Curved Slot-Mortise and Tenon

Contoured joinery for enhancing frames

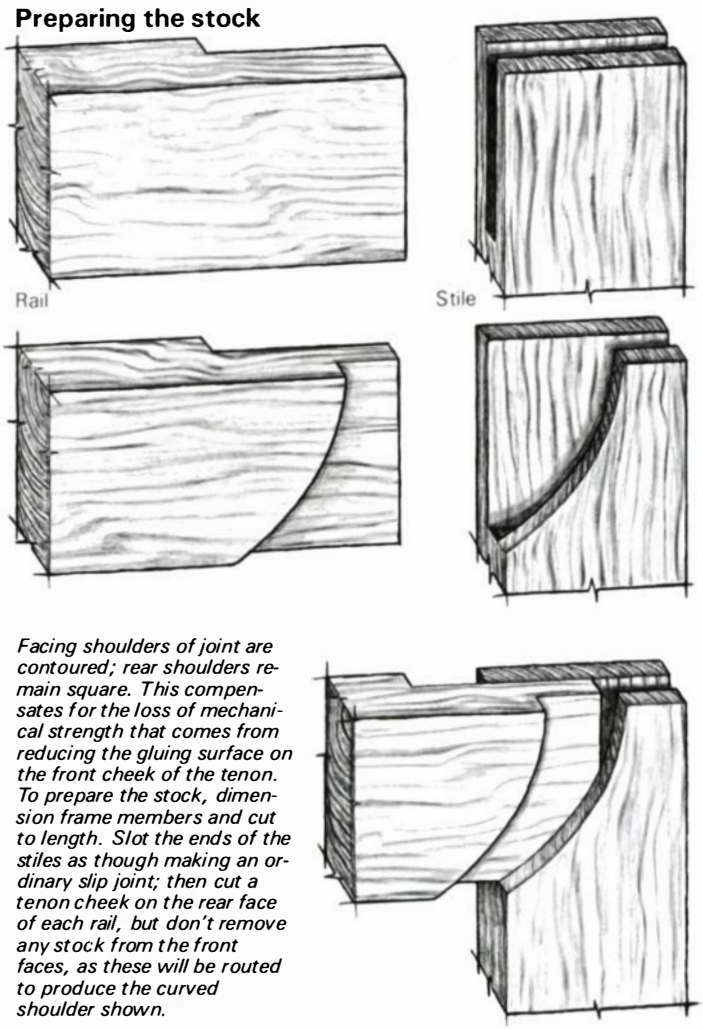
by Ben Davies

Design decisions in woodworking cannot be made entirely for aesthetic reasons. Wood is not a plastic medium but a rigid one, and we usually shape it by removing portions of it. Our designs are thus limited by the capabilities of our cutting tools and our skill at using them. To achieve new shapes—to experiment with line and form and the basic geometry of joining wood—we either develop specialized tools or adapt our old tools to perform in innovative ways. Highly specialized hand tools, like molding planes, have limited applications, while more versatile modern tools, like computer-controlled carving machines, can be afforded only by industry. So there's considerable reward for the craftsman in being able to extend the use of general-purpose tools—the router in particular—in imaginative ways.

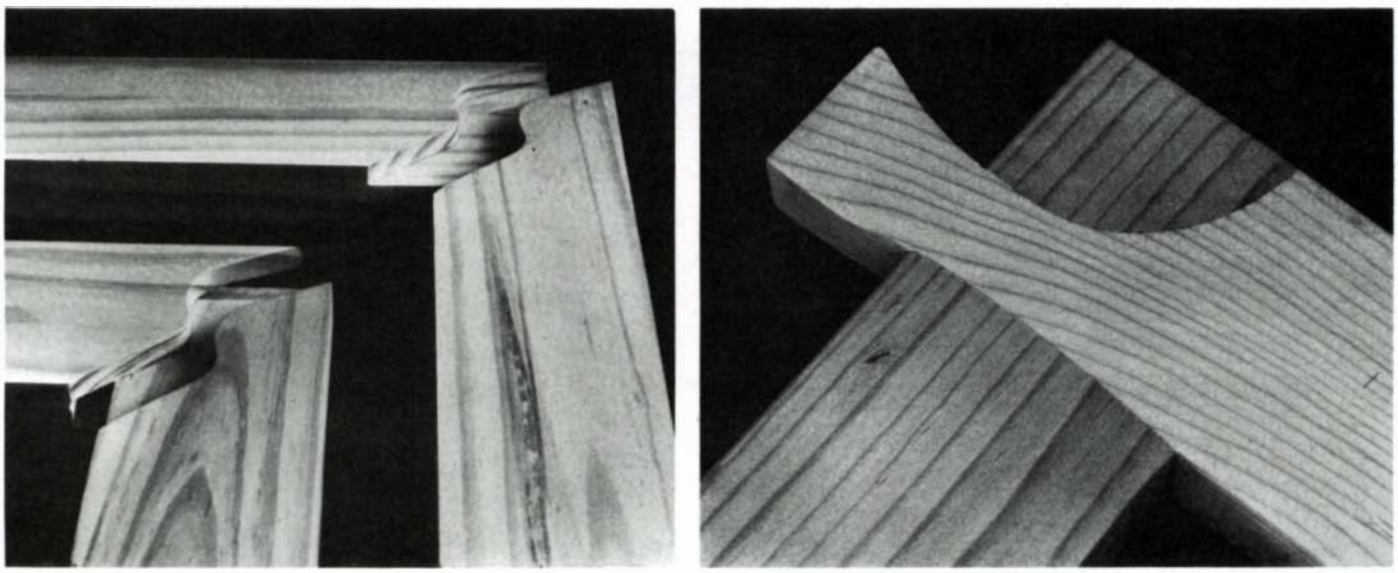
The following description of making a curved joint is not meant to be definitive. Rather, it is a tentative first step toward adding a dimension to our work when struggling to achieve a balance between geometric and organic forms. When we build we are faced with a dichotomy—crisp and differentiated forms on the one hand, soft and flowing forms on the other. Consider the rigid control exemplified by Shaker and Cubist formalism contrasted with the flowing asymmetry of Art Nouveau. The dichotomy transcends woodworking and the visual arts. For more, read Nietzsche's discussion of the Apollonian/Dionysian duality in his essay "The Birth of Tragedy from the Spirit of Music."

Using a router equipped with an ordinary straight-face bit and a pair of guide bushings, plus a shop-built fixture to hold the work and a bearing template to guide the router cut, you can quickly contour the adjoining shoulders of rails and stiles with little chance for error. But making the fixture and template requires careful planning and accurate work.

Preparing the stock

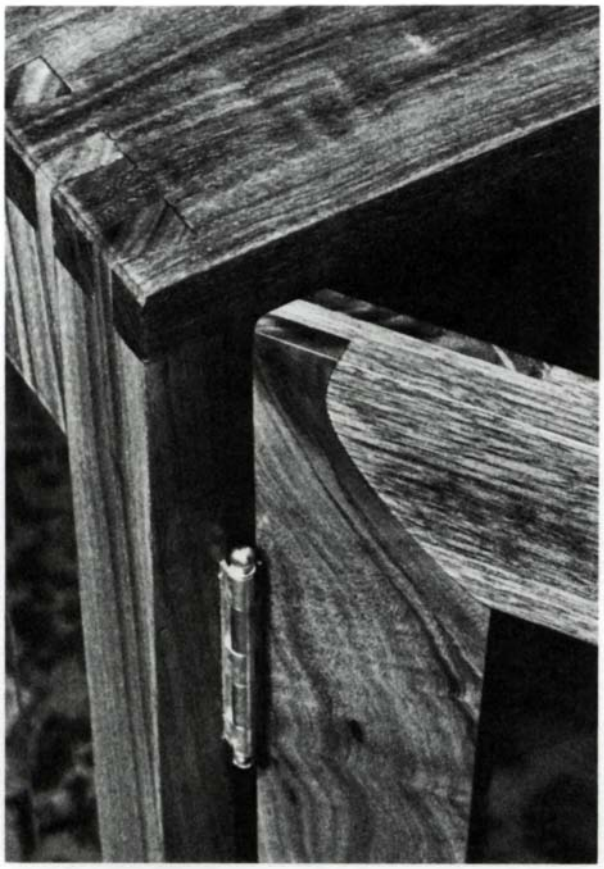


Facing shoulders of joint are contoured; rear shoulders remain square. This compensates for the loss of mechanical strength that comes from reducing the gluing surface on the front cheek of the tenon. To prepare the stock, dimension frame members and cut to length. Slot the ends of the stiles as though making an ordinary slip joint; then cut a tenon cheek on the rear face of each rail, but don't remove any stock from the front faces, as these will be routed to produce the curved shoulder shown.



Reverse curve defines joining shoulders of rail and stile, left. A variation of the technique can produce a curved half-lap joint, right.

Photos: Charles Turner



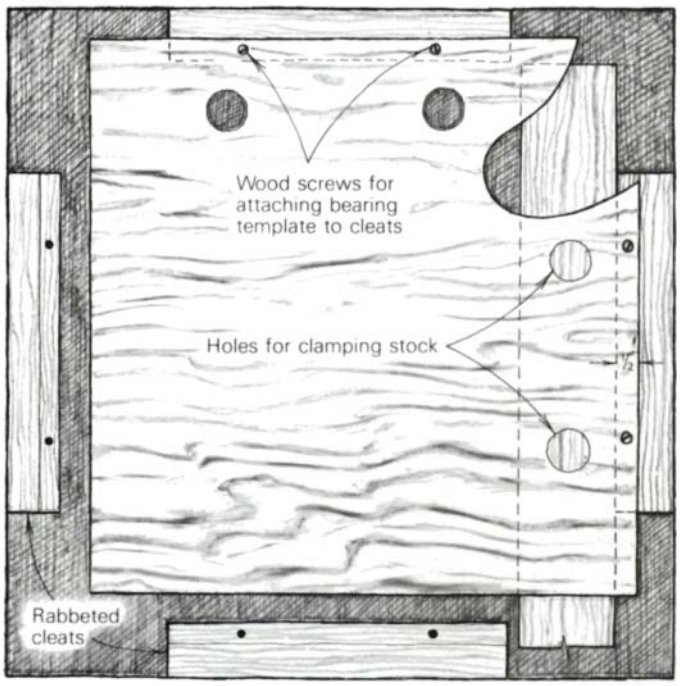
The door on this cabinet shows how contoured joinery can be used to advantage. The wood has been carefully selected so the grain conforms to the curvature of the joint, which repeats the gentle curve made by the bottom sides of the cabinet. The two bottom joints of the door frame have been cut square, complementing the upper corners of the case.

Making the fixture—This part of the system consists of a plywood base and four rabbeted cleats as in the drawing at left. Its job is to hold the rails and stiles and to support the bearing template. The base should be made from a piece of ¾-in. plywood about 15 in. to 24 in. square, a suitable size for joining the frames of cabinet doors. The cleats should be cut from stock whose thickness equals the thickness of the frames plus the thickness of the bearing template, usually ½ in. If you're joining ¾-in. thick frame members, the cleats must be 1¼ in. square, rabbeted to an exact depth of ½ in. and to a width of about ½ in.

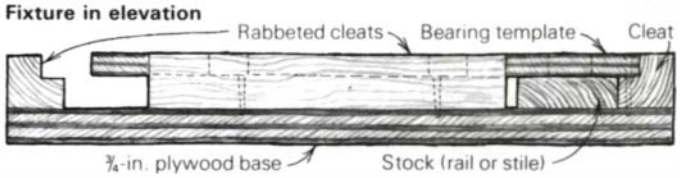
To set up the fixture, position the cleats, rabbets in and up, on the edges of the square base; use a true framing square to orient the cleats at precisely 90° to one another (other angles are possible), and screw them to the base with countersunk wood screws. The cleats should not meet at the corners; you have to space them far enough apart so your stock will slide easily through the gap.

The guide bushings—Most routers are designed to accept standard guide bushings generally available as accessories. With a ½-in. bit, use a ⅝-in. O.D. bushing with your router, but any bushing of this general size will do. Because the bushing bears against the curved template when making a cut, and because you're cutting complementary curves using the same bearing template, the line of the cut must be offset from the curvature of the template, and two bushings are required—a large-diameter one for making the cut on the rail,

Fixture **Plan view showing bearing template screwed in place**



Fixture in elevation



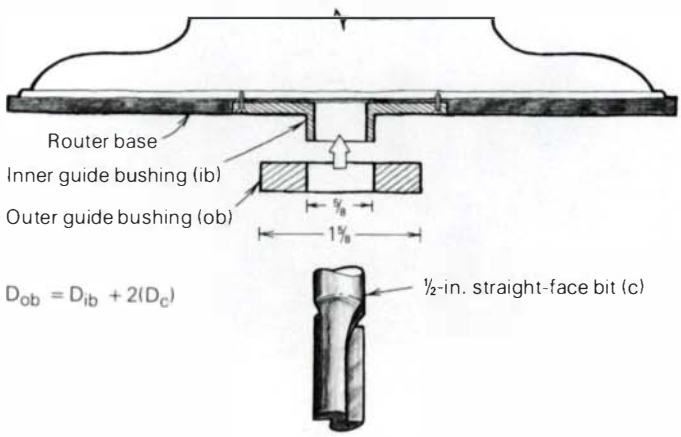
and a small-diameter one for cutting the stile (as is the case with the examples here).

Purchase two ⅜-in. guides from the manufacturer; one will serve permanently to hold the outer bushing (epoxied to it), the other as the inner guide bushing. The outer bushing should be turned from brass or aluminum. It is necessary to observe the following mathematical relationship between the diameter of the cutter (D_c), the O.D. of the inner guide bushing (D_{ib}) and the O.D. of the outer guide bushing (D_{ob}): $D_{ob} = D_{ib} + 2(D_c)$.

The bearing template—This step involves making three separate templates: one that exactly duplicates the curved line of the joint, another whose profile is offset from this curve and parallel to it, which serves as a pattern for the third tem-

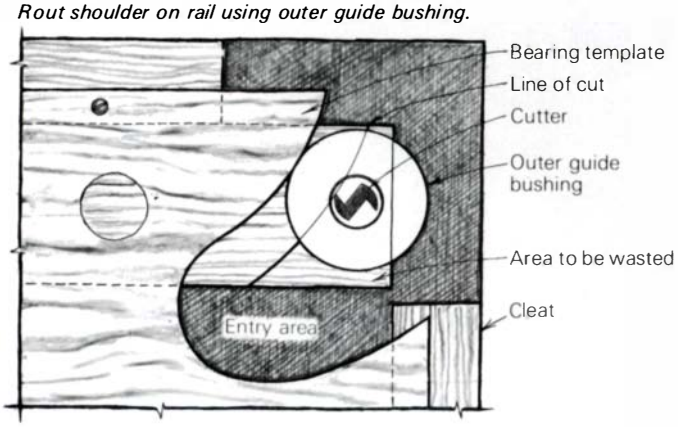
Guide bushings

Section through router base and bushings

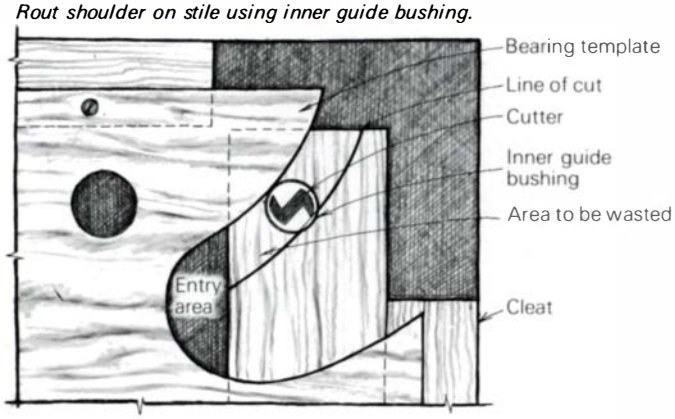


Guide bushings in use

Rout shoulder on rail using outer guide bushing.

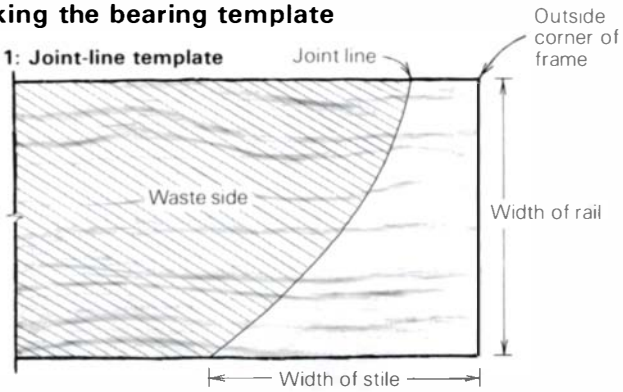


Rout shoulder on stile using inner guide bushing.

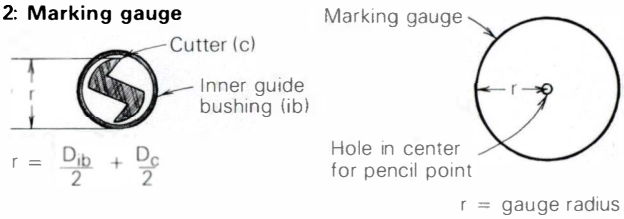


Making the bearing template

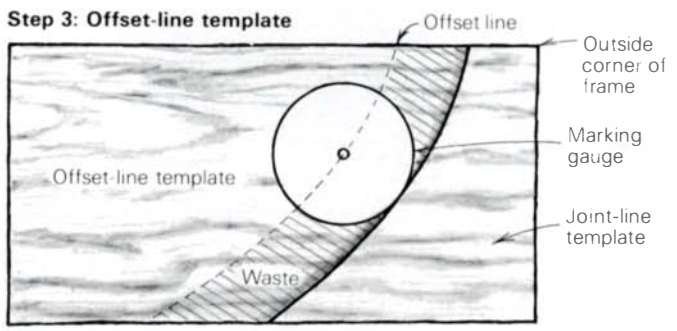
Step 1: Joint-line template



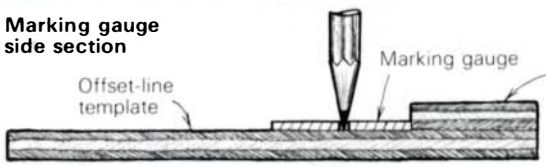
Step 2: Marking gauge



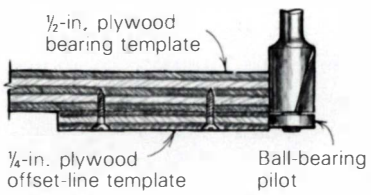
Step 3: Offset-line template



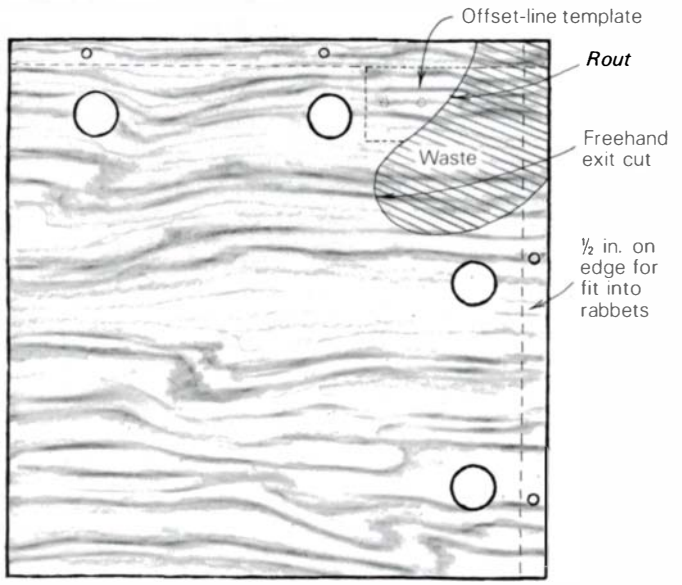
Marking gauge side section



Step 4: Bearing template



Screw offset-line template to bottom of bearing template to guide router-bit pilot during cut to produce a smooth, precisely vertical edge.



plate, the bearing template itself. After composing the curve of the joint on paper, taking into account the width of the rails and stiles, transfer the line to a piece of ¼-in. plywood; then cut along this line with a band saw or jigsaw and smooth the contoured edge with a file. This becomes the joint-line template (step 1 in the drawing at left).

The next thing to do is to make a marking gauge that will allow you to scribe a line on a second template parallel to the curve of the joint-line template. The gauge is made from a plastic disc with a hole in the center for a pencil point, as in step 2. The distance from the outside of the gauge to the pencil point equals the distance from the cutting circle of the router bit to the opposite outside edge of the inner guide bushing (*r*), which also defines the smallest possible radius of curvature in the joint.

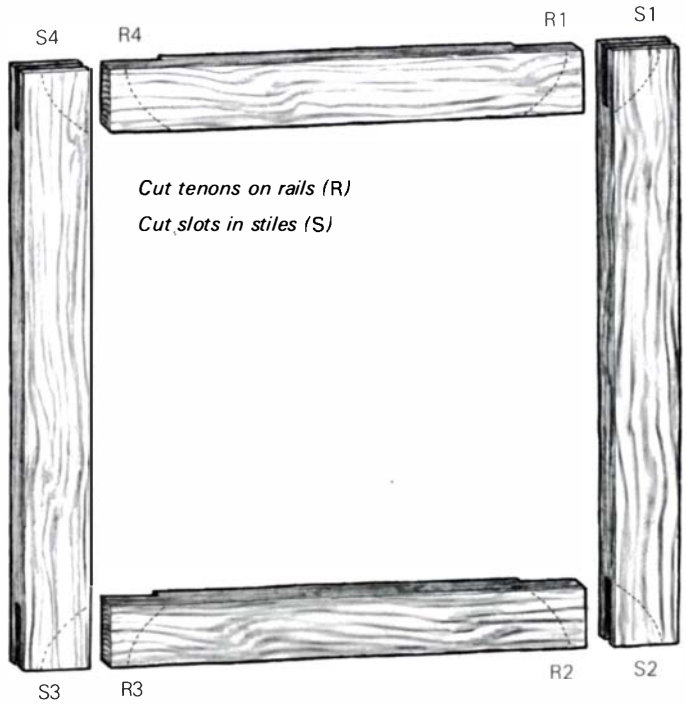
Cut along this offset line and smooth the sawn edge with a file. For the bearing template itself, dimension a piece of ½-in. plywood so that it is slightly smaller than the inner dimensions of your fixture and so its corners are absolutely square. On two adjacent sides, scribe lines that are exactly ½ in. in from the edge and parallel to it. These lines mark the boundary defined by the inner edges of the cleats on the bottom of the bearing template. Now position the offset-line template as shown in step 3 and screw it to the bottom of the bearing template. It should abut one of the cleat lines and be positioned out from the joint line (drawn on the bearing template) with the help of the marking gauge. Using a straight-face flush cutter with its pilot bearing against the offset-line template, cut the curve in the bearing template (step 4). It may seem like a lot of trouble to make one template just to cut another, but only by routing the curve on the bearing template can you get walls that are smooth and perpendicular to both faces.

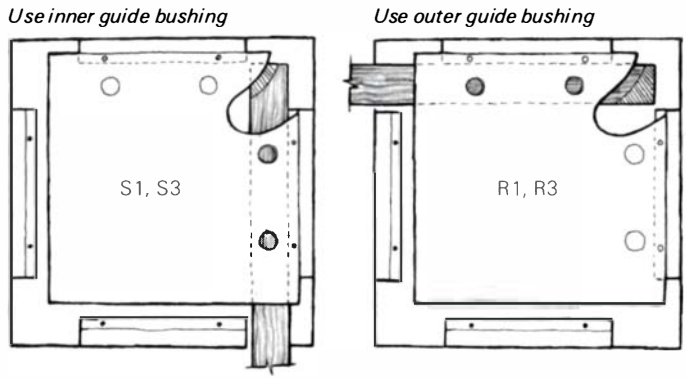
Next bore four 1¼-in. diameter holes in the bearing template; these permit you to clamp the rails and stiles into place for routing. Also bore four pilot holes for wood screws on the template's edges and countersink them on both sides—top and bottom. This completes work on the fixture and bearing template.

Routing the joints—After preparing the stock, place the frame members in their respective positions and mark each end as shown in the drawing at right so you can orient them properly in the fixture. With the bearing template screwed into position, clamp one of the stile ends (S1) into place so it is flush against the inside cleat and so the end-grain edge is lined up with the inside edge of the top cleat. Attach the inner guide bushing to the router, and set the bit to a depth that equals the thickness of the cheeks of the mortise on the stiles. Insert the bit and bushing into the entry area and rout towards the corner, holding the bushing firmly against the bearing template. Make only a single, careful pass when routing the shoulders on the stiles. Now rout the opposite end of the other stile (S3).

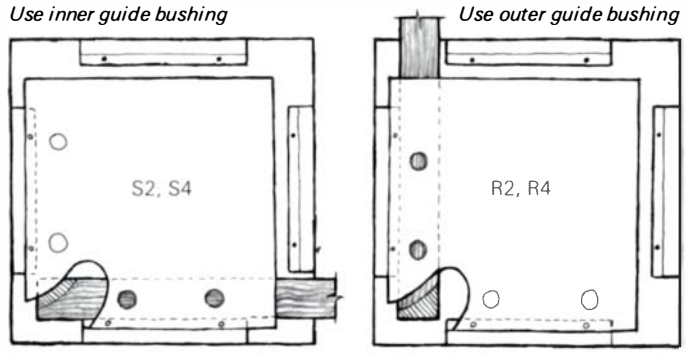
Remove the inner bushing and attach the outer bushing. Insert one of the rail ends (R1) into the fixture so it is flush against the top cleat and its end-grain edge is in line with the inside edge of the right-hand cleat. Rout the tenon on the rail, first wasting most of the stock and finally making one decisive pass with the bushing pressed firmly against the curve of the bearing template. Now rout the tenon on the opposite end of the other rail (R3).

Positioning of stock for routing sequence





Flip bearing template diagonally.



At this point you've cut half the joints for one frame, and they are diagonally opposed to one another. To cut the other pair of joints, you will have to flip the bearing template and screw it in place on the opposite corner of the fixture. Then repeat the entire process described above, now for S2, S4, R2, R4. On the back side of the frame the joints are left square, which increases the strength of the joint. When you're done, all four joints should fit snugly, and their curves should match up without a flaw. □

Ben Davies, 35, owns and operates Muntin Woodworks in Chattanooga, Tenn., where he designs and builds furniture and doors.