



# Making Full-Sized Doors

*Combining machine and handwork makes a tightly coped joint where rail meets stile*

by Joseph Beals

**M**aking full-sized doors is a fine job for a small shop. The design for frame-and-panel doors offers an opportunity to draw from a broad spectrum of traditional styles. One of the most important design questions concerns something you can't even see when the door is finished—the joinery that holds it together. To hold up over time, the frame must be joined with full mortise-and-tenon joinery or with dowels. I've made more than two dozen doors for local contractors using dowels, and I have decided that it's a demanding, tedious and unforgiving method.

When I found time to build several doors for my own house, I devised a method that combines simple machine work and traditional mortise-and-tenon construction. The joints are strong, and they can be fitted and tuned before final assembly, a convenience that doweling does not offer. You can cut the joints in a number of ways that don't require expensive tools or machinery. I use a shaper to cut the pattern molding on the inside edges of the rails and stiles, but you could also cut it with a router, tablesaw molding head or even by hand with a molding plane.

## Lay out the joints with scraps

Rip and joint all the frame stock to the finished width. Leave all the pieces several inches long for the initial pattern shaping to allow for snipe and to dress off any bad ends. At the same time, mill several test pieces for laying out the molding, the panel groove and the joints. These test pieces can be the same width as the stiles, and



*A passage door built to last—The author always dry-fits a door before final assembly (facing page) and fine-tunes the joints as required. The finished door (above) is well-suited for the site, a 150-year-old house in New England,*

the pieces should be at least a foot long for convenience and safety.

With the first test piece, set up the pattern molding and panel groove. Install a single standard pattern cutter on the shaper to make the molding. I use a single cutter as a simple profiling tool, so it's not restricted to a particular door thickness. And I mill the pattern molding on one edge of the test

piece at a time, making a separate pass for each side. If the pattern looks good, I plow the panel groove with my shaper. You could also cut the groove with a dado blade on the tablesaw. The first pass removes the bulk of the waste; a second pass made with the stock turned over will ensure a perfectly centered groove.

The depth of the panel groove must match the depth of the pattern molding (see the top drawing on p. 60). The width of the panel groove will define the thickness of the tenons, about  $\frac{5}{8}$  in. for a  $1\frac{3}{4}$ -in.-thick exterior door and  $\frac{3}{8}$  in. for a  $1\frac{1}{8}$ -in.-thick interior door. The exact width can be fine-tuned to work with the pattern molding and can be adjusted as needed.

## Lay out the mortises with a pencil—

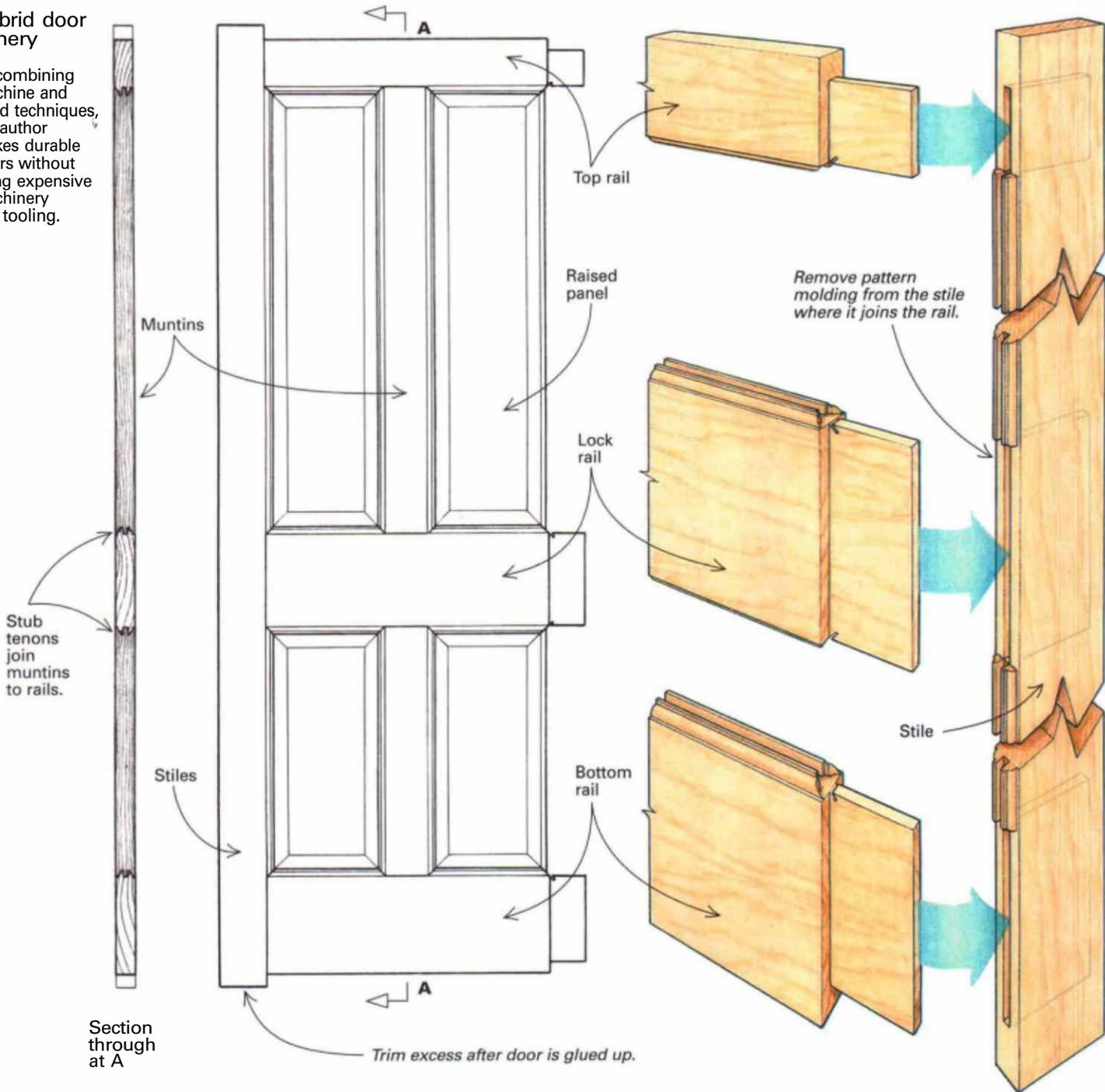
Use the first test piece, with the pattern-and-groove cut, as a guide for marking the stiles. Clamp the two stiles together, face to face (see the bottom drawing on p. 60), and define the two up edges as the inside edges. Mark the top and bottom of the door, leaving an equal amount of excess length at each end. Mark where each of the three rails intersects the stiles.

Within these three pairs of marks, lay out the bottom of the panel grooves, as measured off the test piece. That mark will show you where to cut the mortises. Finally, mark 1 in. inward from the top and bottom of the door to define where top and bottom rail mortises will end.

**Cut the mortises before shaping the frame pieces—**Cut all the mortises with a drill press and hand chisels before doing

## Hybrid door joinery

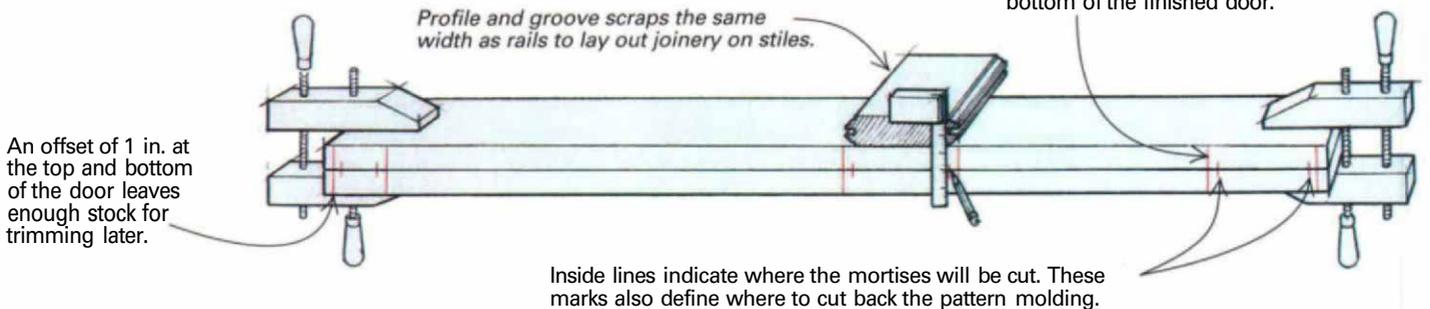
By combining machine and hand techniques, the author makes durable doors without using expensive machinery and tooling.



## Marking the mortises

Stiles, ripped and jointed to width, are left long and trimmed after the door has been assembled. Pencil marks provide easy guidelines to follow in cutting the joinery.

Outside lines indicate the location of all three rails, and they define the top and bottom of the finished door.



any more work on the stiles. Using the test piece as a guide, set up the drill press by centering a regular twist bit in the panel groove. It's important to use a fence or a clamp, like the one shown in the photo at right, to register the stiles so that the bit cuts consistently at the center of the mortise. Set the depth ½ in. or so short of the outside edge of the stile to leave enough material to trim the door to width.

A twist bit equal in diameter to the width of the panel groove is ideal for drilling out the mortises. A smaller bit will serve the purpose, but you will have more hand-work when cleaning out the mortises. Avoid using spade augers: They can wander and produce an oversized or eccentric hole. Drill all the holes for the mortises, but wait until after you have cut the panel grooves to clean them up with chisels.

***Muntins can be fit to the frame one of two ways***—Before machining the panel grooves and pattern molding, you'll need to choose the style of joint between the two muntins at the center of the door and the rails. I use my door-making cope-and-pattern cutter set. This joint is not structural, and the stub tenon that fits into the panel groove in the rails is quite adequate. If you don't have a cutter set or if you would prefer to make full mortise-and-tenon joints, you can cut mortises in the rails just as you did in the stiles. The mortises can be shallower—1 in. or so would be plenty deep.

If you machine-cope the muntins, determine their length by measuring from panel groove to panel groove between the rails. You can take their length right off the marked stiles. Set up the coping cutter by using the test piece as a reference, and cope one end of another test piece to check the fit. When all is well, cope the muntin ends. Some splintering is normal on the exit side of the cut, but it will disappear when you shape the pattern molding.

### **Clean out the mortises, and shape the moldings**

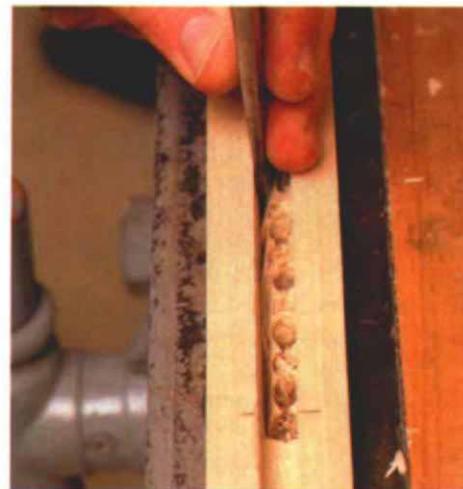
At this point, you can machine the pattern moldings and the panel grooves on the inside edges of the stiles, the top and bottom rails, both edges of the muntins and the lock rail. It makes no difference which shape you cut first, unless you are concerned about protecting the pattern molding when you clean out the mortises in the stiles. If so, cut the panel groove first, clean out the mortises as described below and machine the pattern molding afterward.



***Mortising the stiles***—The author uses his drill press with a twist bit to remove most of the stock. You could also use a router, a mortiser or chop out the waste by hand.

***Sharp chisels make a difference***—Lay the stiles on a flat surface, such as a good bench or a machine table, and clean the mortises with a wide chisel honed to a very keen edge. Pare the mortise sides dead flush with the sides of the panel groove (see the photo at right). I use a mortising chisel to clean out the bottom of the mortises and to square the ends. You could leave the ends round from the drill bit, and round over the tenons to fit.

***Remove the pattern molding from the stile***—The tenon shoulders of the rails seat on the common bottom of the pattern molding and panel groove on the stiles. To make the seat, you need to remove the pattern molding on the stiles between the ends of the mortises for all three rails. You can cut the pattern molding down with a back-



***Cleaning out the mortise***—After drilling mortises, the author cuts the panel grooves on his shaper. The grooves provide a good reference for paring the mortises with a chisel.



*A dado blade on a radial-arm saw works well for cutting back the pattern molding on the stiles and for making the tenons on the ends of the rails. The author cuts to precisely marked lines and uses stop blocks for repetitive tasks.*

saw and pare off the waste with a chisel, or you can use a dado blade on a tablesaw or radial-arm saw, I prefer the radial-arm saw for this task because it's quick and accurate, once you've spent the time setting up the cut with scraps.

### **Mark the rail tenons directly from the mortises**

After all the stiles have been mortised and the pattern molding cut back to receive the rails, mark the rails for length, and cut the tenons. Lay the stiles on a table or a set of sawhorses, spaced apart the exact width of the finished door. Lay the rails across the stiles. If the rails have been mortised to receive hand-coped muntins, make sure these mortises are dead center between the stiles. Mark the location of all tenon shoulders directly off the joint seats, as described previously. At the same time, mark the ends of the rails for tenon length— $\frac{1}{4}$  in. or so short of the bottom of the mortise.



That clearance provides space for excess glue and debris and ensures that the joint will draw up tightly.

For uniform accuracy when cutting the tenons, I use the radial-arm saw with a stop block against the fence (see the bottom photo). Always check the setup with a test piece. The tenon, as it comes from the saw, should fit the mortise snugly. If it slides home easily, it's too loose.

Because the top and bottom rail mortises stop 1 in. from the actual top and bottom of the door, you must remove this excess from the tenons. Cut down the shoulder with a backsaw, and saw off the waste or split it off with a chisel. Dress the tenons with a rabbet plane, and chamfer the ends to ease the tenon's entry into the mortise.

**Cope the pattern molding on the rails**—This final step in making the joints—coping the rails—looks like a difficult, exacting job. But as the four photos on the

facing page show, it's rather simple, and it gives a very satisfying result. Pattern moldings on both rail and stile could also be mitered, but that is not a good option. A mitered joint between the pieces of a door frame is difficult to fit precisely, and any movement of the rails will spoil it.

To cope the pattern molding, first cut a miter on the ends of the rails (and the muntins, if applicable) with a tablesaw. The end of the pattern molding is the exact end of the miter. I use a block against the table-saw fence as a convenient stop. If the muntin ends are to be mitered for a hand-coped joint, you will have to reset the fence for the shorter tenons.

As the photos on the facing page show, start coping the joint by darkening the miter profile with a pencil to show the line clearly. A chisel and an in-cannel gouge complete the job (undercutting the cope slightly ensures a tight joint).

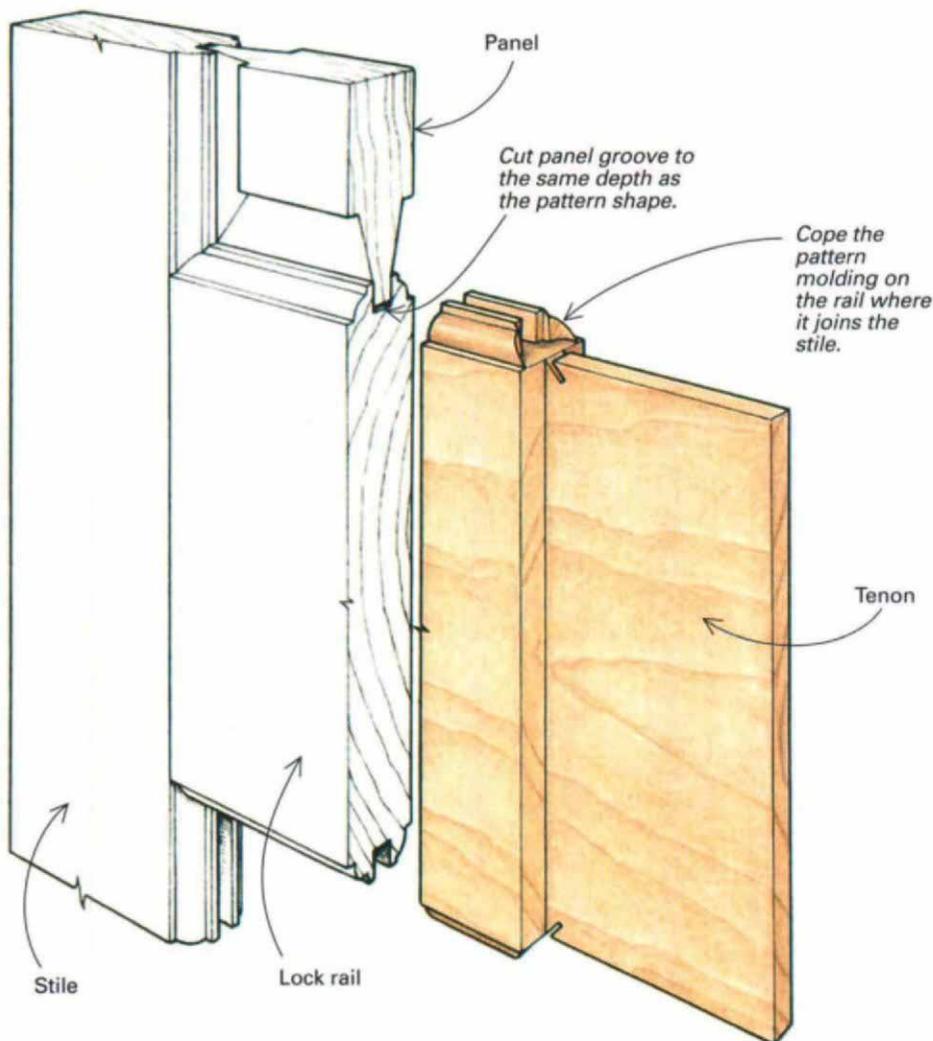
### **Dry-fit the door frame before assembly**

With this type of construction, you can test the door frame before assembly. I fit all the joints individually, and mark all the pieces, shaving the tenons, mortises or both for a smooth fit with just a little resistance. Then I dry-assemble the frame.

Because the muntins are trapped between the rails, all three of which are fit into their own mortises in the stiles, any discrepancy in muntin length will be instantly apparent. Muntins that are too long will prevent the frame from coming together. The obvious cure is to shorten them as necessary. If muntins are too short, the problem can be corrected by shifting the top or bottom rail toward the lock rail. You can do this by removing stock from the tenons at the inside edge of the rails and trimming the pattern molding on the stile by the same amount. This will allow the rail to slide toward the lock rail, tightening the loose muntin. If shifting the top or bottom rail locations makes the door too small for the opening, you'll just have to bite the bullet and make new muntins.

**Check that the frame is flat**—When the frame is fully assembled and all the joints are tight, clamp lightly across the rails to simulate the pressure applied when the final assembly takes place. The large shoulders on the rails will square up the frame, but they are not proof against twisting. You can correct twist by shaving the tenons or paring the insides of mortises on diagonal-

## Coping the pattern molding



ly opposite joints until the clamped frame lies dead flat. Such a small amount of stock is removed that fit isn't compromised.

Take panel dimensions off the assembled door frame, with appropriate allowances for panel movement. There are several ways to make panels (*FWW* #94, p. 65). One design option I like is to make panels that are raised on both sides. They can be solid or made from a pair of panels placed back to back, which is especially useful for exterior doors. Panels can be machined to fit the groove snugly, inhibiting water entry, and the inside and outside surfaces can move independently.

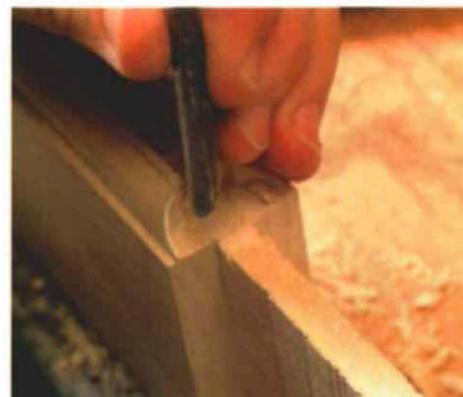
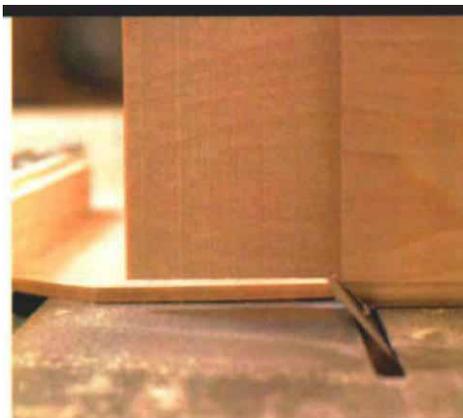
### Use epoxy for the final assembly

Mortise-and-tenon door joints are traditionally fastened by pins or wedges, but for exterior doors, epoxy is a superior alternative. I use West System epoxy together with a thickening additive (available from Geogon Brothers, Inc., 706 Martin St., Bay

City, MI 48706; 517-684-7286). Epoxy is strong, waterproof, gap-filling and creeps only slightly under load. West System epoxy has a very long shelf life and mixes easily using metered dispensing pumps. Unlike aliphatic resin glues, epoxy has no initial grab. In fact, its lubricity is a great convenience when drawing together the large multiple joints in a full-sized door. Since I started using epoxy, I dumped my plastic resin and resorcinol glues in the bin.

Assemble the door by making a tree of the rails and muntins, slip the panels in place, apply glue to the mortises and tenons, and draw both stiles home simultaneously. Clamp lightly, check for twist and make any corrections by fine-tuning opposing pressure on the clamps. Check the pattern molding at the coped joints, and remove glue squeeze-out. □

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**Coping the rails**—To define the shape of the cope, the author starts by mitering the rail of the pattern molding on the tablesaw. He uses a stop block off the fence as an index. The pencil mark along the edge helps to highlight where the cope will be cut. The curved part of the cope is cut with an in-cannel gouge. All flat surfaces are cut with a paring chisel.