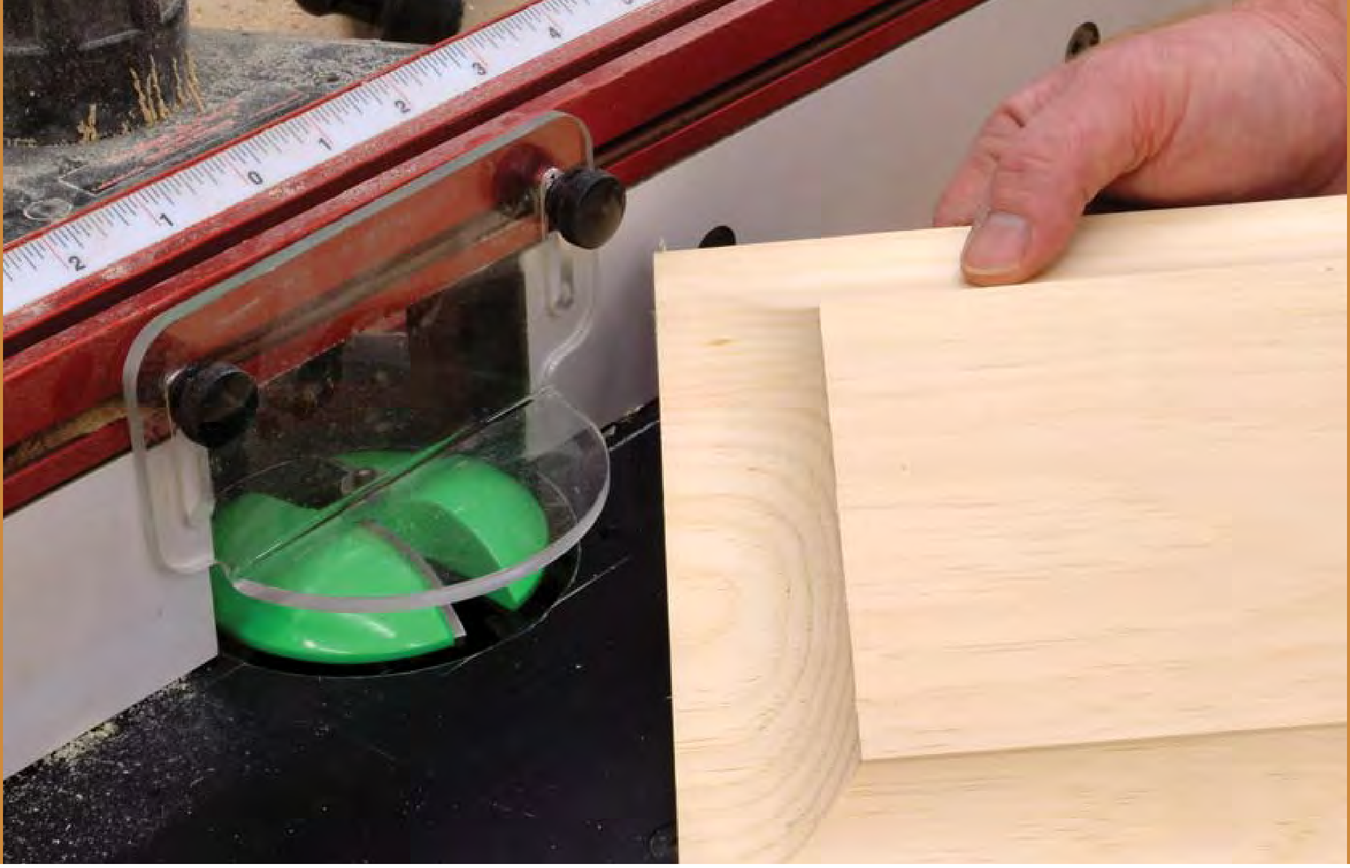


How to Build a Door

Cope-and-stick Joints

Run the moulding and make the joint with this time-tested technique.

The moulding profile cut in reverse forms an integral part of the cope-and-stick joint.

The so-called cope-and-stick joint – a.k.a. the rail-and-stile joint, the rail-and-pattern joint, etc. – is an efficiency expert's dream system. The joint is virtually synonymous with raised-panel doors. However, that's a little parochial; you can use it for constructions other than doors, and the panels don't have to be raised. But its utility in doormaking is more than enough to merit a place in your power-tool joinery repertoire.

Typically, two separate bits are used. One is the sticking (or stile or pattern) bit, and the other is the cope (or rail) bit. In one pass, the so-called sticking cutter forms the panel groove and the decorative edge profile. With this cutter you machine one long edge of the stiles, and the top and bottom rails, and both edges of mullions and intermediate rails. (To my understanding the term "sticking" stems from the profile being formed directly on the frame member – it's "stuck" there – as opposed to it being a separate strip that's attached.)

The cope cutter forms, all in one cut, a stub tenon (or tongue) that mates with the panel groove and the cope of the sticking profile. Copes are cut across the ends of all rails and mullions. Perhaps it's a bit of stretch to say this, but a coped joint won't peek open seasonally the way a miter will. Finish carpenters cope architectural trim at inside corners rather than mitering it for just this reason.

The joint thus is cut by milling every frame piece with one bit and selected pieces with the second. I've never timed it, but I'd bet that with a little experience, you can set up and cut the joinery for a door in about 10 to 15 minutes.

To fully grasp what I mean about efficiency, compare that two-step process against this routine of the traditional door maker:

- Lay out each joint.
- Excavate the mortises with chisels and a mallet, with a hollow-chisel mortiser, or maybe with a router and jig.
- Next, cut the tenons and then fit them to the mortises.
- Cut the decorative profile.
- Cut the panel groove.
- Trim the profile at the joints, an operation usually called mitering the sticking, so the joints close and the profile on the rail meets the profile on the stile in a crisp miter.

I've recently done this. It's a lot of setups. It required a hollow-chisel mortiser, three

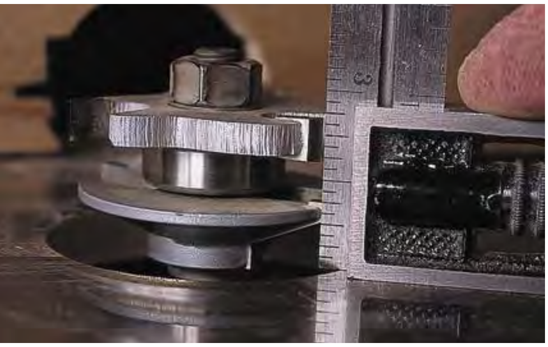
continued on page 32

by Bill Hylton

Bill is the author of several woodworking books including "Bill Hylton's Power-Tool Joinery" (Popular Woodworking Books). To purchase, visit your local bookseller, call 800-448-0915 or visit popwood.com.

Bits are available as pairs of matched cutters or single bits. Single bits are either height adjustable or stacking with a reversible cutter.

continued from page 30



Set the height of the cope cutter by measuring the position of the tongue.

Use a block of scrap to push the end of the rail into the cutter for the cope. It will prevent tear-out and give you better control.

Use one of the coped pieces to set the height for the sticking cutter.

router-table setups and two table saw setups. And to get an acceptable assembly, I actually had to use one of those old-time cordless tools – a chisel. With cope and stick, it's two router-table setups and you're done.

The trade-off (there's always a trade-off) is strength. The joint is easy to make, but it isn't as strong as a mortise-and-tenon joint.

Is it strong enough for the average frame-and-panel application? Personally, I think the joint is fine for doors on cabinets and cupboards, and for casework components. Provided it is machined accurately and glued well, it's plenty strong. If the strength of a mortise and tenon is deemed essential – for heavier assemblies such as architectural doors, for example – there are good ways to reinforce the cope-and-stick joint, such as with dowels and loose tenons.

To make a frame using this joinery, you need the proper bits and a mid-power, table-mounted router. With a few exceptions, the cope-and-stick bits can be run full-tilt in a 1½-horsepower router.

Preparing the Stock

By industry convention, cope-and-stick bits are designed for ¾"-thick stock. Because this stock thickness is standard in most areas of the United States and Canada, you shouldn't have problems if you buy dressed stock.

You do have some leeway. You can finesse the bit height setting to reduce the profile depth and increase the width of the panel-groove shoulder, or to increase the profile and reduce the shoulder. The problem when you creep below 11⁄16" in thickness is in fitting the sticking profile on the edge and still having enough stock to support the panel groove. As the thickness creeps above ⅞", the problem is the capacity of the cope cutter. You may find it leaves a wafer of waste attached along the stub-tenon shoulder.

For doors especially, the stock must be flat, straight and true. You can get away with using slightly bowed stock for a frame-and-panel unit so long as it isn't a door. If the wood in a frame-and-panel unit is bowed (not crooked, not twisted, just bowed), the unit will be bowed. If the unit is a structural part of the case, it will be anchored to other elements that may pull it into line and hold it there. But if it is a door, it won't hang flat, and that problem you won't be able to conceal.

Dress the chosen stock to whatever thickness you've settled on. You also need several pieces for testing the setups, bearing in mind that these particular pieces can be a secondary wood. The important thing, to me, is to plane all the stock to a consistent thickness. I achieve consistency by planing all of it at the same time.

Now rip the stock to width, then crosscut the parts to length. When you cut the rails, you have to account for the sticking width. Usually, but not always, the width is ⅜". So if, for example, you're making an 18"-wide door and using 1¾"-wide stiles, the distance between the stiles is 14½". But to account for the sticking, you need to add ¾" to the length of the rails (⅜" for each stile, or twice the width of the profile).

Cutting the Joinery

If you have just purchased a bit or set of bits to do cope-and-stick joinery, I think you should spend a little time getting familiar with it. Take as much time as you need to make both cope and stick cuts. Here's your goal: a setup block with an edge sticked and an end coped. With that in hand, you can quickly set up the bits any time you need to.

The usual routine is to cope the rail ends first, then stick all the stiles and rails. So that's the routine we'll follow here.

Before doing any setup or cuts, reflect on the fact that the cope cut is cross grain. That means you need to back up the work to prevent splinters from being torn from the back edge by the cutter. Depending on the size and number of rails, I'll gang them up and feed the lot of them past the cutter, pushing them along the fence with a square scrap. The pusher acts as a backup, preventing any splintering.

Some woodworkers prefer to use a more formal guide, such as a coping sled. There's no shame in that at all. However a sled does impact the bit height setting so you have to accommodate the sled base's thickness.

The first setup task, of course, is the bit. Secure the cope cutter in the router's collet. Then establish a height setting. Knowing the industry standards, you won't be wrong to measure 7⁄16" to ⅝" from the tabletop (or coping sled base) to the corner of the tenon-cutter. You'll get an ⅛"- to 3⁄16"-wide shoulder on the stub tenon.

If you already have a setup block – one that came with the bits or one you made – tuck it into the bit and adjust the bit up and down. If you are using a coping sled, you must, of course, set the block on the sled when gauging the bit elevation.

Set the fence next, positioning it with its face tangent to the pilot bearing. It helps to use a zero-clearance facing. The zero-clear-

Make the sticking cuts by running the long edges along the fence. Featherboards will keep the stock flat on the surface of the router table.

ance fit is most important on the infeed side of the cutter. If your fence is split, you can feed the infeed half of a sacrificial fence into the spinning bit, right up against the pilot bearing. With the solid fences on my router tables, I use an expendable strip of thin plywood or hardboard to make a zero-clearance opening as shown in the photo above.

Of course you need to make a test cut. If you have a setup block, fit your test cut to its sticked edge. If not, look at the cut and assure yourself it's not obviously misaligned.

The cope cuts should be completed in one pass. Repeating a pass can enlarge the cut and create a loose fit. In theory, a second pass can enlarge the cut only if there's some movement in your setup. In practice, there probably is a "skoshe" of movement possible, no matter how firmly you grip the work.

Pay attention when you turn the rails to cope the second end. You want to turn them, not flip them over. Mark the face that's supposed to be up as you make the cope cut. Before you cut, look for the mark.

Rout the sticking second. Chuck the sticking bit in the router collet, and adjust its height. It's great if you can do this without moving the fence, but that's not always the case. If you can get away without resetting the fence, you'll save some time and effort.

If you have a setup block, use it, of course. Otherwise, set the bit against a coped workpiece. Make a test cut, and fit it to one of the coped rails. You want the surfaces flush, and running your fingers across the seam will tell you if you've achieved that. If some adjustment is necessary, make it and run a new test piece across the bit. Keep adjusting and testing until you have the fit you want dialed in.

Set featherboards, if you favor their use, positioning them just fore and aft of the bit, where you need the pressure.

When everything is set up properly, after you've adjusted and micro-adjusted the bit height, created zero-clearance support around the bit, positioned the featherboards, and done a test cut that resulted in a pleasing fit, rout on. Stick the stiles and the rails. You may find that it won't take as long to do the work, as it did to set up for it. Taking your time with the setup will guarantee you smooth sailing when you put the parts together.

Assembly

Assembling a cope-and-stick frame is pretty straightforward. Work on a flat, true surface. Apply glue judiciously to the ends of the rails. Tighten the clamps gently, alternating back and forth, and keeping the rails flat on the clamp bars. Very little pressure is required, and over-tightening the clamps will likely distort the joints and thus the assembly. Make sure the assembly is square and flat by comparing the diagonal measurements and by checking with winding sticks. **PW**

The pieces should come together flush on their faces (left), not offset (right).

A zero clearance opening in the fence will help prevent chipping as the cuts are made.

Cope-and-stick joinery is an efficient method for assembling doors and other panels.

Building Glazed Doors

Most cope-and-stick bits can produce frames that will house glass as well as wood panels. Here's how to do it.

The same bits and techniques used for frame-and-panel doors can also be used to make glazed door assemblies. Special bits and bit sets broaden the spectrum from single-pane to divided-light applications.

Here at chez Hylton, our kitchen cabinetry includes a mix of raised-panel doors and glazed doors. Most things are hidden, but some handmade pottery, a few family heirlooms and lots of knickknacks are displayed behind glass. We don't actually use these things a lot, but we like to see them all the time.

The ambitious hobby woodworker, hankering to redo the kitchen cabinetry or to build custom cabinetry for the family room, might want this mix of paneled and glazed doors. But how do you actually do it? The cope-and-stick bits discussed in our August 2005 issue produce a 1⁄4"-wide groove suitable for a panel, but that's too wide for glass.

A cursory scan of bit catalogs suggests that bits scaled for window sashes are readily available, but not for cabinetry. Cabinetry-scale sets are available, but they tend to be special-application cutters. The explanation is that you can use most cope-and-stick sets to produce frames that will house glass rather than wooden panels. The bit manufacturers just don't document how you do it, but I will.

At the same time, I want to tell you about the capabilities of those special-application cutters. All work in the same fundamental way, like cope-and-stick bits, but some actually help you produce frames with mortise-and-tenon joinery.

Using Cabinetry Cope-and-stick Bits

To transform a cope-and-stick joint for a wooden panel into one that will accommodate a pane of glass, you need a rabbet instead of a groove. A simple alteration to the cope bit and an extra step – at the table saw – make this easy to accomplish.

To replace the groove-sized stub tenon with a rabbet-filling block, you just remove the slot cutter from the coping bit. You can do this with most two-bit sets and with bits that are reversible assemblies.

Loosen and remove the arbor nut from the bit, and pull off the slotter. It's easy to do with the bit secured in the router collet, so you can keep the bit from turning when you attack the arbor nut with your wrench. Use a sleeve-type spacer or stack of washers to take up the vacated space on the arbor and replace the nut. Leave the bearing in place. And that's all it takes.

A couple additional notes here: You have to have an "assembled" bit, meaning one with a slot cutter and bearing that are held on a stem with a hex-shaped arbor nut. If you have a solid bit that has cutting edges that inseparably combine the profile and the slotter, you are out of luck. The same is true if you have a stacked bit with both coping and sticking cutters on a single shank.

The spacer you add must have an inside diameter matching the stem and an outside diameter that is the same as or smaller than the bit's pilot bearing. It can be a steel or bronze bushing, a nylon sleeve, or a stack of washers – so long as it fits the stem, is smaller than the bearing, and fills the gap between the bearing and the end of the threads on the stem.

Set the modified cope bit in your router

by Bill Hylton

Bill is the author of several books about furniture construction and router operations. His most recent book is "Bill Hylton's Power Tool Joinery" (Popular Woodworking Books).

table, adjust the height, position the fence and cope those rails. The cut will be nothing more than the negative of the profile – no stub tenon.

The sticking cuts are made with the standard bit – no alterations needed. Set the bit and fence, then make the cuts. After these cuts are completed, go to the table saw and rip the back shoulder from the panel groove, transforming it into a rabbet. Be careful not to make the rabbet deeper than the groove. You won't get a tight joint.

Assembly follows. To secure the glass, you can use glazing compound or slender wooden strips that you glue in place or fasten with brads. The upshot is that the same bits you use for frame and raised-panel cabinetry work can be your primary cutters for frame and glass pane cabinetry work.

To adapt your cope-and-stick set, remove the slot cutter from the cope bit. You may need to use small washers or a sleeve-type spacer to fill a gap between the bearing and the threads on the arbor. Amana provides a flush-trimming cutter with its cope-and-stick sets for just this purpose.

Machine the rails and stiles with the sticking bit unaltered. Then rip each piece on the table saw to open the panel groove, transforming it into a rabbet that will accept glass.

Dividing the Frame

If you want to divide the framed area, you can make the divider strips with the same bits. Though they are often called sash bars, the vertical divider is a mullion, the horizontal divider a muntin. If you halve the opening, either vertically or horizontally, the divider obviously will be full-length. But if you divide the space both vertically and horizontally, either the mullion or the muntin will need to be broken. The structure will be stronger if you segment the longer piece, but you can break up either one.

Because these parts are usually quite slender, you should adjust your procedures. Do as much work as you can with wide stock. And before you stick a sash bar that's been reduced to its final width, make yourself a custom pusher, as shown below. The pusher keeps your hands clear of the bit.

If you need two muntins and three mullions, for example, crosscut one wide blank for the muntins and one for the mullions. Cope the ends of these pieces and stick both long edges. Rip one mullion from the blank, then stick that blank's "new" edge. Rip the second and third mullions from that blank and the muntins from the muntin blank. Then use the pusher to hold the slender parts as you stick the second edge of each piece.

To assemble the divided frame, you apply glue to the coped muntin and mullion ends as well as the rail ends. Press the coped ends into the sticking on the stiles (and rails and mullions and muntins).

Even a simple frame can be vexing to glue up. Add mullions and muntins, and there are many more parts to hold in alignment. Having

The mating pieces fit together nicely. The sticking profile nestles into the cope, and the butt of the rail seats tight against the shoulder of the rabbet.

Assembling a sash frame is easy. It's aligning the sash bars and keeping them square that's vexing. Assembly "panes," pieces of plywood or hardboard cut to the dimensions of the glass panes, are a boon here. As the frame is pieced together, set the panes in place. They keep the narrow sash bars in alignment, even as you apply clamps.

To stick the parallel edge of the sash bar, tuck it into a shop-made pusher. The pusher holds the strip in proper alignment throughout the cut, and it keeps your fingers away from the cutting zone.

a panel to keep the parts in basic alignment is a big help. Trying to assemble the frame around glass panes is hazardous, so make yourself temporary "panes" out of hardboard. Nip off the corners off these "panes" so they don't get glued to the frame.

Clamp the assembly until the glue sets. Apply a finish, install the glass and the unit is completed.

Making a divided glazed frame with modified cabinetry bits has two drawbacks: aesthetics and joinery strength. The latter is relatively easy to deal with by reinforcing the joints with dowels or loose tenons. The former you either accept or you switch to specialized cutters.

The aesthetic issue is the proportion of the sticking profile. When the assembly has a wood panel, half the frame thickness must be allocated to the panel groove, leaving only 3/8" for the profile depth. Moreover, the convention with cope-and-stick cutters is to have the profile width match the panel groove depth, which is 3/8". This looks fine, even when the assembly is divided with intermediate rails and a mullion. And when it frames a single glass pane, it looks fine.

Freud's divided-light bit set simplifies cutting the profile and rabbets for cabinetry frames on both rails and stiles, muntins and mullions. But the cut configurations force you into mortise-and-tenon joinery that makes the frame stronger. Without cutting mortises for the stub tenons formed in the cope cut, you can't join the cope and the stick.

But divide the frame for several panes, and the visual appeal fades. The mullions and muntins are too wide. Bear in mind that aesthetics is pretty individual, and you may be perfectly happy with what you get.

Reinforcing the Joints

Glass is heavy, and a door with a half-dozen or more panes needs to be assembled with strong, enduring joinery.

One solution is to reinforce the joints with dowels, or mortises and loose tenons. In some circumstances, dowels can be added to a joint after it has been glued and assembled. Drill through the edge of the stile into the joint, then drive a dowel into the hole.

Introducing mortise-and-loose-tenon joints to the construction is manageable if you have a plunge router, an edge guide, and a suitable workholder. Back in our April 2004 issue, I explained how I rout mortises for loose tenons, and that system works well in this application. Before making the frame as outlined above, rout mortises in both the rails and stiles. Plane down scraps of the working stock to make loose tenons. You can reinforce the sash-bar joinery with dowels. Use the router mortising setup to bore holes for the dowels. Having these joints not only strengthens the frame, it makes it easier to assemble.

A few bit manufacturers have bits intended specifically for divided-light frames. The bits are designed to integrate traditional mortise-and-tenon joinery with cope-and-stick profiling (see photo above).

Freud's set has two bits. The cope bit produces a 3/16"-long stub tenon at the same time that it forms the cope. In that, it's just like a cabinetry cope cutter. But the sticking cutter doesn't plow a groove to accommodate the stub tenons. You have to cut mortises for them. In addition, you must trim the tenons by hand unless you are content to have them match the full width of the rail or sash bar.

My experience is that it's best to make the router cuts with the bits first. The sticking cut leaves a flat between the profile and the rabbet, making it easy to align the mortises. Lay out the extents of each mortise and cut them with a hollow-chisel mortiser. Finally, trim the stub tenons to fit.

CMT's set, designed by Lonnie Bird, has three bits: an inverted-head cope cutter, a beading bit to produce the sticking profile, and a regular rabbeting bit. The big advantage with this system is that you can make tenons longer than 3/16". This gives you stronger joints everywhere except between mullions and muntins. But there are operational differences that make this a more time-consuming system.

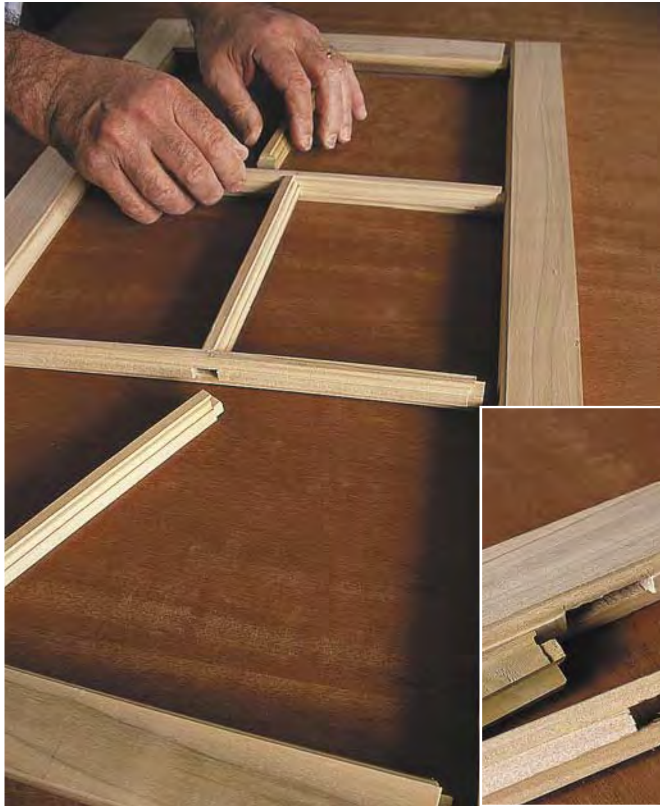
The expeditious approach is to rout the copes and the sticking on all the parts. The stub tenons formed by the cope cut extend from edge to edge, and the sticking cut doesn't shorten them. On the rails, trim them back with a chisel (left). Leave them full-width on the mullions and muntins. Use the tenons to lay out the mortises on the flat between the profile and the rabbet. Then cut the mortises with a hollow-chisel mortiser (right). The tenons are stubby, so cut the mortises only 1/4" deep.

After laying out and cutting the mortises and tenons, by whatever means you prefer, do the copes. You adjust the cope-bit height by raising it until it just skims the tenon. Instead of the standard router table fence, use a strip of 1⁄4"-thick plywood with a bit cutout in the center as a fence. This low fence can guide the shoulder without obstructing the tenon. Position the fence, then cope the rails, and the muntin and mullion blanks.

Follow up this operation with the two-step sticking cuts, and you should be ready to assemble the frame.

An added benefit of either of these bit sets is that the profile is proportioned to the application. It is narrower than the sticking profile on standard cabinetry cope-and-stick cutters, and it is placed somewhat deeper on the stock. Thus muntins and mullions cut using the bits are narrow, and the assembled frame "looks right."

Unfortunately, if you want to orchestrate a project with both wood-paneled and glazed doors, you won't find companion cutters for making the wood-paneled doors. **PW**



One swell result of mortise-and-tenon joinery in a divided-light frame is that the many parts align positively during assembly. None of the skinny mullions and muntins slide out of position as you work, because their tenons are seated in mortises.

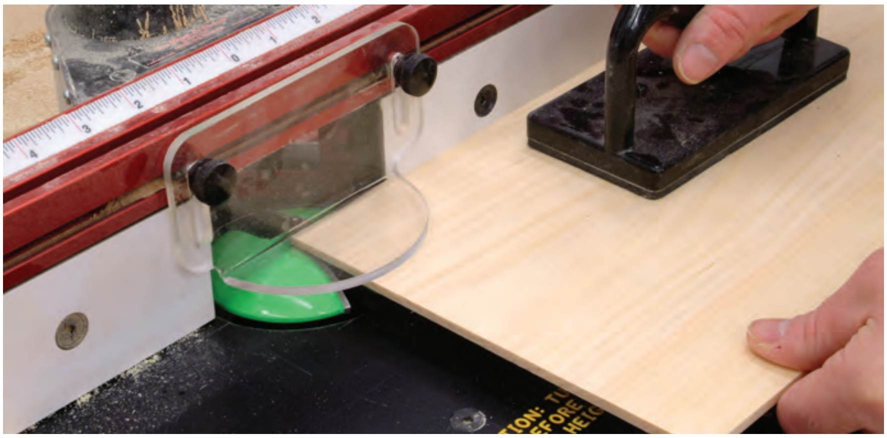
Raised Panel Doors

I've sandwiched this section between the section on flat panel doors and the next on cope-and-stick doors because raised panels can be used with all these doors. There are a number of techniques that can be used to "raise" a solid wood panel, but I will be focusing on the method using raised panel cutters, either in a sturdy router table, or in a shaper. Use the method that best suits the equipment you have in your shop.

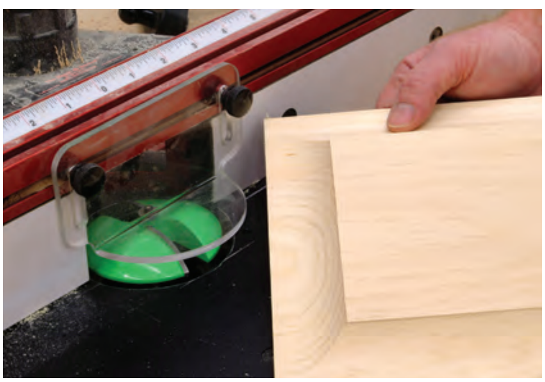
Plain Profile Panel-Raising Cutters

There are many plain panel-raising router bits, but the most common is a simple cove style. These bits have long, medium and short radius cuts, so you'll have to decide which profile best suits your needs.

This group of plain panel-raising bits also includes tapered cutters, which are available in a few different profiles. These bits can be used to make door center panels that can be used with many furniture styles, so it's probably the best one to purchase for general use.



1 Install the panel-raising bit in your router, making certain that it's properly seated and tightly locked in the chuck. Your table should be equipped with a router that's rated at 2 horsepower or more. Many woodworkers maintain that only variable-speed routers should be used because these bits seem to cut better when the router is set at one-half or three-quarter speed. There's a lot of truth in that belief, but I have successfully used fixed-speed routers to raise my panels. Experiment with router speed and panel feed rates to achieve clean cuts. However, even the correct speed and feed rates may not guarantee success; some types of wood, such as oak or maple, tend to splinter or tear out in chunks, so a lot of testing may be necessary.

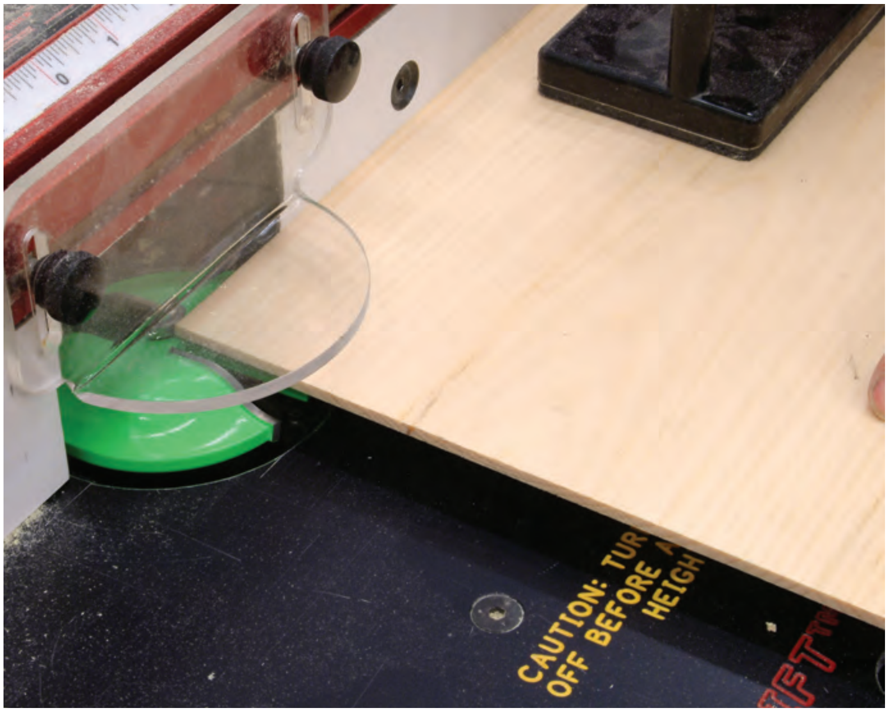


2 It's often better to make a number of small passes rather than one large cut with these cove panel-raising bits. Mill the end grain first, as that's where most of the tear-out occurs; then follow up with cuts along the grain. Continue making the cutting passes until the panel edges are 1⁄16" thick, or the proper thickness for stile and rail frame grooves.

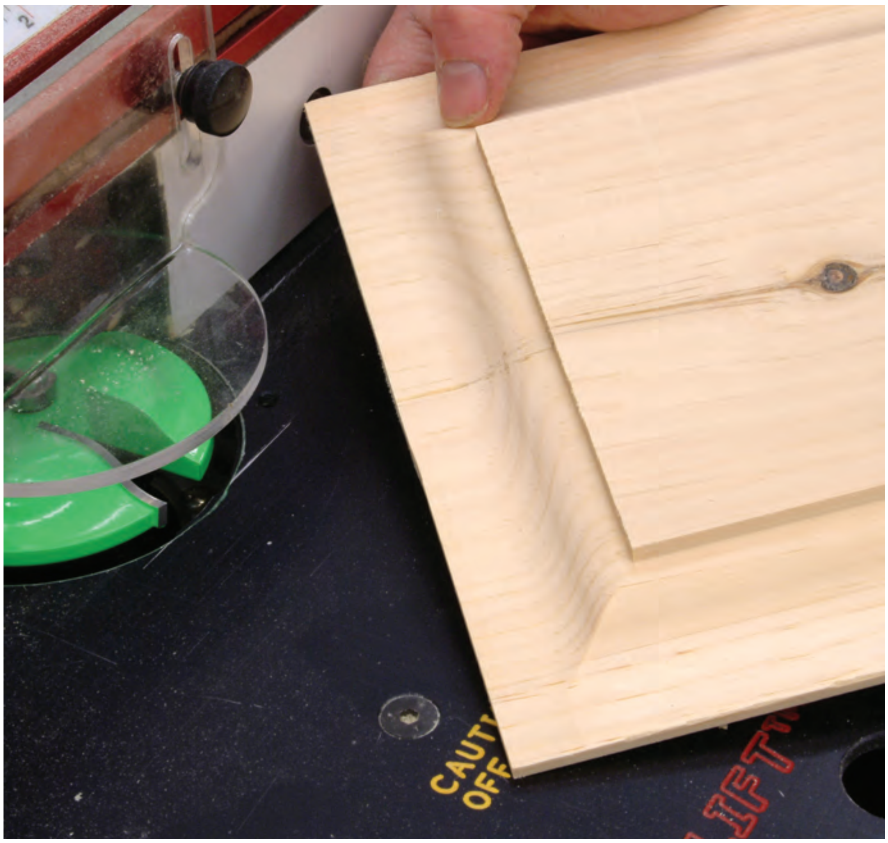
Figured-Profile Panel-Raising Cutters

Figured panel-raising bits cut a pattern into glued-up panels. I'm using a common ogee-style bit.

Figured bits are often chosen to match cope-and-stick bit sets, which are used to cut tenons, grooves and patterns on the edges of door-stile members and the ends of door rails. You'll find pattern styles called Roman Ogee, Classic Bead, Classic Frame and so on for both stile-and-rail bit sets as well as the panel-raising bit.



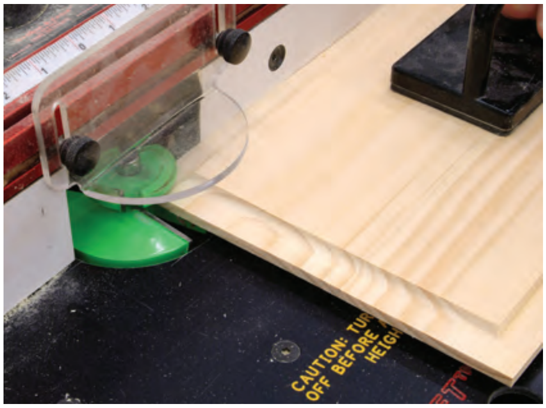
1 The milling steps and procedures for the figured bits are the same as those for the simple plain bits. Make a number of small passes and test the cuts on scrap material before making the final cuts on the panels.



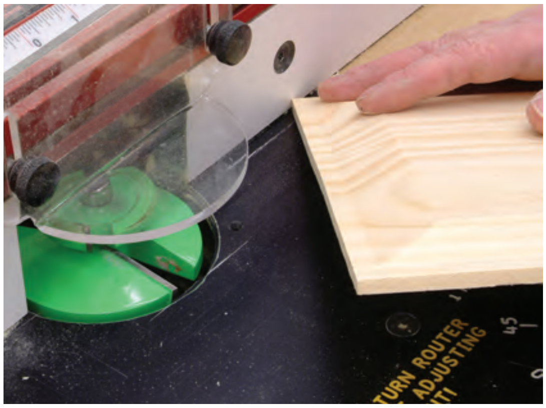
2 The panel should be guided by a bearing on the bit using a medium feed rate to achieve smooth cuts. A certain amount of finish sanding will always be required, but you can minimize it by testing for the best feed rate and router speed.

Bits with Back Cutter

These special bits are available in many of the standard profiles but are also equipped with a rear-cutting blade. The back cutter forms a rabbet cut on the rear face of the panel as the face is profiled. This rear cut positions the door so the front face of the frame and panel are on the same level.



1 Both front and rear faces of the raised panel are milled during a cutting pass. The double-profile cut means that a panel must be raised with only one pass per edge. There's a lot of material being removed on each pass, so be sure your router bit is sharp; also test the feed rate as well as the router speed with scrap material before you begin.



2 Typically, a guide bearing controls the cut depth, but I always set up my router-table fence slightly behind the bearing's front face as a safety device. The bearing is the primary control, but the fence prevents the panel from being kicked back in case of a jam. With all these cutters, dust is a major concern, so a good vacuum system is necessary.

Raised Panel vs. Door Frame Position

This photo shows the edge profile on a panel that was milled with a raised-panel bit equipped with a back-cutting blade. It has a specific purpose that is best explained by studying a raised panel's relationship to the front surface of a door frame.

Door frames, made with two stiles and rails, have a groove in the center to hold a flat or raised panel. The stile and rail grooves can be cut on a table saw or by using a cope-and-stick bit set (see the next page).

These stile and rail grooves are normally centered on the edges, which means that a raised panel of the same original thickness (¾"- thick door-frame material and ¾"-thick raised panels) as the frame will be ¼" higher than the front face of the stiles and rails. The panel is said to be "proud of the frame" because it's held in the groove, which is ¼" in from the frame's back edge.

If you don't mind having a raised center panel proud of the frame, then there isn't a problem. If you want the center panel's front face to be on the same level as the door frame's face, you have two options.

First, you can use ⅞"-thick material for the stiles and rails and ⅝"-thick material for the center panel. The ¼" difference, because the panel is in the grooves that are ¼" above the frame's back face, is accounted for by the thinner panel material.

The other option is to use the same thickness material for the door frame and raised center panel, but you must use a panel-raising bit equipped with a back cutting blade. The center panel's back face will have a ¼" rabbet, which will lower and level its position with respect to the frame's front face. Simply put, we would remove ¼" from the back of the panel edges so the panel would be recessed ¼" from the front surface of the door frame.

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