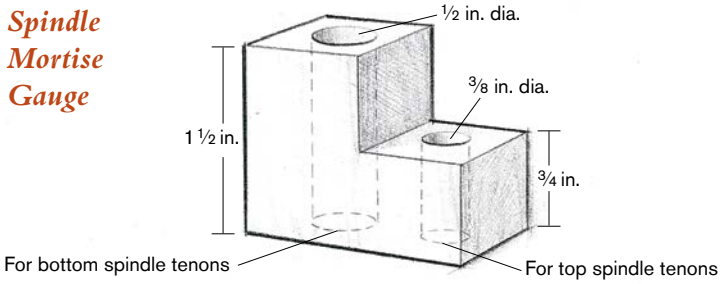
TEST TAPERS AND SPINDLE GAUGES

Test Tapers

Tapers match reamer.



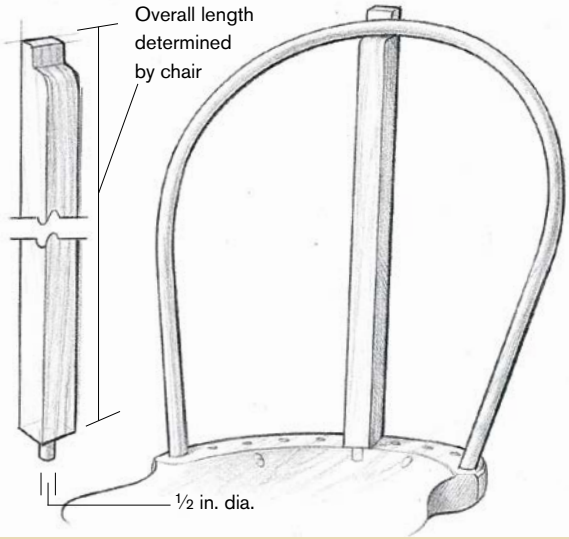
Spindle Mortise Gauge



Assembling the Back

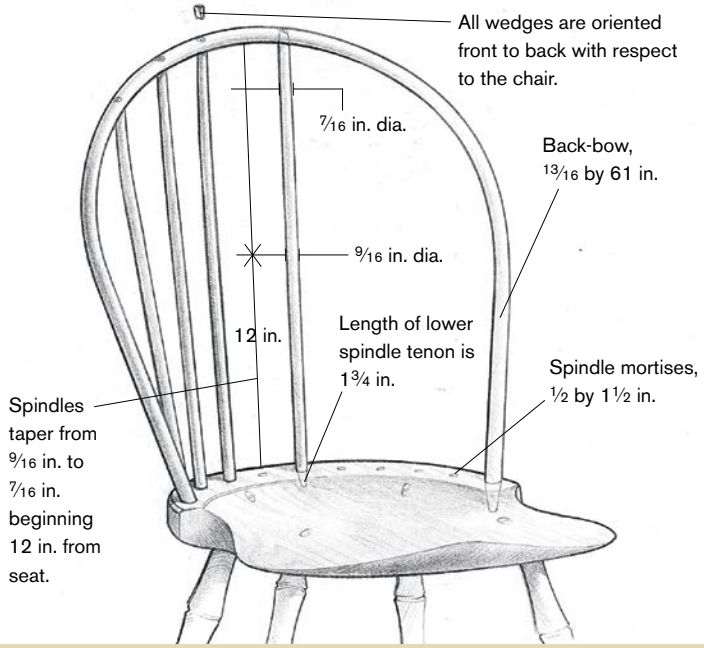
ASSEMBLING THE BACK. **A wooden back-support fixture keeps the back-bow steady as Hodges drills spindle mortises in it. Two pieces of metal rod connected with nuts serve as a visual guide to keep her bit aligned with the spindle mortise in the seat.**

Back Support Fixture



Back Assembly

Thickness dimensions are green and will shrink.



holes with a ⅜-in. auger bit. In addition to the back-support fixture, I sometimes use a ½-in. dowel or a pair of all-thread rods connected with washers to steady the bow further and to drill true. I also use the mirror to stay true in the other plane. What you're trying to do is to sight "through" the bow to the spindle mortise in the seat, even though the bow's obscuring it. Begin perpendicularly to an imaginary tangent at the bow's surface, and then bring the bit gradually up to the correct angle within 10 turns. Bore until you can just feel the tip of the drill. Repeat for the rest of the spindle mortises in the bow, and then remove the back and finish the holes from the other side.

Make a spindle-tenon test gauge (see the drawing on p. 143), and size all the bottom ends of spindles to fit snugly. Insert them in the spindle mortises in the seat, place the back just behind the spindles and arrange the spindles, so they're lined up with their corresponding back-bow mortises. Mark spindles with a pencil where they intersect the back-bow bottom and again ½ in. above the back-bow top. Cut them at this top mark. Now mark them, L1, R1, and so on, and scribe a line around each at its penetration into the seat.

Remove the back-bow. Remove the spindles and shave their tops, so they will slide easily into the spindle mortises in the back-bow down to the lower intersection.

Chamfer the spindles heavily on top, and replace them in the seat. Test-fit the back, reaming spindle holes very lightly or shaving from a spindle as necessary. Draw a line down the spindle fronts and onto the seat, so you can replace them in the same orientations. Now cut them off level ¼ in. (on the short side) above the chair, and mark for a kerf across their tops—perpendicular to the grain of the back-bow. Make sure the line at the intersection of the underside of the bow and the spindles is well marked. Now disassemble the back; rechamfer the spindle tops; kerf all spindles at the top, nearly to the line below the bow; and kerf the back-bow tenons nearly to the seat-depth scribed lines.

Lightly brush glue in seat holes, two at a time. Insert spindles. Brush glue in the back-bow holes, and with a mechanic's feeler gauge (or anything else that's thin, flexible, and won't self-destruct with glue on it), work glue into all the wedge kerfs. Start spindles into their mortises in the back-bow, and then start the back-bow into its mortises in the seat. Pick up the mallet and a scrap of wood, and moving from side to center to alternate side, hammer the back down. Wiggle recalcitrant spindles. Sometimes the sharp points of the bow tenons hang up in their holes. If they do, pull forward on the bow while hitting it. When the bow tenons reach their depth mark, that's it.

Smear glue on the spindle wedges, and hammer them home. Turn the chair upside down, and insert wedges in the bow tenons. Look for gaps in the fit, inserting little wedges wherever you can get them. When the glue has set, saw the spindle, back-bow and leg tenons almost flush; then chisel, scrape, and file to finish. Level the legs, and chamfer their bottom edges so they won't split when great-grandchildren skate the chair over a floor. Finally, sand, raise the grain, sand again (to 180 grit), and fill small gaps.

Finish

Paint makes the chair read as sculpture. I use milk paint, which is not like other paints. Practice with it. Penetrating-oil topcoats will make a chair water resistant. This finish gives off a soft glow and is extremely durable. Virtually unchippable, it is only burnished by the years.

HARRIET HODGES builds Windsor chairs and settees, in addition to raising sheep and harvesting chair wood on a Craig County, Virginia, farm. She is also the indexer for *Fine Woodworking*.

The Shaker Revolver

BY MARIO RODRIGUEZ

Back in 1986, I was lucky enough to attend a New York exhibition of Shaker furniture that had been gathered from private collections. One of the pieces was an unusual rotating stool called a revolver (see the photo at left). Like most Shaker furniture, the design was clean and spare, and the stool had been made with the Shaker's remarkable craftsmanship. Unlike most Shaker furniture, this stool was a completely original design. It was a versatile piece of 19th-century workplace furniture well-suited to any 20th-century interior.

I put the stool out of my mind until recently, when I needed a compact home-office stool—something small enough to slip under a desktop yet large enough to be comfortable for more than a few minutes at a time. I didn't want some chrome and fabric contraption, so the revolver seemed like a good answer.

Although the stool requires both turning and steam-bending, it's still fairly simple to make. The only sticking point seemed to be a hardware problem: Where was I going

THIS REPRODUCTION REVOLVER looks right at home in the old Ministry Shop on the grounds of Hancock Shaker Village in Pittsfield, Massachusetts.

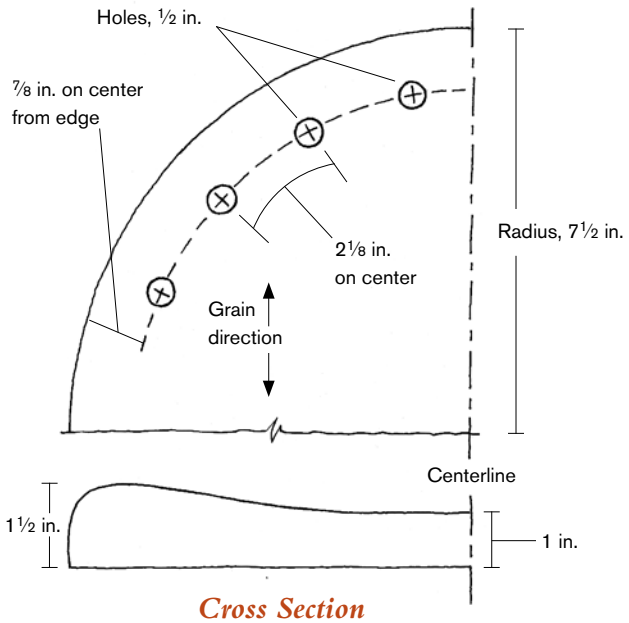
to get the parts to make the rotating mechanism that connects the base to the seat? After a few failed trips to local hardware suppliers, I found Jeremy Lebensohn of Studio dell'Arte, who constructed a working mechanism from odds and ends he uses to fabricate staging platforms for theaters. His design is simple: a ¼-in.-thick steel plate, 6 in. sq., welded to a 10 in. length of ⅝-in.-dia. Acme® threaded rod. The rod passes through a 1-in.-sq. tapped block of steel that controls the vertical travel of the plate. Studio dell'Arte (see sources on p. 151) will sell this mechanism for $40*, which includes shipping charges. You could also check with a machine shop in your area.

A Look at the Basic Parts

Each of the stool's parts requires different skills. The base is made up of two identical arches of 3-in.-thick solid walnut joined with a half-lap joint at the center and secured to the bottom of the pedestal with four #10 flat-head screws. The pedestal is a two-part lamination that holds the tapped block of the mechanism captive. The seat is simply a round block gently dished in the center. After being turned to a perfect taper on the lathe, the spindles are steam-bent to a subtle curve. The back rail crowns the revolver with a gentle curve, steam-bent to a 9¼-in. radius.

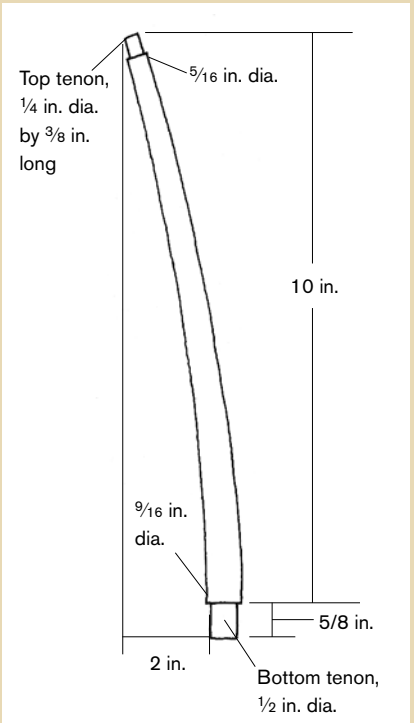
I made my stool of walnut. Shaker versions usually were a combination of several different woods: hickory for the spindles and rail, cherry or maple for the pedestal and base, and pine for the seat. These everyday stools were constructed from whatever was handy. Whichever wood you choose for the bent parts, it must be green (freshly harvested) to ensure successful bending. Kiln-dried wood does not bend easily and will spring back more readily.

SHAPE AND SIZE OF TURNED SEAT



Cross Section

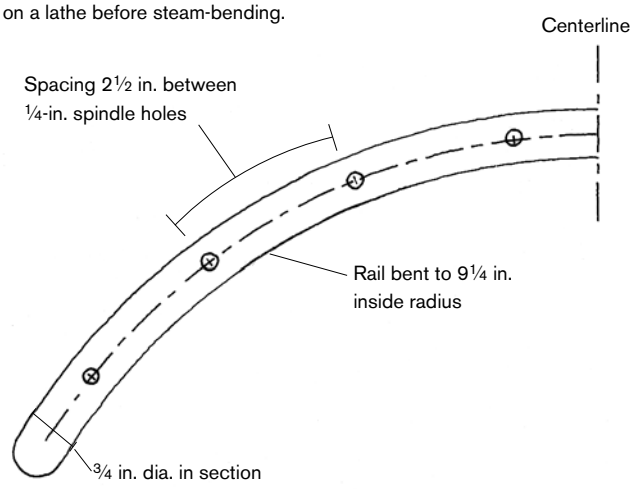
Turned Spindles



ROUGH OUT THE SPINDLES with a gouge, and clean them up with a block plane. Cut the tenons with a parting tool.

BACK RAIL

Blank is cut to 21 in. long and then turned on a lathe before steam-bending.

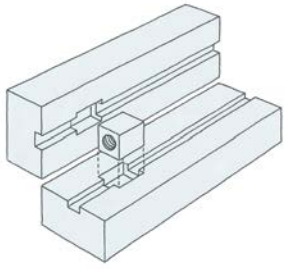


Turning the Seat, Spindles and Rail

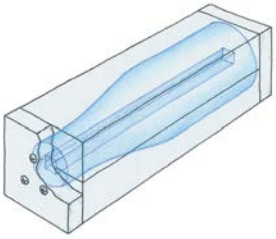
The seat was glued up from two pieces of walnut, 1½ in. thick, to form a 16-in.-dia. blank. To make turning easier, I bandsawed the shape to within ¼ in. of the finished 15 in. dia. and mounted the blank on my lathe with a 6-in.-dia. faceplate.

When turning large pieces of wood on a lathe, it's a good idea to turn your project at a slow speed (I set my lathe speed at 600 rpm). Turning at a high speed will cause excessive vibration, posing risks to both you and your work. The shape of the seat is fairly straightforward (see the top drawing on p. 147). It has a rounded top edge and a ½-in.-deep depression in the

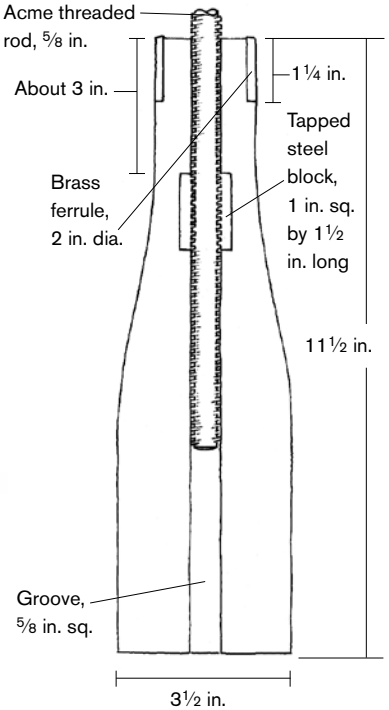
Pedestal, Inside and Out, Before Turning



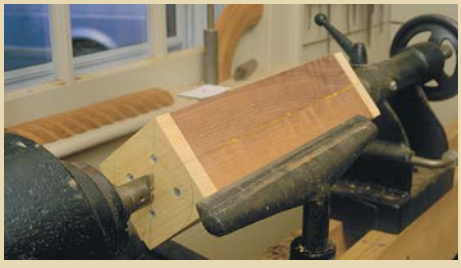
Plow ⅝-in. grooves 5/16 in. deep in pedestal blanks; then chop mortises for tapped block by hand. Glue blanks together with tapped block in its mortise; then turn on lathe.



Section through Pedestal



THE TAPPED STEEL BLOCK, buried in the glued-up pedestal, accepts the threaded rod attached to the seat bottom.

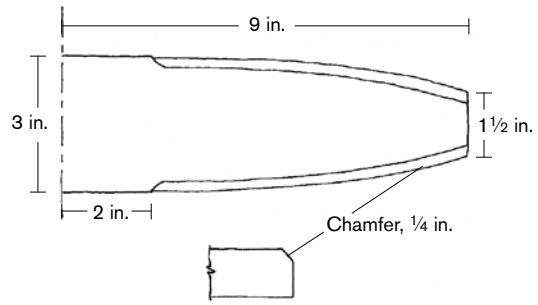


SCRAP PINE SHOES MAKE TURNING POSSIBLE. Take care placing the screws, so they won't interfere with turning tools.

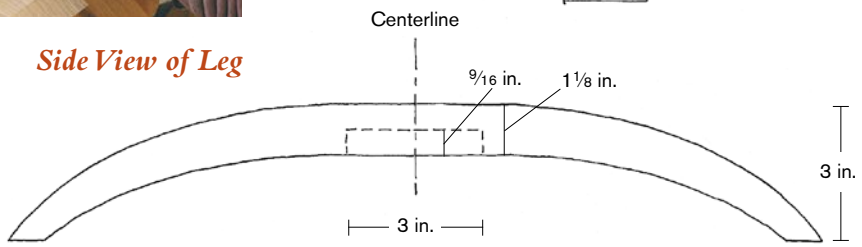
Arched Legs form the Base

HALF-LAP JOINT IN ARCHED LEG.
The joint is roughed out on the bandsaw and cleaned up with a chisel and shoulder plane. A few test-fits may be needed.

Plan View of Leg



Side View of Leg



center. After turning the seat, I sanded it to 400 grit at about 1,725 rpm.

Both the spindles and the rail should be turned before they are bent. A common problem in turning thin pieces is whip, which occurs when a workpiece vibrates and moves away from the cutting edge as force is applied. Sometimes the tool will slip between the workpiece and the tool rest, either deforming the spindle or popping it free. Once these pieces are damaged in any way, they must be discarded.

An easier way to turn the spindles is to use a block plane on the lathe (see the photo on p. 147). This technique leaves a smooth and even taper. I made sure to turn the top and bottom tenons slightly oversized to allow for shrinkage when the parts dried. Later, I shaved them down with a coarse file for a tight fit.

The back rail, at 21 in. long, required the use of a steady tool rest to reduce whip. If you don't have one, the back rail can be steamed square, and after bending, shaped with a ⅜-in. quarter-rounding bit mounted in a router. It's a good idea to prepare the back rail bending blank with a few extra inches at each end: This will give you leverage during bending and minimize kinking.

Glue Up the Pedestal, and Then Turn to Shape

The pedestal is made from two pieces of 2-in. by 4-in. rough walnut. I plowed a ⅝-in. channel down the center of each piece on the tablesaw for the threaded rod. Then I marked out the position of the tapped block and chiseled out a mortise to receive it (see the top photo on the facing page). This part had to fit perfectly—any slop was eliminated with shims. Once the

BACK-RAIL DRILLING JIG. **Worth the time spent making it, this jig guides the drill at just the right angle for each hole. To keep the depth of all the holes consistent, you might want to put a piece of masking tape on the drill bit as a stop guide.**

block fit, I dry-clamped the two halves together and engaged the threaded rod to make sure the alignment was perfect and the threaded rod didn't bind. Care and caution now saves work later on. The two pieces may now be glued together with the threaded rod in place.

To turn the laminated pedestal to the final vase shape, I added pine shoes at each end (see the bottom photo on p. 148). With the center channel cut, I needed a solid surface for mounting between centers on the lathe. I turned the top of the pedestal down to a 1⅞ in. dia. to receive a brass ferrule, which strengthens and decorates the slender neck (I used a short length of brass pipe that I got from Space Surplus Metals, see sources on the facing page). Then I mounted a 1¼-in.-long piece of the pipe over the live tailstock center and checked the fit periodically as I turned the neck. I left the last ¼ in. of the pedestal neck a little oversized and tapped the ferrule into place. Later, I set a countersunk #4 brass screw to hold it secure.

So the rod wouldn't wear out the wood in the neck, I used a ¼-in. chisel to clean out the top of the plowed channel and hammered home a ¾-in.-dia. by ½-in.-long flush copper bushing (available from any plumbing-supply dealer).

Building the Base with a Half-Lap Joint

For the arches, I used 3-in.-thick solid walnut and oriented the grain lengthwise, like the original Shaker stool. Initially, I was concerned that any weight placed on the arches might cause the short-grained sections to split, but this construction technique was used by the Shakers. Many of their stools have survived, and mine hasn't split either.

The two legs are cut with a half-lap joint at the center. Because the legs taper in two planes, the sequence of cuts is important. I cut out the silhouette first and marked a centerline and a 4-in.-wide section for the half lap (see the drawing on p. 149). One arch was marked topside for the cut, the other on the underside of the curve. After laying out my joint on both pieces, I rough cut each half on the bandsaw by making multiple cuts to a depth equal to half the thickness of the arch but just shy of my scribed lines. Then I chiseled out the waste and used a shoulder plane to clean up everything for a perfect fit (see the photo on p. 149).

With the half-lap joint cut, I laid out the taper on the arches and cut them on the bandsaw. All of the curved surfaces, both concave and convex, were cleaned up with a spokeshave, files, and a cabinet scraper. I finished off the curved arches with chamfered top edges.

Joining the Seat and the Rail

The position of the holes for spindle tenons on both the underside of the back rail and the perimeter of the seat are important. Properly placed, the spindles enhance the stool's grace and delicate beauty. If not, the stool will look lopsided and unbalanced.

There are eight holes, spaced 2⅛ in. apart, bored on a drill press at 90 degrees

Bending Rails and Spindles

Bends for this stool are mild and easy to produce, but you'll need some sort of steambox. I use a fairly large one made of 6-in. PVC pipe, 60 in. long, mounted on a plywood cradle. But for a small, one-time project like this, I'd recommend constructing a small plywood box. A commercial wallpaper steamer, which can be rented from paint stores or rental centers, produces the steam.

The jig for the back rail (see the photo at right) is a design based on one I use for Windsor chair making. It consists of a ¾-in. plywood form mounted to a backing board. Around the form, I drill 1-in.-dia. holes to accommodate the pegs and wedges that hold the steam-bent blank in place. I cut the pegs from dowels and the wedges from shop scraps.

I used a jig for the spindles to bend them all at once. I glued up pieces of scrap lumber to make an arched form. The bottom tenons fit into holes at the base of the arch. The top tenons are clamped down and held by a plunger.

The pieces are slender and require no more than 30 minutes in the steambox. When removing parts from the box, I always use gloves because the steam is hot enough to burn hands and forearms. I leave the steamed pieces in their jigs about five days, so they will retain their curved shape and not spring back. When dry, I clean them with 120-grit sandpaper.

RAIL-BENDING JIG. Four hands are better than two for forcing the steamed rail into shape. The author is assisted by Les Katz, one of his students. Wedges hammered between the plywood form and the wooden pegs hold the rail tightly in place.

into the top of the seat. The holes in the rail are drilled at two angles—75 degrees for the four center holes and 70 degrees for the four outside holes. This fine degree of change helps to make the spindles fit right and look good. I made a drilling jig based on a 9¼ in. radius to help locate my holes at the correct angle (see the photo the facing page).

Assembling and Finishing the Stool

It's always a good idea to dry-assemble any project before glue-up. In the construction of the Shaker revolver, it's critical. After the rail and spindles fit correctly, I drew registration marks on masking tape applied to both spindles and seat, so I could reassemble the parts exactly the same way later. When I went to glue-up, I simply lined up the marks on the masking tape.

Many of us have horrible memories of using shellac in junior high school shop class. It was thick and pungent, difficult to brush on and left awful streak marks. It never seemed to dry. I overcame these problems when I learned to mix my own, using fresh shellac flakes and a good-quality solvent blended to a water-like consistency. Such a thinned mixture makes shellac a versatile and attractive finish, and that's what I used for the stool, adding a little red pigment to warm up the color of the walnut. After four coats of shellac, I applied two coats of furniture wax.

★ *Price estimates from 1995.*

MARIO RODRIGUEZ teaches woodworking at the Fashion Institute of Technology in New York City. He's also a contributing editor to *Fine Woodworking*.

Sources

Studio dell'Arte
Pier 63, North River
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Space Surplus Metals
325 Church St.
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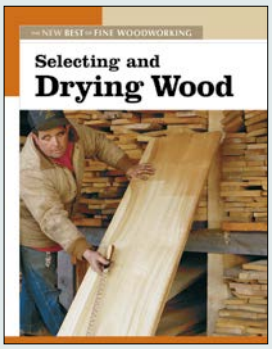

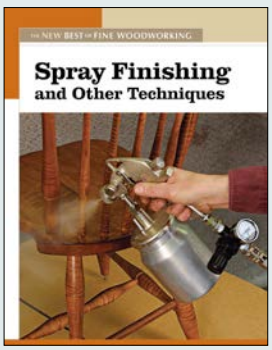

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