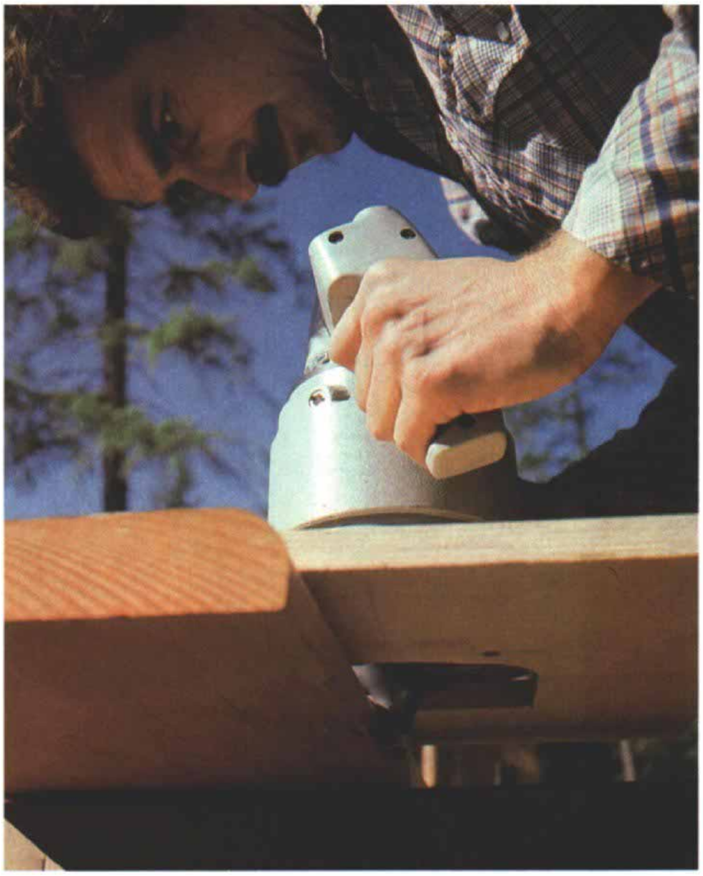
Routers

Knowing the basic bits and how to guide the router will help you get the most from this versatile tool on site and in the shop

by Craig Savage



I build custom homes for a living. This requires that I set up, at least for a short period of time, a millwork shop on the construction site. Bringing my two routers along lets me leave several heavy machines at my permanent shop. At various times I've used the router to perform the work of a shaper and a slot mortiser, and with my 3-in. trim bit I can put an edge on a board that looks as though it has been passed across a jointer.

Rabbeting, grooving, dadoing and edge shaping are the simple operations that most people associate with routers. But routers are versatile enough to do dozens of other useful operations, including pattern cutting, laminate trimming, mortising, dovetailing and finger jointing. Routers can cut all of the wood structural joints, including tongue-and-groove, half-laps and splines. Other more esoteric operations include straightening and flattening boards, plunging holes, making dowels, inlaying, freehand carving and even sharpening tools.

Choosing a router—A router, in its basic form, consists of a direct-drive motor/arbor assembly, a base assembly and a chuck for holding the router bits, as shown in the drawing on the facing page. The motor-assembly housing nests inside the base assembly (like concentric cylinders). A threaded-collar device for raising and lowering the motor assembly relative to the base unit changes the depth of cut.

There are many routers on the market. Their rated outputs range from ¼ hp to 3¼ hp, while their rated speeds range from 18,000 to 30,000 rpm. Because of this they can produce smooth, crisp cuts and leave the wood fairly free of telltale mill marks. There are specialty routers that only trim plastic laminates, overhead pin routers that do pattern cutting and edge trimming, and stationary routers, set upside down, that function as small shapers.

I think a good general-purpose router should be moderately large—at least 2 hp. A router this size can do everything that a small one can do except get into tight corners. This much power will keep you from overloading the motor by running it at lower than rated speeds. Small routers can manage deep cuts that remove a lot of wood, but you have to make several shallow cuts instead of a single pass. If you are thinking of using the router for more than edge-shaping, then buy a 2-hp or better router.

Rating systems for router motors vary among manufacturers, much as they do for skillsaws (see *FHB* #24, p. 41). This makes comparing performance a difficult if not impossible job. And don't think that just because your Brand A electric drill is a good tool that Brand A's router will also be good. It doesn't always work that way. Your best bet is to consult someone who uses routers on a regular basis, or a tool dealer you trust.

Routers come with several different handle configurations. At first all of them seem awkward to hold. Two handles low and at the sides work best for me; others prefer the D handle in front, with trigger switch. Some routers have no handles at all. These are usually small routers that lend themselves to one-handed work like laminate trimming and freehand carving.

Some routers just have a toggle switch, which means that if the switch is on and the cord plugged in, the tool will come to life. This is a very dangerous design. I recommend a spring-loaded switch in a handy position so the power is turned off if the switch isn't depressed. Another thing to look for is wrench access. Most collet systems require two wrenches and some allow ample room for them, but others are built as if you were never going to change the bit.

You'll have to pay for performance. Good ball bearings, horsepower and close-tolerance castings cost money, and usually the more you pay the more you get. Look for value not only in initial price, but in dealer support. Ask about spare-part replacement time. Even quality tools break down, and it's frustrating to have to wait four to six weeks because your top-of-the-line router needs a switch unit that's on a siding in Topeka or Tokyo.

Routers commonly accept three sizes of bit shaft—¼ in., ⅜ in. and ½ in. Naturally, a ½-in. shaft is stronger than a ¼-in. shaft, and if you're trying to put a 1-in. wide groove ¾ in. deep in miles of maple, then you're going to want a powerful router and a bit with a ½-in. shaft.

Routers that accept ½-in. shafts can usually be converted to smaller sizes by inserting smaller-diameter collets into the arbor. This is another reason for starting out with a larger router, since it will accept any bit. Also, some bits just can't be made with small shanks because of cutter size or the bearing-guide design.

Plunge routers are becoming popular in the United States, and with good reason. They have a motor that rides up and down inside the base assembly (photo facing page) or on a pair of posts anchored to the base. This allows the bit to be turned on above the work, then lowered vertically into it. Plunging turns the router into a slot mortiser. Slot mortising is a convenient and fast way to get strong mortise-and-tenon joints. With the use of a few jigs, slip-joining has replaced doweling as my main method of joining cabinet face frames and door frames (more on this later).

The plunge router can also do blind dadoes and grooves, and it can be locked to function as a normal router. This makes the plunge router the most versatile of the routers, and I strongly suggest you consider purchasing one—especially if it is going to be your only router.

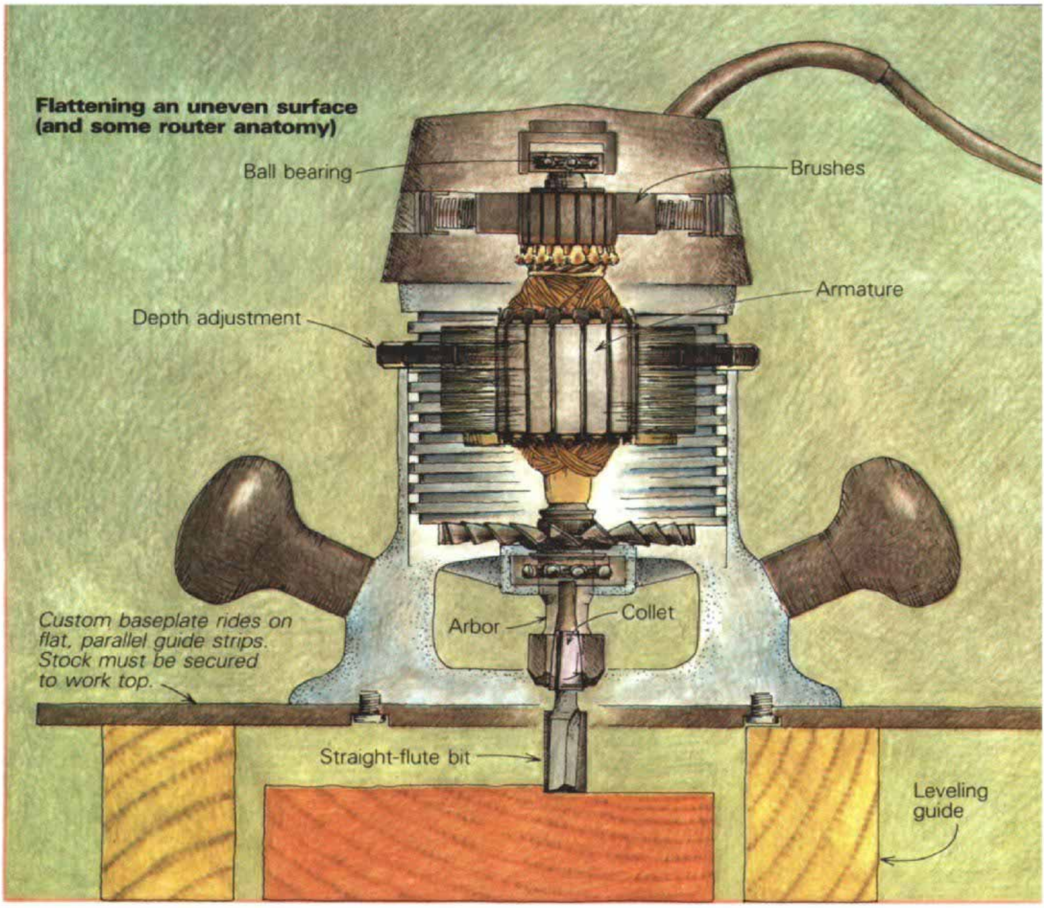
I think that plunge routers also have the edge in safety. I'm in the habit of raising the bit into the body of the router after each cut, even if I'm not plunging. This gets the cutting edges out of the way of fingers, and lets me set the router on its flat, stable baseplate rather than on its side.

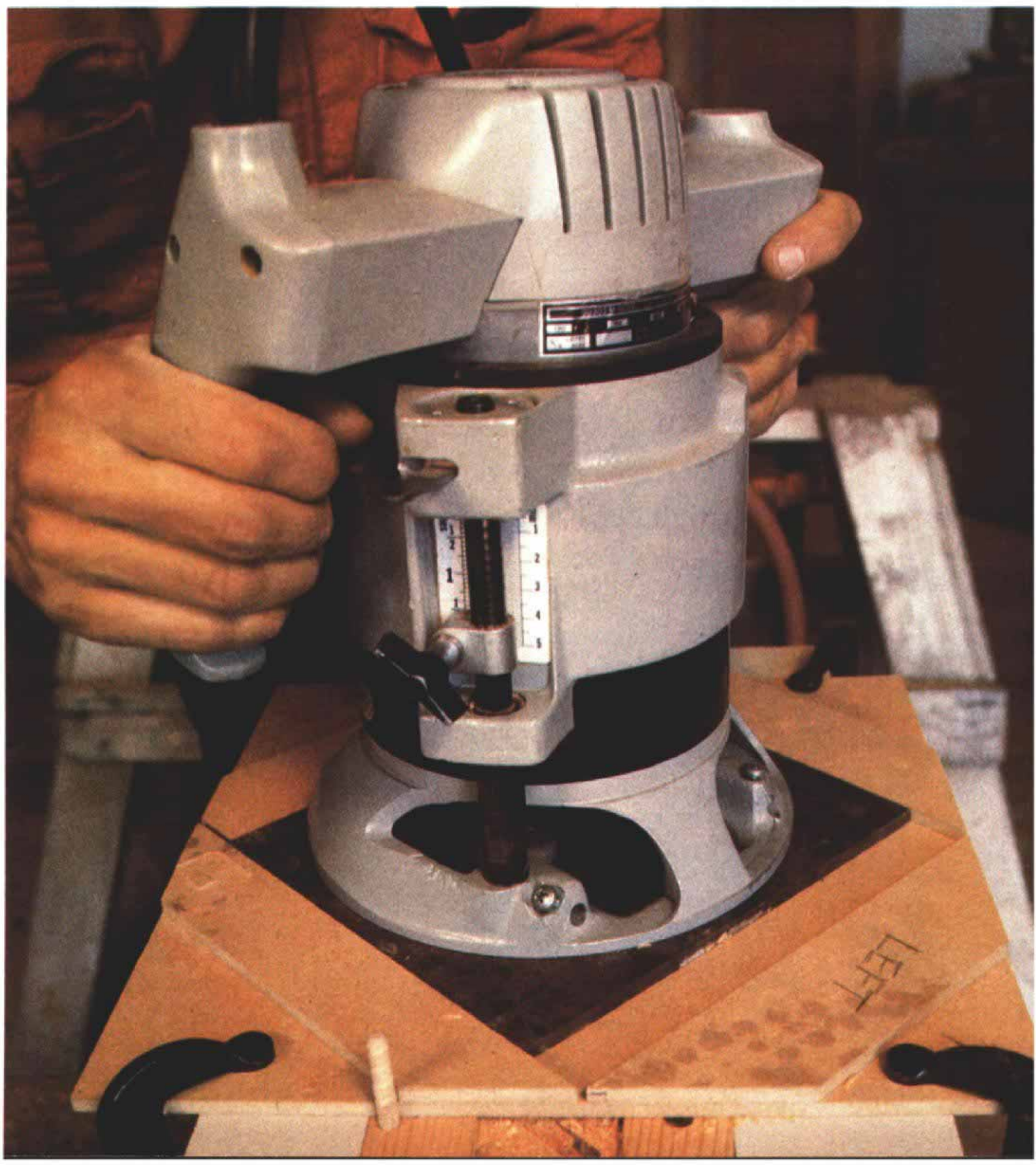
Baseplates—The surface that rides on the work and frequently guides the router is the baseplate. It is usually made of black phenolic-resin plastic. You can custom-make your own out of Plexiglas, aluminum, plywood, medium-density fiberboard or hardboard. Bases can be round or square.

I thank Makita for introducing me to the square baseplate. The square baseplate gives a constant distance between bit and base edge. The round base, even when accurately made, isn't always perfectly concentric to the bit. This error, although slight, can double in certain operations and become a nuisance. Even if your baseplate starts out round with a centered bit, the screw holes in the base eventually get worked out of round, and the result is the same. Of course, you'll need round baseplates to follow curved templates. The trick then is to mark a spot on the baseplate and always keep the mark pressed against the guide surface.

I find that the round bases that came with my routers are most useful as screw-location templates for the baseplates that I custom-make to perform specific tasks. I usually make these of ¼-in. hardboard, tempered on both sides. They range from 8 in. by 8 in. to over 24 in. by 24 in. The small one rides on a template, and I use the large one to increase my baseplate bearing when I'm doing edge-forming work (photo facing page). The big one can also ride on two guides, allowing the router to float over the workpiece as it flattens an uneven surface (drawing, above right).

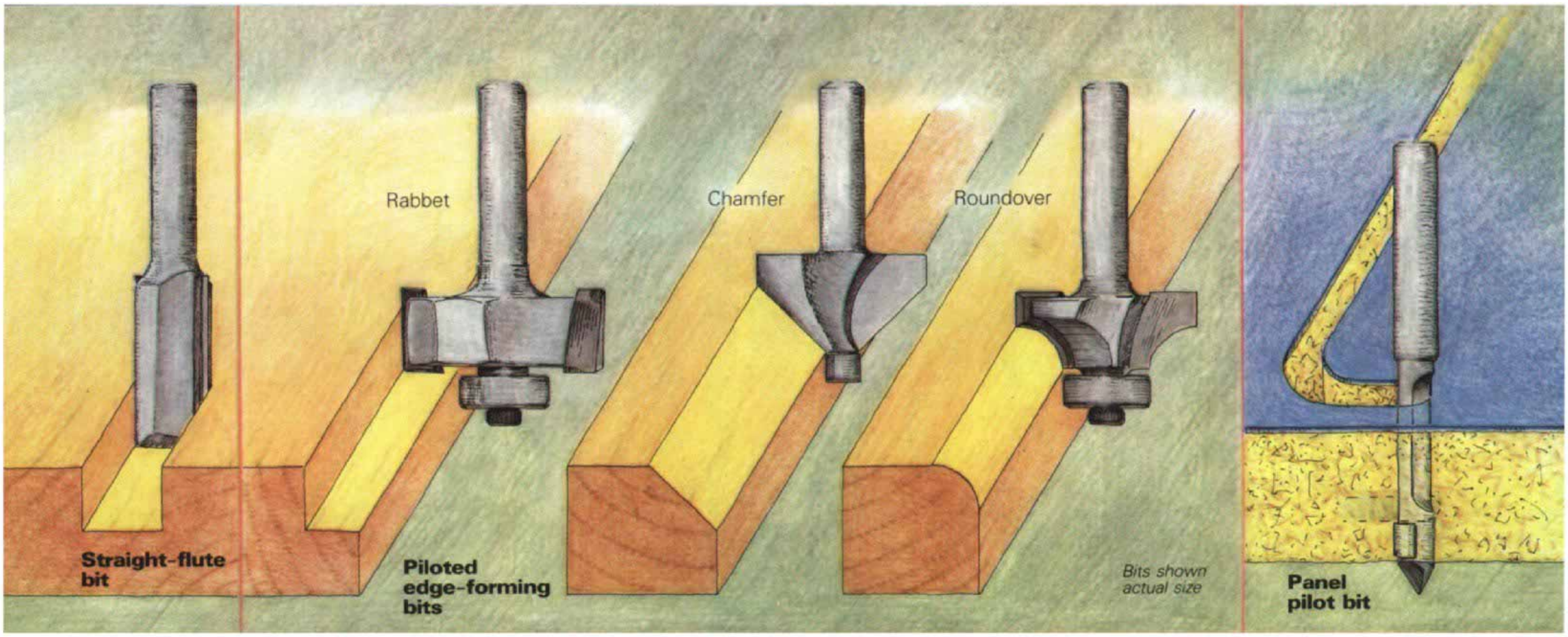
Bits—The bit is the business end of the router. Bits have hundreds of profiles, but they all fall into two basic categories: piloted and unpiloted. A piloted bit has a cylindrical surface on the





Savage uses a ¾-in. radius roundover bit with a bearing pilot to soften the edge of a redwood handrail (facing page). A 2-ft. square router baseplate allows more contact between the work and the router, which makes it easier to keep the bit perpendicular to the work during the cut. The motor assembly in a plunge router (right) moves up and down inside the cylindrical base casting. The vertical bar is an adjustable depth stop. Here a 3½-hp Stanley (now Bosch) plunge router cuts louver mortises in a door stile. The dowel in the 2x4 is a registration mark for the particleboard template. The 8-in. square hardboard baseplate makes it easy to align the template fences, and keeps the bit a consistent distance from the fences.

Drawings: Christopher Clapp



shaft of the bit that bears against the edge of the work during the cut. This surface guides the router, and it can be either above or below the flutes, or cutters. At least 1/16 in. of the original edge must remain for the pilot to follow. Some pilots are solid and some are ball-bearing. Solid pilots use a polished portion of the shaft as the bearing surface, but these can burnish and sometimes burn the work. Ball-bearing pilots are the best because they won't mar the work. Unpiloted bits lack this built-in guide.

A bit's cutting edge can either be high-speed steel (HSS) or carbide. There are production bits that use exotic coatings such as diamond and zirconium, but only HSS and carbide are affordable. Carbide bits (some are solid carbide, most are carbide tipped) cost three or four times more than HSS, but they last seven to fifteen times longer, depending on the material they are used to cut. Most of my bits are carbide tipped. If you do one-of-a-kind pieces and need only a few feet of some unique profile, then go ahead and buy the HSS bit. It won't hurt to have it around. With a grinder you can even change its shape and create your own bit, the way John Leeke does (*FHB* #18, p. 75),

Within the broad categories of piloted and unpiloted, there are distinct families of bits, shown in the drawings on these pages.

Straight-flute bits. These unpiloted bits cut grooves, rabbets, and dadoes (grooves across the grain), and they can have one, two or three cutting edges (flutes). The more flutes, the smoother (and slower) the cut. They can also be used to template-cut, flatten or remove lots of wood. They are among my busiest bits.

Edge-forming bits. These bits do decorative cuts, such as chamfers, ogees, roundovers and coves. For routers with ½-in. collets, you can get a matched pair of piloted bits that will cut a bevel-and-tongue profile that's 1⅝ in. wide. Rabbeting bits also fall into this category. Many edge-forming bits don't have pilots. You use a fence to guide them.

Piloted edge-forming bits cut a profile that can be varied only in the vertical plane, by raising or lowering the bit.-Unpiloted bits, because they have to be used with the router's fence, can be adjusted vertically and horizontally, and so are more versatile.

Panel pilot bits. These bits are used for drilling through the workpiece, and then cutting laterally. They are used for scrollwork and latticework. The pilot underneath can follow a template and do things like sink cutouts and curved designs.

Groove-forming bits. Like the straight-flute bits, these unpiloted bits make grooves, dadoes and rabbets. They include core-box bits, which can make the half-round flutes in a column or pilaster, and V-groove bits, which can simulate chamfered plank construction. They also include hinge mortise bits and dovetail bits.

Plunge bits. These unpiloted bits have cutting edges on their ends as well as on their sides. They can be straight or spiral fluted, carbide or HSS. They have two tasks: to cut material and to remove it from the hole—not an easy job. This probably explains why there's so much variety and confusion concerning plunge-bit configuration. I've had good luck using the Ekstrom Carlson spiral-flute HSS plunge bits (Ekstrom Carlson & Co., 1400 Railroad Ave., Rockford, Ill. 61110). They come in ¼-in. to ¾-in. sizes with ½-in. shafts. They last a long time and remove chips better than straight-flute bits. They can also be used to cut grooves and trim edges.

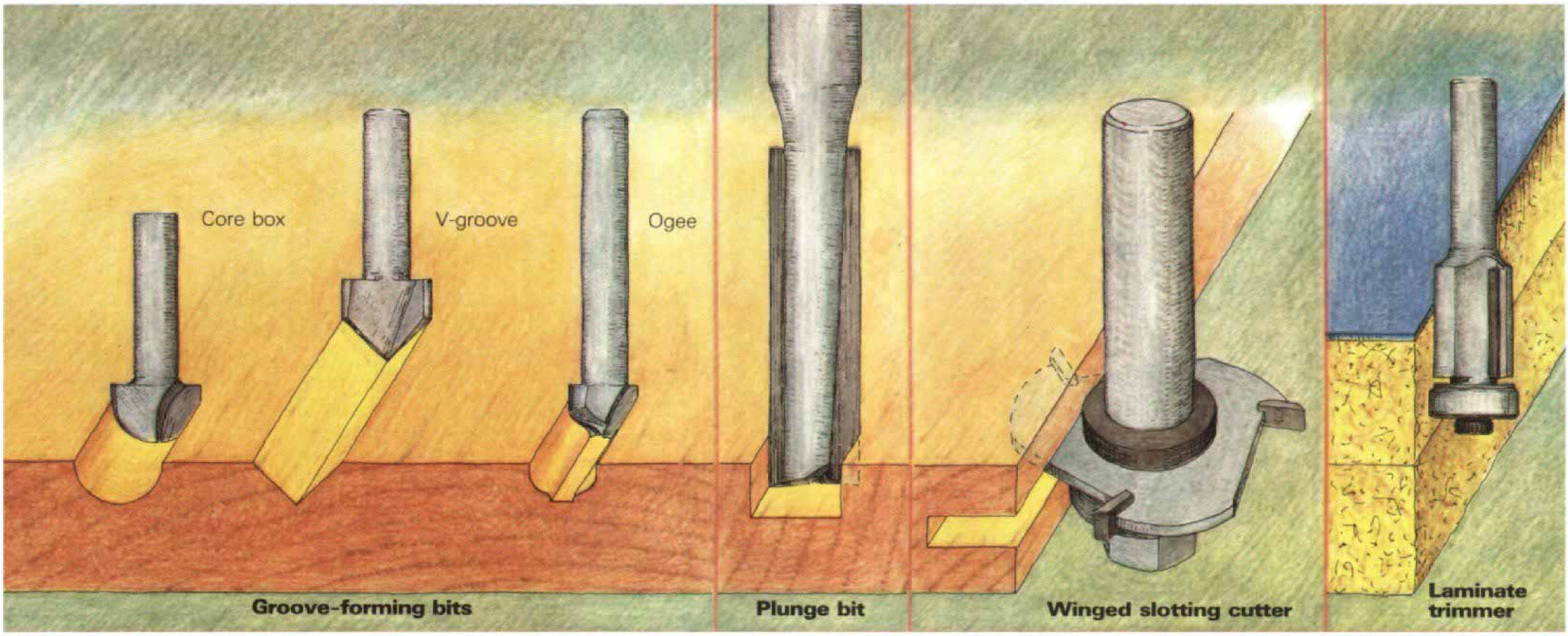
Slotting cutters. If you've got to cut a groove in the edge of a board, slotting cutters are what you need. They have two, three or four "wings," and each has a carbide cutting edge brazed to it. A slotting cutter's pilot bearing allows the wings to penetrate to a preset depth. Both dimensions, the depth of cut and the distance off the face of the workpiece, are very consistent. With one of these, you can cut *a* slot to accept the panel in your frame-and-panel door, or the tongue on your T&G flooring.

The slot width is determined by the cutter face. It can be from 1/16 in. to ¼ in. It is possible to get arbors, wing cutters and bearings, and interchange them to get the size slot that you want. These are very useful bits.

Laminate trimmers. Laminate trimmers are usually straight-flute carbide bits with a ball-bearing pilot that's exactly the same diameter as the bit's cutting arc. The bearing travels along the vertical surface of the workpiece, and trims the overhanging horizontal sheet flush with it. There are laminate-trim bits with 7½°, 10° and 22° bevels to ease the sharp edges on countertops where laminates meet at 90°.

Trim bits. This kind of bit resembles a laminate trimmer, but it is larger. And because the pilot bearing is positioned above the cutter, it can be used to follow a pattern or template that's mounted on top of the workpiece. These bits come in all sizes, from ½ in. to 3 in. long, and from ½ in. to 1 in. in diameter. They usually have straight flutes, but I have a 3-in. long, 1-in. diameter version made by Oakland Carbide Engineering Co. (1232 51st Ave., Oakland, Calif. 94601) that has spiral cutters. It's similar to the

Trim bit
A trim bit is used with a pattern to produce a finished surface. In the photo below, a 3-in. bit with a bearing above the cutters follows a straightedge clamped to a door.



one shown in *FHB* #10, pp. 38-39. With it, I can trim the bottom of 2-in. thick doors by using a straightedge as a guide (photo facing page), or I can make a pattern out of ¼-in. hardboard for curved surfaces. Curved or straight, the bit cuts a faithful copy of the pattern. Panels that are too large for the table saw can be cut with a skillsaw and then trimmed precisely with this type of bit.

Router-bit care—I keep my bits stored upright in a block of wood. Their shanks rest in holes drilled ¹⁄₆₄ in. oversize. Stored this way, they never touch anything that could damage them, especially neighboring bits.

A stubborn sludge of resin and wood dust can build up on the faces of router bits and actually make them duller by compacting right on the cutting edge. This can cause bits to overheat and sustain permanent damage. I keep my bits clean with a strong detergent like 409. I've tried various ammonia and commercial blade cleaners, but none seems significantly superior. I just give the bit a squirt and then wipe it clean in a few minutes. Every so often I'll mist all my bits with a light oil like WD40. Pilot bearings should get an occasional drop of oil. If you get contact cement on the pilot bearing while you are doing plastic-laminate work, take the time to soak the cement off in a solvent like lacquer thinner. Otherwise the bearing may seize, putting a decorative burn in your work.

After I've cleaned a bit, I drag it across my fingernail to see if it's sharp. A sharp one will drag and dig into the nail—dull ones simply slide across. You can hone and sharpen steel bits yourself, and I'm told that carbide bits can be successfully touched up with a diamond hone. But to tell the truth, I don't mess with sharpening bits. It doesn't cost much, and the pros are set up to do it right.

I clean the collet and bit shafts with fine steel wool. This helps to keep the bit from freezing in the collet. When I run up against a frozen bit, I take out a small brass mallet and gently tap someplace on the bit that is not a cutting edge. I try to tap at an angle that slightly tweaks the bit in the collet. I turn the shaft frequently between the slight taps. Eventually the bit comes free.

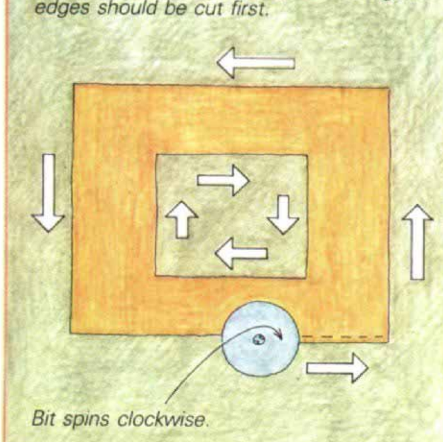
Putting router to wood—Before you install a bit in the collet, unplug the router. This is one rule I never break. Insert the bit shaft, and make sure it extends at least ½ in. into the collet. Better yet, put the shaft to the bottom of the collet, lift it ⅛ in. and then tighten the nut.

Now adjust the depth of cut—the distance between the baseplate and the cutter tip. Some routers have a threaded motor case that screws up and down into a threaded base. Others have rack-and-pinion gears that move the motor relative to the base. I measure the bit extension off the baseplate with a steel ruler scaled in 64ths, and I add a known amount to compensate for the slight movement that happens when you tighten the depth-lock wing nut. This slop is built into most routers, and you must take it into account if you want accurate results. Precise settings are critical in such operations as dovetailing drawers and mortising for hinges. Then I make a test cut and repeat; loosening, adjusting, tightening, until it's correct.

Before I turn on the router, I go over a mental list of safety checks. Is the work snugly clamped? Are the fences secure? Is the bit tightened? Is the cord out of the way and free to travel the distance of the cut?

Directing the router

Because of the high-speed clockwise rotation of the bit, there's a right and a wrong direction to enter the work. The router should be moved around the work so that the cutters are exiting the material as the router advances. In wood, the end-grain edges should be cut first.



If you've never used a router before, try a test cut in softwood with an edge-forming bit. The bit should enter the wood at full speed, so make sure the two aren't touching when you turn on the router. With the baseplate flat on the workpiece, slowly let the bit into the wood until the pilot touches the edge. Now lead the router around the edge so that the cutters are exiting the wood as the router advances from left to right, if the edge is facing you (drawing, left). If you go the opposite direction (back cutting), the bit will want to dig into the wood—self-feeding, it's called—like a little high-speed, steel-studded tire, taking the router with it. In some cases, however, back cutting can be useful. When routing across the grain, making a little back cut at the extreme right-hand edge of the work will eliminate the chance of the wood splintering out when the bit exits the cut.

Listen to the router. When you turn it on it will sound like it's running too fast. When it enters the wood it will have a lower pitch. As you feed more forcefully into the wood it will be lower still. But these changes in pitch are nothing compared to the lowering of the pitch when you begin to force the feed and overload the motor. Feed rates are affected by the obvious things—the power of the router, the sharpness and number of the cutters, the depth of cut and the type of material you're working.

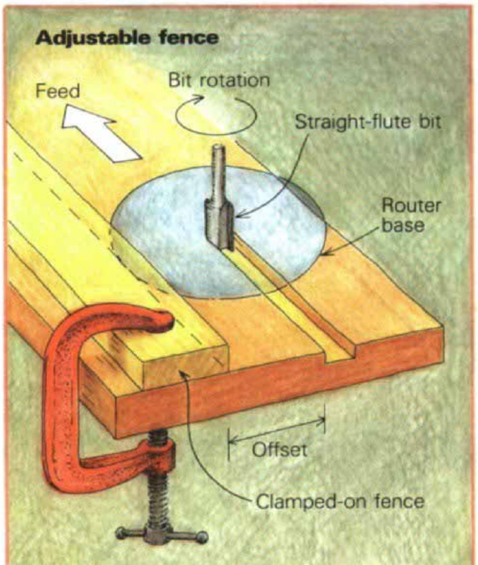
If your feed rate is too slow, the router will spin too fast, burnishing, often burning, the edges of the cut and tossing out chips that resemble baby powder. When it is cutting correctly, the router glides smoothly across the work, making mounds of large, smooth, clean chips. A router doesn't have to be gripped too tightly, and it doesn't have to be guided with too much force. If you relax and try to feel what the cutter is doing, you'll get consistently good results.

Fences—Most routers come with a fence attachment (called a guide assembly by manufacturers). It is typically made of two steel rods that attach to the baseplate, and a metal fence that slides over the rods. These fences work but they are inevitably too short or slightly skewed to the base, or the cutter is too large and the fence interrupts its arc. I hardly ever use factory-made fence attachments.

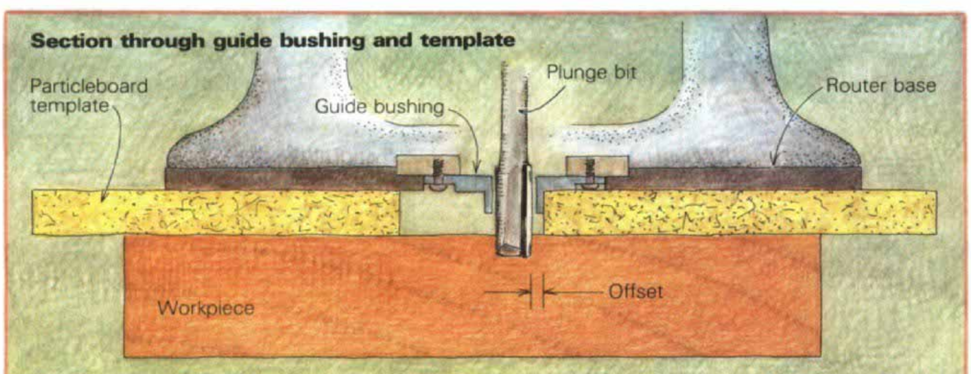
A fence can be clamped to the work (photo below) or to the router baseplate. It's usually a straight piece of scrap, but it can have an inside or outside curve in order to follow a matching curve on the workpiece. When you use a straightedge to guide a cut—for instance, a groove with a straight-flute bit—you should lead the router in a direction opposite the one that it's inclined to take (drawing below right). This way the router will snug itself against the fence, rather than try to push away from it.

The router mounted upside-down can act like a shaper. I had a machinist mill away some of the webbing under my table-saw wing, and drill a hole for the bit and some smaller holes for flathead screws that hold the router to the wing. This lets me mount my small router to the saw table (photo facing page, top left). The cutters protrude perpendicularly through the hole in the wing. A notched wooden fence clamps around the cutter (photo facing page, center left). I use fingerboard hold-ins and hold-downs made of Baltic birch plywood to steady the work. I can move the saw fence right up to the cutter, letting me make linear passes for moldings and casings. The saw's miter gauge can be used to make crosscut passes, easing the construction of finger joints, slip joints, half-laps and tenons.

Bushings—Guide bushings are collars that are screwed to the router base and surround the bit. The guide bushing (drawing, bottom left) is designed to bear against a template, allowing you to make accurate pattern cuts. These guides work especially well for small jobs where repetitive, accurate setups are required, such as hinge mortises (photo facing page, bottom left), dovetails and box joints. I find setting up bushing-and-template systems tedious, and they're frustrating to use. Often it's difficult to install the guide bushing so it's concentric with the cutting diameter of the bit. And when making templates, it can be a pain to figure the small offsets that have to be taken into account when using guide bushings. I prefer fences and templates, though some jigs and fixtures have to be used with guide bushings. This is certainly the case with stair-routing jigs and dovetail fixtures, where precise depth-of-cut adjustments are important.



A fence is usually a straight piece of scrap that is clamped to the workpiece (photo left). Here a worker uses a straight-flute bit to cut a groove in a piece of fir. In this arrangement, as in the drawing above, the bit's natural reaction will be to move to the right. Instead, you should feed the router from right to left. This prevents the router from cutting into the work too fast, and it will help to keep the baseplate against the fence. Make sure to calculate an accurate offset distance from the cut to the fence.



The bushing encircles the bit, and is screwed to the router base. As the bushing's collar follows the edge of the template, the bit cuts a mortise in the workpiece.

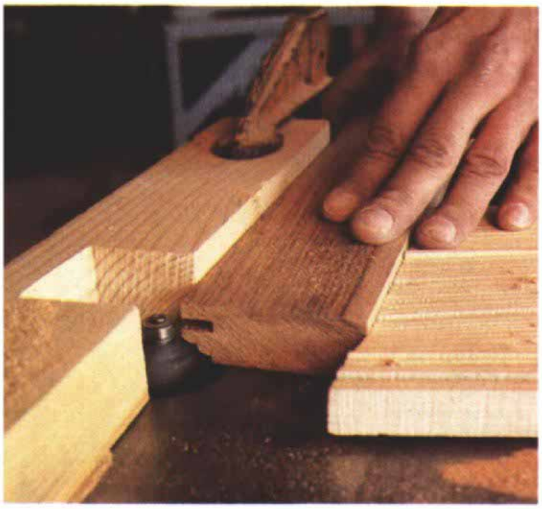
Templates—I made a simple template to mortise the butt hinges into the stiles and jambs of some custom doors. It works in conjunction with a custom-made square baseplate, and consists of a 7-ft. 1x4 with three identical mortise templates (photo facing page, right) made of ¼-in. particleboard. I can clamp this entire unit to a door, ensuring equal hinge spacing every time. I used hot-melt glue to position the fences, and then I tested each one for accuracy with a cut. The hot-melt glue lets me fabricate a template quickly, though the bond isn't very strong. When I'm satisfied with the fit, I anchor the fences with screws.

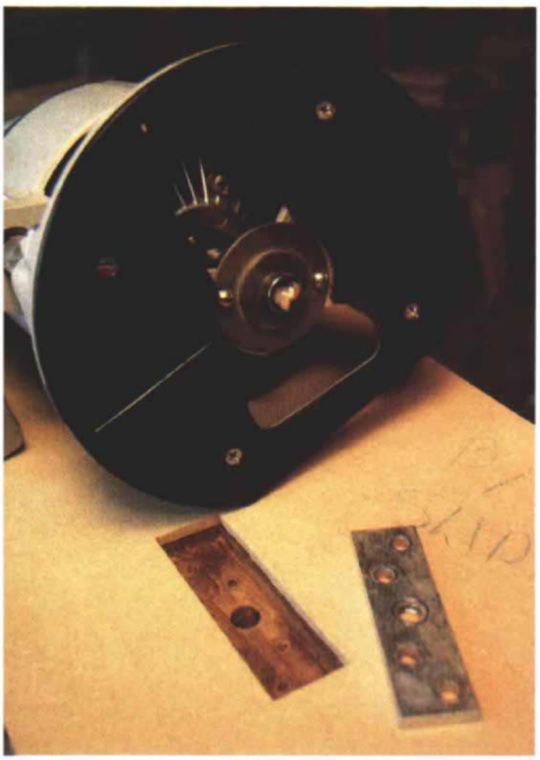
To cut a hinge mortise, I use a straight-flute bit set to a depth that equals the hinge thickness plus the template thickness. The bit enters the stile from the side, in a space cut into the template for this purpose. As I pass the router baseplate around the confines of the template fences, the bit cuts a mortise. If the mortise is a little wide, I stick a few strips of tape to the inside of the fences for shims.

Louver-door jig—My co-worker Peter Feirabend came up with a jig to cut louver mortises in a door stile. It takes advantage of the plunge router's capabilities and the square baseplate. A pair of 2x4 rails are clamped to the stile, and a template fits atop the 2x4s (photo p. 37). Holes drilled in one of the 2x4s are spaced one louver apart. They accept a dowel registration pin. Peter made the template by placing the square baseplate on a piece of ¼-in. particleboard, and gluing fences to the template on opposite sides of the baseplate. These fences lightly touch the baseplate, guiding the router in a straight line. Then he added stops to the template to limit the router's travel. These determine the width of the louver. In use, the template is oriented at 30° to the stile. Using a ¼-in. plunge bit, Peter lowers the bit into the work and makes a few passes back and forth. Then he retracts the bit, slides the template down the stile and moves the registration dowel to the next stop.

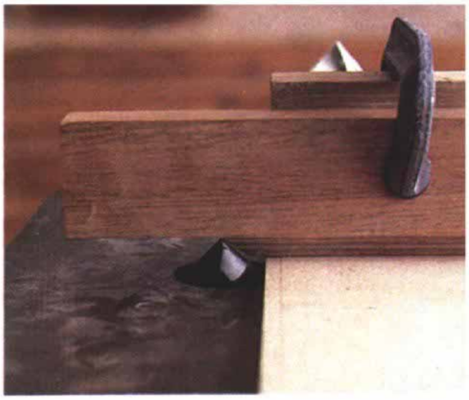
To make the louvers, I rip stock to the right dimension, and then I run it by a roundover bit mounted in the router/table-saw setup.

Cabinet doors—I use slip tenons (sometimes called loose tenons or inserted tenons) instead of dowels to reinforce doors and face frames at



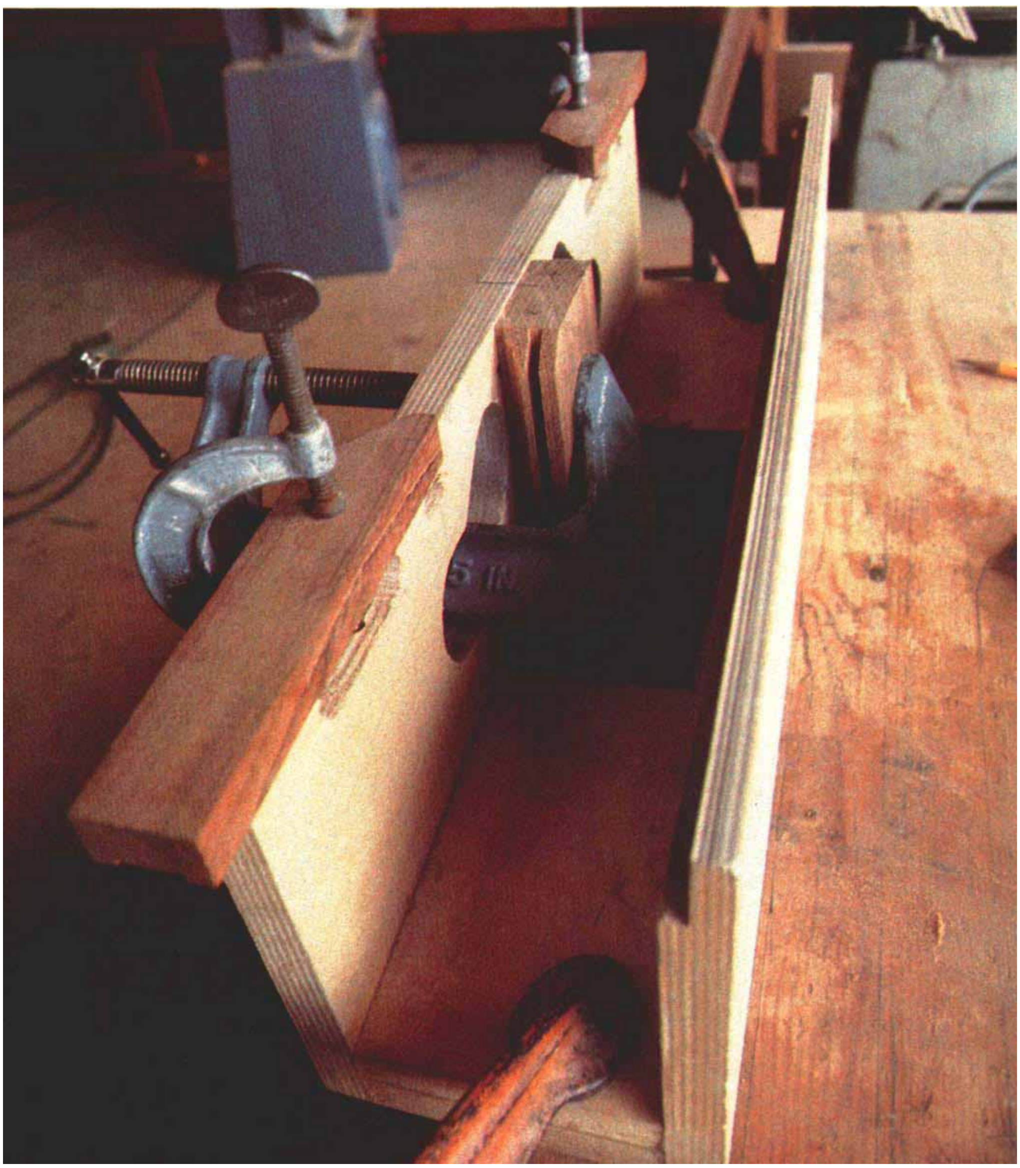


A router mounted under the wing of a table saw turns the saw table into a shaper (top left). The bit protrudes through the table, where a clamped-on wooden fence is aligned with it. At center, the author uses an ovolo bit with a fillet to carve a decorative edge on a door rail. A slot for the door panel was cut with a winged slotting cutter. The template at left is used along with a guide bushing (drawing facing page, bottom) to cut a hinge-plate mortise. As with all routed mortises, the corners are rounded and have to be squared with a chisel. Above, this template uses fences to guide the router base as the bit cuts mortises for butt hinges. The rectangular hole in the center of each template shows the area where the bit cuts. The slot in front of the stile is an entry hole for the bit.



Plunge-router door frames. **Savage's frame-and-panel doors are reinforced at the corners with slip tenons (above). The tenons are inserted into mortises cut with a ⅜-in. plunge bit. Where the rail and stile meet, the ovolo pattern must be mitered at 45°. To cut the miter, Savage uses a V-groove bit mounted under the wing of his table saw to act as a shaper (above right). The saw's miter gauge guides the work during the cut.**

The fixture in the photo below secures door-frame members while they are mortised with a plunge bit. The penciled centerline on the rail aligns with a centerline on the face of the fixture. During the cut (right), the router base rests on the fixture and travels between the two clamped-on stops. A fence clamped to the router base guides the cut. The first cut is ¼ in. deep. Subsequent cuts are ½ in. deep, until the final depth is reached.



the joints (top photo, far left). These joints aren't limited to light duty—I've used them with great success on entry doors up to 3 ft. wide.

I start by cutting grooves for the door panels in the rails and stiles with a ¼-in. winged slotting cutter, mounted shaper style under the table saw. At this point I could slot the end of the rails and butt-join the stile to the rail with a spline and have an acceptable frame for a cabinet door. But these doors have a pattern running on the inside of the frame, and they meet at 90°, so they must be mitered where the patterns join, as shown in the photo.

Next I run the pattern, in this case an ovolo with fillet, on the inside edge of the rail and stile stock (photo previous page, center left). Then I lay out the frame as if it were to be butt-joined, and I draw centerlines for the mortises across the rail and stile faces. Next I miter the decorative edge with, you guessed it, a V-groove bit (top photo, left).

Now I can plunge the mortises for the slip tenons. For this operation I use a fixture that clamps to the edge of my workbench. It has slots cut into it for various clamps to hold the frame parts and the stop blocks. The fixture's front panel has a penciled registration mark that aligns with the mortise centerline drawn on the rails and stiles (photo bottom left)- The fixture's front and back panels are at the same height, creating a surface for the router baseplate to ride atop that is perpendicular to the workpiece (photo center left). A fence clamped to the baseplate regulates the horizontal relationship between the cutter and the workpiece. To cut the mortises, I use a HSS ⅜-in. spiral-fluted plunge bit.

Finally, I make tenon stock the same way I shaped the louvers, and I cut them to length. The various parts are easy to assemble, and a strong custom door is the result.

Maintenance and safety—Most of the bearings in today's routers are sealed and don't need any maintenance other than wiping or blowing away the dust and dirt. The same goes for the motor and brushes. If you don't force the tool and overload it, it will do lots of work.

Routers are noisy, they make a lot of dust and they sometimes send bits of wood and metal flying about at high speed. Ear protection, dust masks and goggles are standard precautionary garb. To be honest, I don't always wear these things when I'm doing plunge cuts because the bit is contained by the work. But if I've got my snout down there at ground zero watching the bit make a cut, I've got every piece of safety equipment in the shop on my head.

When you are back-cutting around a corner where the change in grain direction causes tear-out of the fibers, use great care. Hold the router firmly and be ready to counter a good amount of pull.

A safer way to get the same result is to clamp a scrap piece to the edge of the workpiece for the bit to exit through. This protects your finished edge from tear-out. □

Craig Savage builds custom homes near his home in Kootenai, Idaho.

Photo top right: Dick Oniell