No shortage of choices. *Router bits come in a variety of profiles, materials and sizes. Storing them in a fitted box helps protect edges and makes bits easy to find.*

All About Router Bits

How to choose the ones you really need

by Jeff Greef

For many woodworkers, a good-quality router may seem like an expensive tool. But few of us realize as we start to acquire tools that the cost of a router, or even several routers, pales in comparison to what we'll spend over time for bits. The growing selection of bits is what makes the router so versatile. They're capable of everything from molding edges to cutting raised panels. But with so much to choose from, it's harder than ever to buy wisely.

It's surprising that a tool with roots in metalworking should become such an indispensable tool for woodworking. The router has no hand-tool counterpart—it's a milling machine.

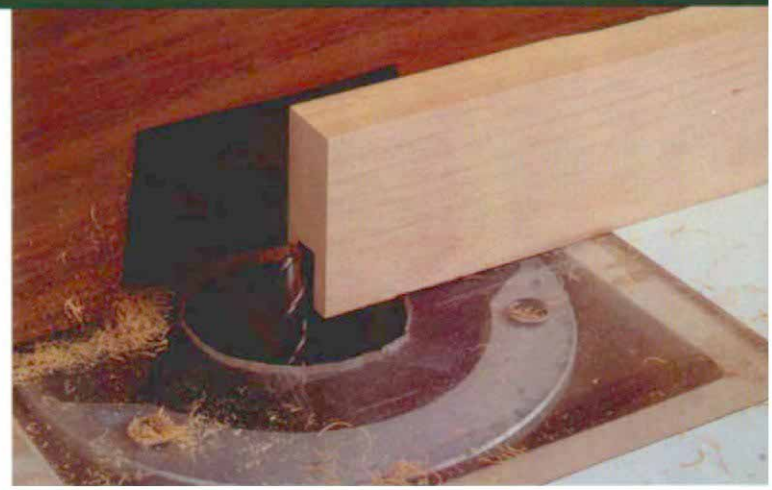
Router and bit technology was transplanted first to industrial woodworking operations and then to the small shop. And industry is still the source of advances we see in bit design. At one time, for instance, carbide was an exotic material for industrial use only. Now it's more common than steel.

Similarly, new materials, coatings and bit styles are slowly working their way into the mainstream. It's easy to amass a wallet-flattening, little-used collection. You have to weigh the bit's intended use as well as its cost and overall quality. The story on pp. 46-47

Photo this page: Scott Phillips

Both bits make a cut 1/2 in. wide, *but the 1/2-in. shank (left) reduces chatter and allows a more aggressive cut than the 1/4-in. shank bit.*

Spiral flute cutters slice wood fibers. *The down-shear bit (left) leaves a crisp edge at the top surface. The up-shear bit efficiently ejects chips.*



Machinist's end mills look just like router bits for wood. *End mills make good, inexpensive alternatives to spiral bits.*

gives suggestions on bits for specific cutting operations.

Carbide stays sharp longer than steel

High-speed steel and tungsten carbide are the two most widely used materials in router bits. Steel is inexpensive, and because of its uniform crystalline structure, steel can take a keen edge and can produce a very smooth finish.

Steel bits may be the right choice for short runs or one-time operations. You easily can sharpen flat-fluted steel bits and, with a grinder, modify the profile. But steel wears quickly, especially in highly abrasive materials like plywood, medium density fiberboard (MDF) and particleboard.

Tungsten carbide is an alloy of carbide granules and powdered cobalt fused under high pressure and temperature. The hardness of carbide is directly related to the amount of cobalt used—the smaller the percentage of cobalt binder, the harder the alloy.

But an extremely hard metal is brittle, too fragile for a cutting edge. So manufacturers strive for the best compromise between hardness and shock resistance. Because of extreme hardness, carbide holds an edge 25 times longer than steel. And although more expensive than steel, carbide is generally a better value.

Most carbide bits have carbide-cutting tips brazed to a steel body, combining the hardness of carbide and the economy and shock resistance of steel. Manufacturers also offer solid carbide bits. These bits are much more expensive. But a solid carbide bit has two advantages: It will withstand high temperatures generated by high feed rates and continuous use, and it's more than three times stiffer than steel so that chatter and tip deflection are minimal. Sharpening carbide bits is more difficult than steel, but for minor edge touch-ups, a diamond honing stick can be used.

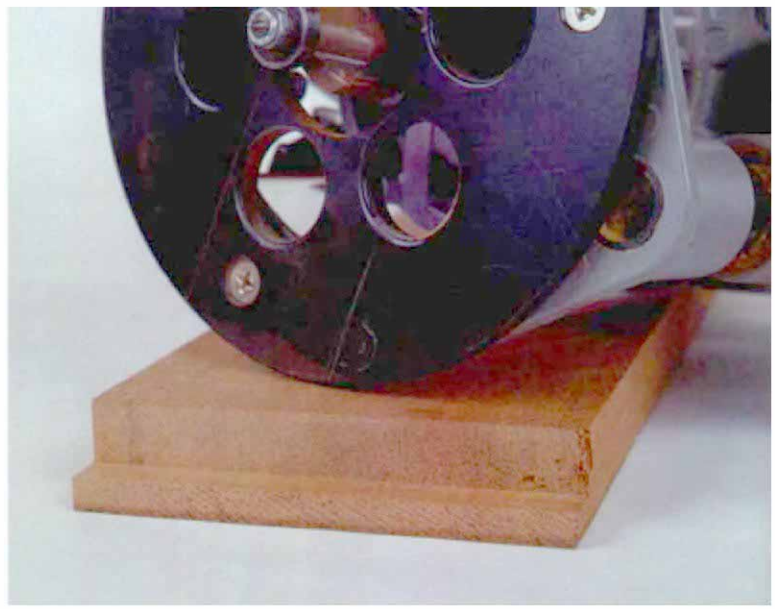
Polycrystalline diamond bits are now being advertised as the ultimate bit for highly abrasive man-made materials. A typical bit costs approximately $500 (which is 40 times more expensive than carbide but lasts 150 times longer). Users are large commercial manufacturers, but if history serves, we may someday see these bits in small shops.

Matching the bit to the job

How well a bit performs depends on factors like shank

Shear angle reduces tearout on end grain. *The angled cutter on this rabbeting bit cuts cleanly in redwood.*

Straight bits chop the wood. *Bits without a shear angle cut cleanly with the grain but not as smoothly on end grain.*



diameter, number of flutes (or cutting edges), shear angle of the cutter and type of pilot

***Use largest shank** diameter*—Shank diameter should correspond to cutter size (see the top left photo on p. 45). Large bits need the stiffness of ½-in. shanks to minimize vibration and deflection. Many bits with small cutting profiles are only available with ¼-in. shanks. If you have a choice between a ¼-in. or a ½-in. shank, pick the larger one. The router's collet will grip better, and the extra mass minimizes chatter (the result of vibration and deflection) to produce a better cut. And select the shortest cutting edge that meets your needs because excessive length increases vibration.

More flutes for a smoother cut—The gap, or flute, in front of the cutting edge provides clearance for chip removal. Most bits have two flutes, but some have one, three or four. More flutes (and, therefore, more cutting tips) produce a smoother cut, but they reduce the feed rate the bit will allow. Conversely, a single-flute, straight bit works great for making rough cutouts in stock quickly.

Choose a shear angle that's right for the job—Bits cut better when the cutting edge is angled slightly in relation to the centerline of the bit. This is called the shear angle, The effect is similar to skew-cutting with a plane or a chisel. Bits with no shear angle chop their way through the stock. The shear angle causes more of a slice than a chop, producing a smoother cut. Most manufacturers I spoke with believe the difference is only pronounced on end-grain cuts (see the bottom photos on p. 45).

The shear direction can be either up or down. Up-shear bits (the most common) quickly clear chips from the cut and tend to pull the router base down on the work. Down-shear bits are used where an upward cut would leave a ragged edge at the top surface. Down-shear bits make exceptionally clean cuts in veneered and laminate-covered surfaces. However, they do not clear chips well when mortising and tend to push the router base off the work.

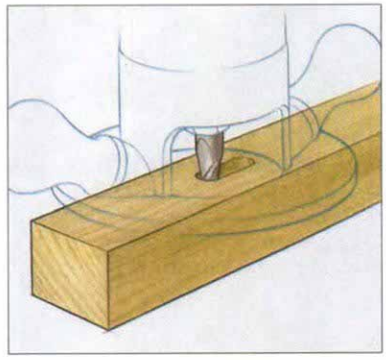
Spiral bits take shear angle to the extreme. The helical flutes (see the top center photo on p. 45) provide a continuous slicing action and are excellent at ejecting chips from the cut. They are especially well-suited to mortising. For a more economical alternative, you can use two-flute, machinist's end mills. These are cutting bits designed for machining metal, but they also cut wood. Like spiral bits, end mills have helical flutes (see the top right photo on p. 45) and cut wood very well. The range of sizes is more limited than router bits, but they are inexpensive and are easily available at industrial tool-supply stores.

A note of caution when using up-shear spiral bits and end mills: the force developed by the high shear angle tries to pull the bit out of the collet. Be sure the collet and bit are in good condition, free of rust and burrs. The bit should be

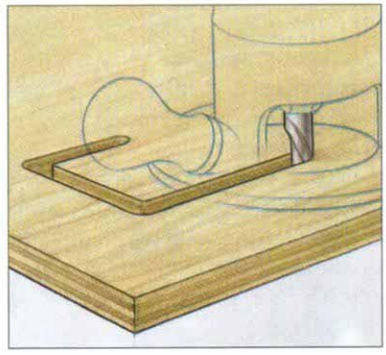
Bits for specific cuts

You'll get the best results by choosing a router bit specifically designed for the job. If the bit is to be used regularly, a bit with a ½-in. shank and high-quality carbide is a good choice. *—Dennis Preston, assistant editor*

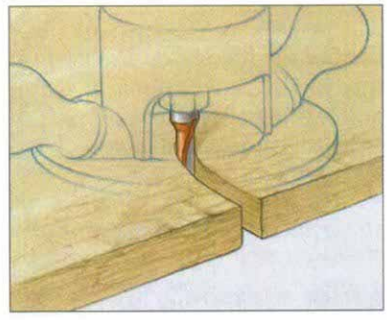
Plunge mortising and dadoes: A spiral up-shear bit (far left) is unmatched in its chip-clearing ability. These bits cut fast and clean with minimum chatter. When cutting into laminate or splintery wood, use a down-cut spiral to eliminate chipping at the top edge of the cut. It will be slow going, though, because you will have to stop frequently and blow the chips out of the cut.



Cutting through stock with two good sides: A compression bit (half of which is an up-shear and the other half a down-shear) is a specialty bit used when the edge of both upper and lower surfaces must be crisp. This bit design sacrifices feed rate and chip-clearing ability for unblemished edges.

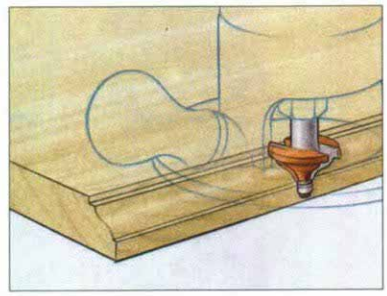


Making rough cutouts through stock: A single-flute, stagger-tooth bit cuts aggressively and roughly. The tooth orientation minimizes chatter.

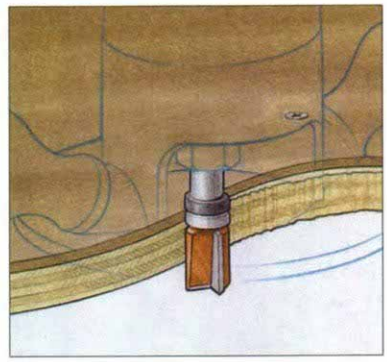


Drawings: Bob La Pointe; photos except where noted: author

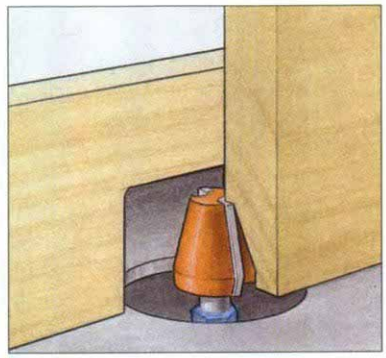
Edge molding and rabbeting: A bit that has a slight shear angle cuts more smoothly. For freehand routing and following curves, a ball-bearing pilot is the easiest to use. An edge-guide attachment or a fence lets you use a bit that doesn't have a pilot.



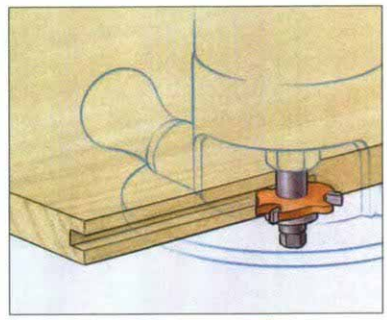
Template and pattern routing: Flush-trimming or pattern-routing bits have a pilot bearing mounted on the shank, either above or below the cutting tips, and are used with a template to guide the bit. The top-pilot location has one big advantage over a bottom-mounted bearing. The template can be mounted above the work and the bit plunged into the work.



Panel raisers: Large-diameter bits let you lay the stock flat on a router table. These bits generally produce a smooth finish. With them, you can easily follow curves. But these bits should be run at about 12,000 rpm, which is slower than most fixed-speed routers. Face molding, or safety raisers (shown at left), can run at higher speeds but the stock must be held on edge against a fence. Molding a curved piece of stock is not easy.



Grooving for splines and biscuits: A slot cutter is really a small saw with a precise kerf width. You can mount cutters from 1/16 in. to 1/4 in. on a standard arbor. Some new sets allow stacking cutters like a dado set to get widths up to 11/16 in. Changing the diameter of the pilot bearing controls the depth of cut.



well-seated, not bottomed out, in the collet, and the collet nut must be securely tightened.

Ball-bearing pilots work best for edge profiling —A pilot bearing, found on edge-trimming and edge-molding bits, guides the bit and limits the depth of cut (see the top right photo on p. 48). One-piece steel bits generally have a solid pilot, which is simply a small knob at the end of the shank that rubs against the edge of the work. Solid pilots work, but two problems can arise. If you don't keep the bit moving, the spinning pilot generates enough heat to burn black marks in the edge of the stock. And because of their small diameter, solid pilots can dig into the surface on which they ride, particularly on softer woods. That causes the cut to go slightly deeper than intended. Ball-bearing pilots take care of these problems. The large-diameter pilot bearing is unlikely to dig into the wood, and burning is eliminated because the bearing doesn't spin against the wood.

Arbors with removable cutters are versatile

Bits come in two basic designs: those with cutters permanently attached to the shank body and those with separate cutters that attach to a threaded shank, or arbor, with a nut. When you want a different profile with an arbor and cutter set, all you do is change the cutter itself.

Bits with separate cutters are versatile and cost far less than buying a number of separate bits. I have one arbor on which I can fit one of two rabbeting cutters with any of three different diameter pilot bearings (see the top left photo on p. 48). This gives me six different rabbet depths. Pilot bearings of different diameters often can be switched even on bits that do not have interchangeable cutters. The bearings change the depth of cut and expand the bit's usefulness. In fact, a slightly smaller diameter pilot bearing is the only difference between a beading and a roundover bit.

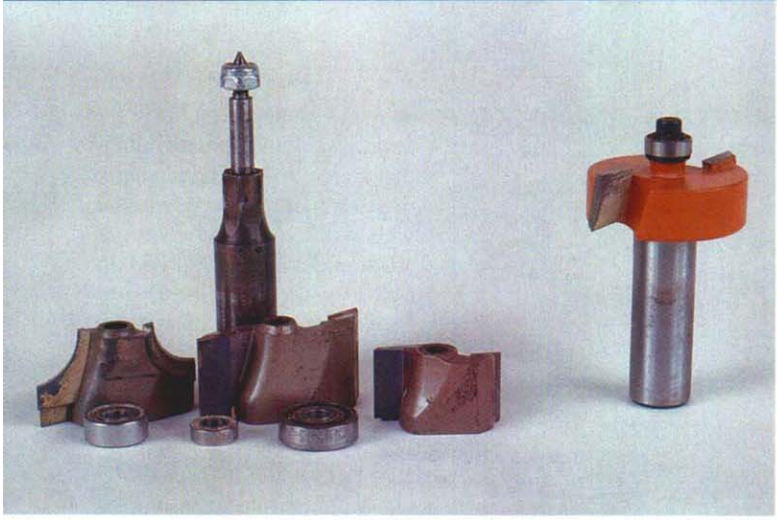
Replaceable cutters and special coatings

Carbide insert tooling, long available in industry, lets you replace just the cutters when they get dull. A disposable cutting bit is fastened to the body with screws. Initially more expensive than fixed-cutter bits, insert tooling may be cheaper in the long run for heavy-use applications because the cutters are cheap to replace. Insert tooling offers a consistent cutting diameter or profile. The same can't be said for standard bits whose dimensions are altered by sharpening.

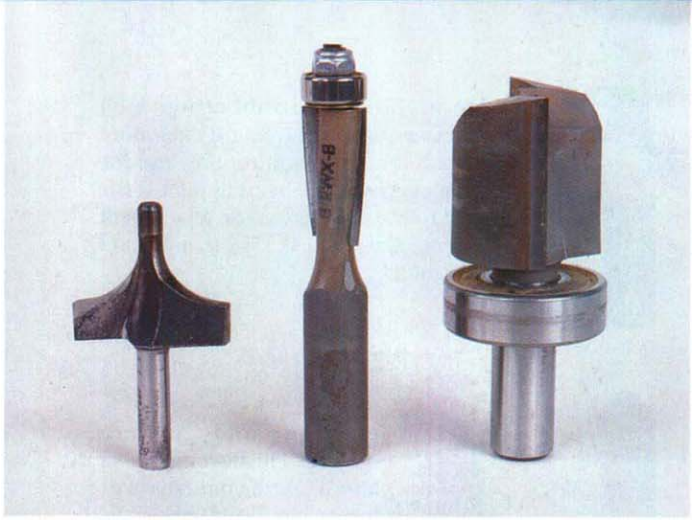
Brightly colored, Teflon coatings are now widespread on several brands of bits. These coatings reduce pitch buildup and promote chip clearing. In my work, I have not found this to be a big advantage, but colored bits do enhance safety. A spinning red or yellow bit is easier to see than a dull gray one.

The coating used on industrial metalworking bits, such as titanium nitride and zirconium nitride, are beginning to push into woodworking. Because these coatings are slippery,

Photos these two pages: Scott Phillips



Interchangeable parts are versatile. *A variety of cutters and pilot bearings can be mounted on one arbor, saving the cost of buying a number of single-purpose bits.*



Pilots guide bits for uniform cut. *The solid pilot on the end of the bit at left spins against the stock and leaves burn marks. The ball-bearing pilots on the center and right bits eliminate burning.*

they withstand tremendous heat and promote faster chip clearing on very abrasive materials. The result is cooler cutting and longer tool life.

Anti-kickback designs are widely available

Most manufacturers now offer an anti-kickback design on their bits, which limits the amount of wood the bit can bite on each revolution (see the bottom left photo). This prevents overfeeding, which can cause kickback. Many manufacturers I spoke with believe this design is most useful on shaper cutters and on large router bits like panel raisers where kickback is a serious threat. The smaller bits, they said, don't present enough danger to warrant the design. I agree with them.

How to spot a quality bit

Finish grinding is the most expensive process in bit manufacture and the most critical. A smooth cut requires a sharp edge, and a sharp edge requires a smooth face and edge. Technically, grinding faces smooth is easy; grinding edges is not, particularly on curved, pattern-shaping bits. I have seen wide variation in the smoothness of edge grinding on bits, and now it's the first thing I look for.

Take a pencil with you when buying a bit. Run the tip along the edge of the bit. If the tip scrapes along rather than slides smoothly, chances are the bit has been ground to a rough finish and will leave small nicks in the work (see the bottom right photo). A rough grind also causes the bit to dull faster because the minutely serrated cutting edge loses relatively big chunks of carbide granules.

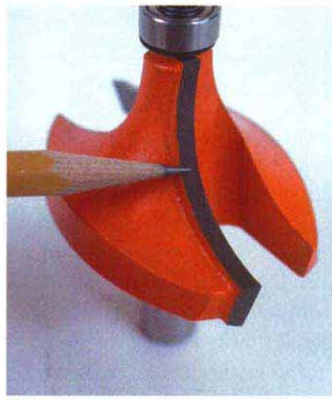
Carbide tips must be brazed securely to the steel body or the brittle carbide can break loose and fly like shrapnel. Always inspect bits for brazing voids. Don't use any that appear unsafe. In industry, a general rule is to reject any bit with a void larger than a pinhole.

Many manufacturers I spoke with said that a visual inspection of a bit says a lot about its quality. If the brazing is splattered or a grinding wheel has touched a spot it shouldn't have, attention to detail was lacking. The presence or absence of any kind of warranty with a bit is probably a good measure of the manufacturer's confidence in its work.

Why are there such wide price differences in bits that look similar? Generally, it's because there are many manufacturing practices affecting quality that you can't see. There is no universal quality standard for rating carbide, and it all looks the same.

The care taken by the manufacturer when brazing the carbide to the body and grinding the edge may not be obvious. Yet these factors can affect the longevity of the material because overheating reduces carbide's ability to hold an edge. Some bit shanks are hardened, others are not. The quality of grinding on the shank itself determines how accurately the bit spins and cuts. All of these factors are reflected in the cost.

Chip-limiting anti-kickback design reduces the bite *that the bit can take and prevents overfeeding.*



A pencil slides easily *along a smoothly ground edge. The lead is scraped away on a coarsely ground edge.*

Choosing bits and building your collection

The most important factor to consider when deciding how much to spend on a bit is cost per cut. Many expensive bits are made to be used in commercial situations where the bits will be used to destruction. In the long run, it is more cost effective for commercial shops to buy the most expensive bits.

But if you won't be using a bit very much, it doesn't make sense to buy the most expensive one. A less-expensive bit might not hold up as long, but you may not use it enough to have it re-sharpened even once.

Many bit manufacturers and retailers offer boxed bit sets at lower prices. Before you buy one of these sets, though, seriously consider whether you will use more than half of them. The price break you get on the set may be substantial, but if you use less than half the bits, you will have spent more money than if you had bought only the bits you'll need.

Choose bits as you go according to the design and profile you need and the quality you want for that bit. □

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