

Tenoning Strategies



HAND TOOLS



BANDSAW



TABLESAW



ROUTER

Finding your way to a well-fitting joint

BY GARY ROGOWSKI

The mortise-and-tenon joint might be the most relied-upon joint in furniture making. After all, a well-fitted tenon can mean the difference between a sturdy table and an embarrassingly wobbly project. Cutting tenons can be approached from a dozen different directions, and the approach you take depends on your tools and how you like to use them. Some folks love the precision and power of their saw or router; others prefer the more contemplative *whoosh* of a backsaw and handplane. The method you choose will determine your speed and the risk factor.

A tenon should fit tightly in a mortise—snug, like a good shoe put on with a shoehorn—not like a ragged old sneaker that you can flip off and across the room as you're sitting down. Regardless of the cutting method you choose, aim for a joint that is loose enough to put together by hand but tight enough that it takes a few mallet taps to get it apart. Leave room for a little bit of glue in the joint, and always cut tenons just shy of the depth of the mortise so there's a gap at the bottom of the joint for excess glue.

Remember that accuracy comes from the patient hands of the builder and that precise joinery depends upon accurate millwork. If your millwork is sloppy—if your stock cups, warps or doesn't have parallel faces—you'll have trouble cutting accurate tenons, no matter what method you choose.

Also, I never cut mortises or tenons without first planning ahead on paper, even if it's just a quick sketch. It's better to risk a few simple eraser smudges on paper than to waste precious wood. A sketch will help you locate the joint for the most strength and best look. For strength, a tenon should be at least one-third the thickness of the stock to ensure there is enough material to support the joint.

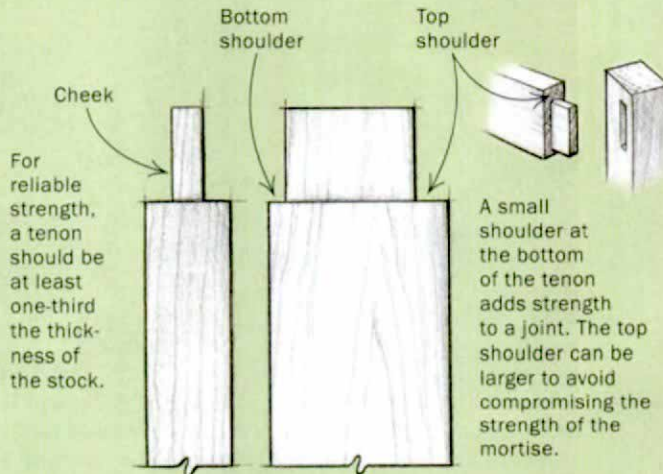
Cutting tenons by hand

In these days of machines, it may seem a waste of time to cut a tenon by hand, but if you have only a few tenons to cut, you may be surprised by how much set-up time you can waste with some machines. When I have to cut only a few simple joints, I'll often reach for a backsaw and a shoulder plane.

Hand-cut tenons require careful setup and layout (see the photos on p. 62). Your method may involve using a marking gauge and square, a mortising gauge or a pencil and square. But whatever your method, be consistent with your approach and always be dead-on accurate. Even if you are using machines to cut tenons,

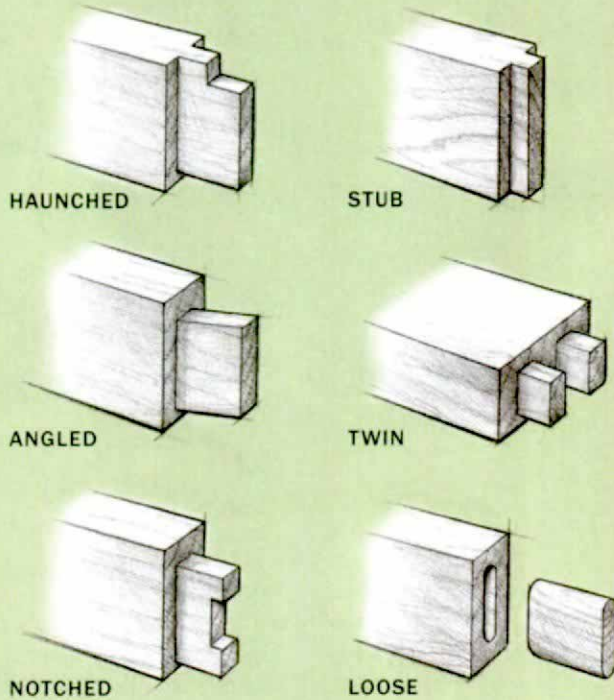
THE BASIC TENON

If it takes more than hand pressure or a few light taps with a mallet, the fit of the tenon is too tight. And if there's too much slop, you're expecting too much of the glue you use. To ensure that the glue adheres well, make sure all faces are clean and smooth. Cut tenons just shy of the mortise depth to allow for excess glue.



A TOUR OF TENONS

Whether you're building a chair or a desk or fitting together a frame-and-panel door, chances are there's a tenon designed to solve your joinery problems.



the same guidelines for marking out hold true.

Use a marking gauge to mark the length of the tenon across its shoulders. Then establish the thickness of the joint by marking out the position and thickness of the tenon. If you cut a 1/2-in.-thick mortise in the center of a door stile, for example, lay out a 1/2-in.-thick tenon centered in the thickness of the door rail. Offset or unequal shoulders become necessary when two tenons meet inside a leg.

A marking gauge will lay out the cheeks of the tenon, but by running a mortise gauge along the face side of the joint, you can mark out both cheeks at once. Use the mortise to set the cutters on the gauge, then mark across the top and sides of the tenon. After cutting the tenon cheeks and shoulders, lay out the width of the tenon and any haunch that is required (if you do this before cutting the cheeks and shoulders, the lines will be removed by the cheek cuts).

Use a backsaw to establish the shoulders. You want to cut right down to the cheek lines, but be careful not to saw past these marks.

Next, cut the faces of the cheeks. Placing the work in a vise allows you to see both the top gauge line and the cheek line nearest you. For a short tenon, cut straight down these lines until you reach the shoulder. For a longer tenon, angle the workpiece so that you can easily see the cheek lines. Cut down to the shoulder line on one side, then flip the piece around in the vise so that you can see the other cheek line as

you cut down to it. Follow the cheek lines as you cut out the remaining wood in the middle of the tenon.

Cut one cheek of the tenon and clean it up with a bullnose or rabbet plane. Then move on to the second cheek and, if necessary, adjust its size before cutting. Or, if caution suits you, cut both cheeks a bit wide and then plane to fit. Once the thickness of the tenon has been fine-tuned with a rabbet or bullnose plane, use

FOR A FEW SIMPLE JOINTS, CUT TENONS BY HAND

If you're cutting only a few small tenons, it can be faster (and quieter) to cut them by hand rather than to set up machines. No matter what method you use, careful layout is key.



Marking out. A pass with a marking gauge (left) lays out the depth of the tenon on all four sides; a mortise gauge marks the cheeks (above).



Backsaw to the line. To cut both the shoulder and the cheek, first saw at an angle on each side (above left), then follow the kerf down the middle until the cut bottoms out (above right).

Trimming for fit.

After a hacksaw cuts the top and bottom shoulders of the tenon, a bullnose plane is used to clean up the cheeks (near right). A little handwork with a chisel trims the shoulder for a tight fit (far right).



the same methods to cut any haunches or other shoulders. Then grab a chisel and a plane to help you fit the tenon exactly to the mortise, trimming only a little at a time and test-fitting frequently.

Cutting tenons by hand doesn't take as long as you might think, and it is a great way to improve your hand-tool skills. Even as you turn to machines for efficiency, you'll find that it is often easiest to do the final fitting and cleanup with a chisel and plane.

Using the radial-arm saw and handsaw to cut tenons

The radial-arm saw probably crosscuts more efficiently than any other machine, and the bandsaw rips better than any tool in my shop. You can take advantage of both features to save time cutting tenons (see Method 1 on the facing page). If you have a few tenons

to cut, use a pencil to mark out one tenon shoulder and cheek. Set a stop for the shoulder cut on the radial-arm saw table or fence. Adjust the depth of cut on the radial-arm saw and cut all of the shoulders to the proper depth.

Move to the bandsaw for the cheek cuts, and be sure to use a blade that suits your material. A 4-tpi (teeth per inch) blade works fine for most tenon cuts. But if you're cutting tenons in something hard like oak or mushy like green cedar, use a 3-tpi blade, which will push chips away and allow you to get through the cut more easily. On especially narrow tenons, a 6-tpi blade will work fine.

The bandsaw fence helps guide the cheek cuts. Set the fence so that the waste falls off harmlessly to the side instead of becoming trapped between the blade and fence. To play it safe you can

clamp a stop onto the fence so that your cut ends before the blade runs into the shoulder. But with the shoulder cuts already established on the radial-arm saw, you should be able to stop when you push through the cut. If you don't have a fence, clamp a block of wood to the table at the proper distance to serve as a fence, or simply pencil-mark your cheeks and freehand the cut. Once you check for blade drift, angle your fence to match the drift angle. There still will be a little cleanup to do with a chisel and plane, but the bandsaw can get you pretty close.

When you use this method, you can move the bandsaw fence over and cut the top and bottom of the tenon and any haunches. Then clean them up with a chisel.

Cutting tenons using a tablesaw

By using various blade setups and jigs, there are several ways to cut tenons on the tablesaw. When choosing a method, consider

speed, safety and accuracy—and make sure that the blades and jigs you use are running true.

A dado-blade setup for quick work—The fastest way to cut tenons using a tablesaw is with a dado blade (see Method 2 below). Set to the proper height, a dado blade will cut your cheeks and shoulders while you hold the stock flat on the saw table. Be careful while using a wide dado setup on the tablesaw, because these blades can take a big bite out of your board. Move slowly through the cut, and keep the board flat on the saw table.

Set up the blade for any reasonable width—it's really not that important. Crucial here are the height of the dado blade and how flat-bottomed a cut it makes. Take some practice cuts in scrap and set the blade height just under what you think you need. That way, there's just a little wood to remove for cleanup. Use a miter gauge with a long fence to push the board through the blade. If needed,

THREE WAYS TO CUT TENONS USING POWER SAWS

With proper setup, almost any machine can cut tenons reliably. To achieve smooth joints and efficient working times, sometimes you have to use a combination of machines.

Method 1 CUTTING TENONS ON THE RADIAL-ARM SAW AND BANDSAW

Radial-arm saw establishes a shoulder kerf.

The saw is set to the correct depth, and a stop block is clamped to the saw table. A single pass cuts a kerf on the tenon shoulder.



A bandsaw trims the cheek. With the fence set in place, a quick pass cuts to the shoulder line. After adjusting the fence, another cut establishes the top and bottom of the tenon. A backsaw and chisel are used to clean up the shoulders.

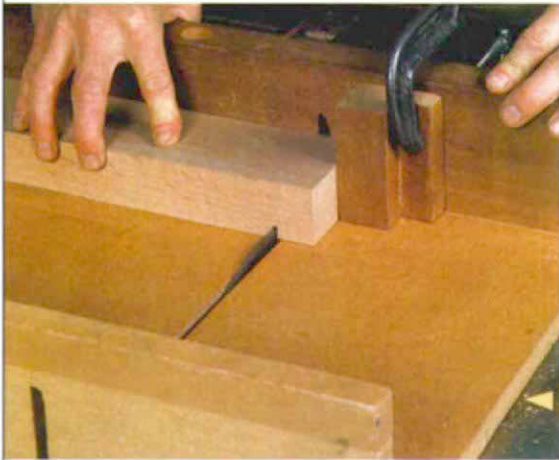
Method 2 CUTTING TENONS ON THE TABLESAW



A dado blade hogs off the waste.

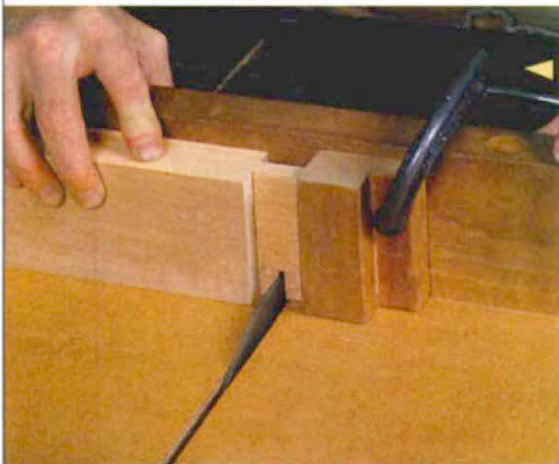
A stop block clamped to the fence sets the depth of the tenon while a miter gauge holds it square. Just a few passes over a dado blade cuts the tenon cheeks and shoulders. The same setup with the stock held vertically cuts the top and bottom of the tenon.

Method 3 CUTTING TENONS VERTICALLY

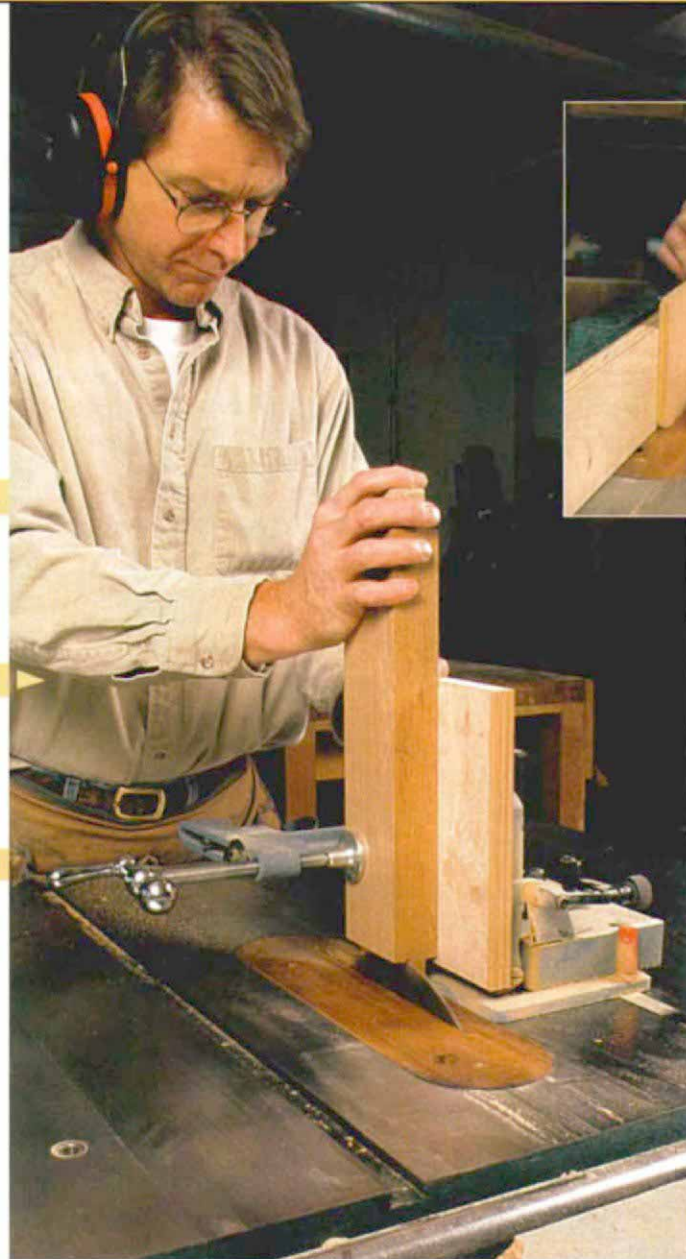


1

Making the shoulder cut. With a stop block clamped in place, a quick pass with a crosscut sled cuts the tenon shoulders (1). After a bandsaw hogs off the cheek waste, a tenoning jig—shopmade or aftermarket—holds the stock vertically to fine-tune the cut (2). Another pass with the crosscut jig cuts the top and bottom shoulder and any haunch (3).



3



Store-bought or shopmade. Aftermarket jigs, like the Delta at left, ride along the miter-gauge slot and secure the board vertically for tenoning, but the author often uses a simple shopmade jig (inset). The shopmade version is nothing more than a piece of plywood with a backer board screwed in place at a right angle.

you can mount an auxiliary fence on the miter gauge for better support. Clamp a stop on the fence to locate the shoulder cuts.

Make the passes for one side of all of the boards first. If your blade cuts well, you'll need to clean these cheeks very little; but if your blade cuts like my dado blade, you'll have to take some time to plane the cheeks smooth. Then move to the second cheek cut and set the blade height for just under what you'll need.

After the tenon has been cut to its correct thickness, you can also use the same dado setup to cut a haunch or to establish the top and bottom shoulders of the tenon. Reset the blade height, rotate the stock in the miter gauge and cut to fit. Approach these cuts carefully to make sure the shoulders line up.

Tenons cut vertically—Because switching to a dado-blade setup takes some time, it doesn't always make sense for small jobs. The

method I've used most often calls for a combination blade on the tablesaw (see Method 3 above). I cut the shoulders with a crosscut jig, rough-cut the cheeks on the bandsaw, then trim the tenons to fit perfectly by holding them vertically on the tablesaw and passing them through the blade using a shopmade tenoning jig.

Cutting the shoulders on a crosscut jig ensures accuracy from one tenon to the next. Set a stop on the jig fence closest to the shoulder. That way, if any dust gets stuck between the stop and the board, it pushes you away from the blade, not into it. (This problem can be remedied easily with another pass.) Next, rough out the tenons on the bandsaw. Everyone cuts a tenon undersized at some time or another. If you make this mistake, simply glue the perfectly matched offcut back on.

Make the cheek cut next with a shopmade tenoning jig. The jig I made is simply a piece of 1/2-in.-thick plywood with a stout right-

angle fence screwed to it. The tenoning jig holds the workpiece vertically as I pass it through the blade. It probably took me five minutes to make the jig, and I've used the same one for years. Just make sure you keep the screws high enough in the fence that there's no risk of ever running them into the sawblade. Set the blade height so that it cuts just under the shoulder cut. Keep the board tight against the fence and jig either by hand or with a clamp, and make sure you don't tip the piece; otherwise, the tenon will have a taper cut into it.

Cut one cheek and check its placement by holding the cheek of the tenon against the face of the mortised piece. If the rail and stile are designed to be flush, you can see how close your first cut has come. If the mortise wall lines up with the face of the tenoned piece, you know your first cheek cut is perfectly placed. Then flip the board around and cut the cheek on the other side. If the tenon doesn't quite line up, you can also determine how much more you need to trim off the tenon cheek. If it covers the mortise wall so

you can't see it all, you'll need to glue on one of those tenon off-cuts from the bandsaw.

You can also use an aftermarket tenoning jig to make and fine-tune tenon cuts. It works the same way as my shopmade jig, but this metal jig has a screw-adjust system for very fine adjustments. It also locks the tenon stock in place for a safer cut. Just make sure there's no slop in the fit of this jig to your tablesaw slot.

You can cut haunches for tenons very simply with a single blade on the tablesaw. Clamp a stop on the crosscut-sled fence to locate the cut, and set the blade height for the proper depth of cut. Go back to the bandsaw to trim the haunch until it just fits inside the mouth of the mortise. On a smaller tenon, you can use the tenoning jig to make this pass.

Cutting tenons using a router table

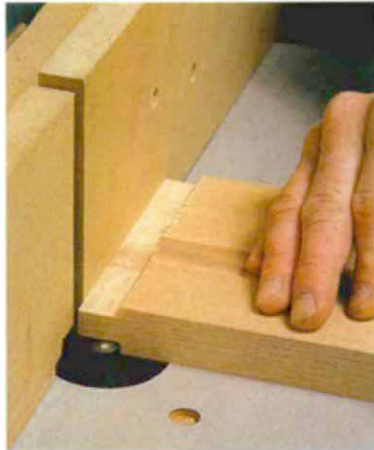
Given the proper amount of patience and set-up time, tenons can be cut successfully using a router table, and this setup really comes

THREE WAYS TO CUT TENONS USING A ROUTER

Whether you're cutting wide tenons or multiples of smaller tenons, a router leaves smooth faces that come off the machine ready for glue-up.

Method 1 ROUTER-TABLE TENONS

Ganging up on the router table. A router table allows you to gang up two or more boards, making fast work of cutting uniform tenons (near right). If the mortises are cut with a router as well, the author uses chisels and files to round the tenon (middle), checking his progress with a template routed to match the top and bottom of the mortise (far right).



Method 2 PLUNGE-ROUTING WIDE TENONS

An edge guide helps rout tenons on wide boards. When cutting breadboard ends or fitting a headboard to bedposts, wide tenons can be a beast to cut. A router with an edge guide (or registered against a temporary fence) does the job in a few passes (near right). After the shoulder has been established, a backsaw and coping saw rough out notches to allow for wood movement (middle and far right), and a final pass with the router evens out the notch.





Method 3 PLUNGE-ROUTING LOOSE TENONS

Loose tenons for long stock. Sometimes lengthy boards are difficult to muscle around machines, but using loose tenons is a simple solution. A mortising template (left) guides a bearing-guided straight bit to cut mortises in both pieces you're trying to join. Tenon stock is cut to width and thickness, then the long edges are rounded (top right) to fit the mortise. Short sections are trimmed to length and glued in place (bottom right).



in handy if you have quite a few tenons to cut. This tenoning method is similar to the dado-blade setup on the tablesaw in that you need to set the bit height for a perfect cut. But with a good bit chucked in the router, you get a much smoother cut than you get with a dado blade on the tablesaw. You can work the stock slowly toward the fence, or to save some wear and tear on your router bits, you can rough out the cheeks first on the bandsaw. Then set a fence for the proper shoulder distance, and set the bit height for the first cheek pass.

With a router table you can package two boards together for a more stable pass by the bit (see Method 1 on p. 65), or you can use a backer board to support the cut and to prevent tearout on the back of the cut where the bit emerges. Make the first cheek pass and then check it against the mortise. Raise the bit for a deeper cut. Even with a wide bit, it will take several passes to get back to the shoulder cut. This is an end-grain cut, which tends to burn when you cut too slowly, so move relatively quickly through the bit, making sure you don't leave uncut any patches of wood on the cheeks of the tenons.

If you're cutting mortises using a router, you'll either have to

square up the mortises or round over the tenons. When I opt to round over the tenons, I do it quickly with a chisel and file. A simple jig (nothing more than a short cut made with the router bit used for mortising) tells me when I've trimmed the tenon to the correct shape.

Plunge-routing tenons on wide stock

To cut tenons on a wide board, use a plunge router with a fence mounted on it (see Method 2 on p. 65). A breadboard end with multiple tenons is the perfect situation to use this method, but it also works well for narrow boards. You just have to package a few of them together to get better support for your router base.

Place a large-diameter straight or spiral bit in your plunge router and mount your fence to it. For better support, attach a longer auxiliary fence to the router fence. Fuss with the bit depth until you are pretty close to the final depth and then cut the first side of all of the cheeks. Work from the outside of the tenon in toward the shoulder, so you have good support for the router base. With thick stock, take several passes until you get to the correct depth and then move the router closer to the shoulder for the next series of

passes. Save the shoulder cut as a final trim pass so you can concentrate on it being accurate. Move the router into the work from both edges to prevent tearout as you exit the cut.

Just like the other horizontal-cut methods, cut one cheek first and check to see that it's correct before moving to the second cheek. Because plunge routers typically have very fine adjustment features, it's pretty simple to take that second pass, check the fit and fine-tune as needed for a perfect fit.

Cutting multiple tenons on wide stock requires haunch cuts as well. Leave these cuts for last; this way, you can use the material to be cut away to test-fit against the tenons. Once the tenons fit, cut them to width on the band-saw or with a handsaw. Reset the fence to cut the haunches to length, and set your bit for a full depth of cut. Plunge to depth and make the cuts, being sure you don't rout into the edges of the tenons. You'll be left with a round corner between the tenon and the haunch, which can be cleaned up with a chisel.

Plunge-routing loose tenons on long stock

When your stock gets too long to cut tenons, you can use loose tenons (see Method 3 on the facing page), which are simply two mortises joined together with a long spline (for lack of a better word). The mortises are easy to cut using a mortising template and a plunge router mounted on a template guide. Make up loose-tenon stock out of the same material as your mortised pieces and trim it to fit in thickness (at the planer) and width (on the table-saw). Then take it to the router table and, with a roundover bit, round the stock on all four long edges. Next, cut a glue-escape slot on the table-saw before crosscutting it to length. When cut to length, the loose tenons should fit smoothly into the mortises.

Using a horizontal routing machine to cut tenons

When a job calls for cutting a large number of tenons, it might be time to call out the big guns. When set up properly, a horizontal routing machine outfitted with a router can save you a lot of time and work (see the photos above). The machine does an excellent job of cutting a large number of tenons very quickly. You can use standard-sized tenon templates or design the joint to whatever dimensions you want. Another advantage is that the machine can cut angled tenons with ease simply by angling the worktable. But with

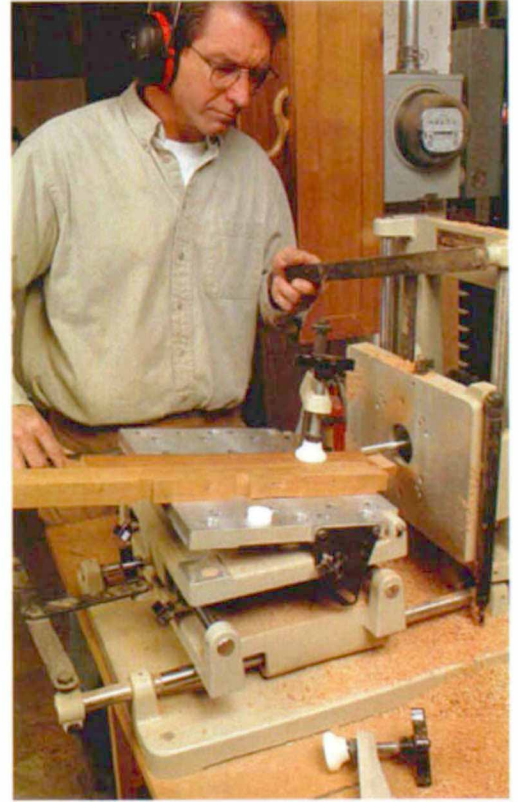
TENONING USING A ROUTER MACHINE

There aren't many faster ways to cut multiple tenons than with a horizontal routing machine. What's more, the same machine cuts mortises just as quickly. Though the prices can be high—these machines start at about \$1,500—the time you save might be worth it.

STRAIGHT TENONS



ANGLED TENONS



Routing machines for production work. Guided by templates or set by hand, the horizontal routing machine takes a little work to set up but can cut countless tenons in no time at all. The table also tilts to make easy work of angled tenons.

prices starting at around \$1,500, you have to be able to justify the cost of the machine.

Start by making a right-angle fence to locate all of the tenon pieces. With a simple, shopmade end stop, you can also set each tenon board in exactly the same location each and every time.

Mount a spiral-flute bit in the router and set its height to cut the tenon. Then set the table stops for both depth of cut and length of travel. With a good routing machine, cutting the tenon actually takes less time than the setup.

There are countless ways to cut tenons. The methods you choose should depend on the tools you have in your shop and on the number of tenons you have to cut. For a single small tenon, you can probably cut it quickly by hand. If you're cutting hundreds of tenons, a horizontal routing machine could save you hours and hours. For many of the jobs you encounter, you might find a happy medium with routers and saws. Just remember that what matters isn't how you cut tenons; it's how they fit. □

Gary Rogowski's video, 12 Ways to Make a Mortise & Tenon, is available from The Taunton Press.