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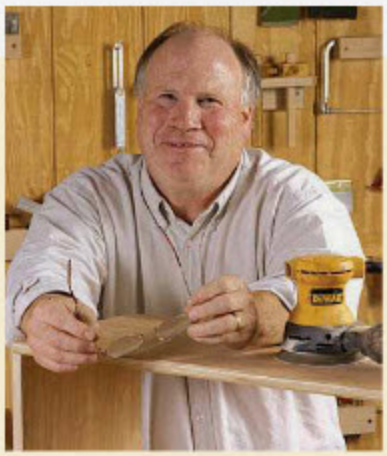

GETTING STARTED

I built my first woodworking project in the mid-1970s. My "shop" was tucked into the corner of a shoebox-sized basement in a small town-house apartment. It contained my entire collection of woodworking tools: a jigsaw, a drill, a few drill bits, a smooth plane, and a pair of wobbly sawhorses.

What it lacked in space and hardware was more than balanced by a full measure of curiosity and enthusiasm. Equipped mostly with experience gained years earlier in junior-high woodworking class, and inspiration from a few recently read books, I began my first serious project—a 7-ft.-long trestle-style dining table made from local eastern white pine.

To my delight, every step of the process proved to be a joy. Despite working with only a few rudimentary tools and a bare minimum of space, I managed to take a jumbled pile of odd boards and transform them into something of lasting value.

I'm pleased to say that table turned out beautifully. Indeed, for weeks afterward, I'd find myself stopping to admire it from various elevations and angles. The fawning ended only after I sold the table to raise cash for more tools. Clearly, the craft of woodworking had me hooked.

My hope is that this special issue of *Fine Woodworking* will get you hooked, too. If you think that working wood might just be for you, if you're just getting started, or if you're a veteran who wants a refresher course, *Basic Skills and Techniques* has a lot to offer.

Good woodworking and good fundamentals go together like a snug-fitting mortise-and-tenon joint. With that in mind, each article in this special issue, including those originally published in *Fine Woodworking* magazine, focuses on one of the fundamentals. Once you learn those basics, your woodworking will have a sturdy foundation, one you can build on to reach any level of the craft.

Woodworking is a wonderful hobby. I've relished it for more than 30 years. Now, perhaps, with the help of *Basic Skills and Techniques*, you also can begin to enjoy its many pleasures.

—Tom Begnal
Basic Skills and Techniques editor

basic skills & techniques

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Fine WoodWorking

Group Publisher	Anatole Burkin aburkin@taunton.com
VP, Advertising Sales	Rick Straface rstraface@taunton.com
Advertising Director	Peter Badeau 203-304-3572 pbadeau@taunton.com
Custom Solutions Manager	Brenden Delaney 203-304-3590 bdelaney@taunton.com
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Q&A

Do I need a 6-in. or an 8-in. jointer?

Q: I'm a novice woodworker, and I'd like to know if an 8-in. jointer is worth the huge price increase over a 6-in. model.

—DUSTIN FUNK, Moose Jaw, Sask., Canada

A: IF I WERE JUST GETTING STARTED in woodworking, I would buy the best-quality 6-in. jointer I could find and use the savings for my next tool acquisition. A 6-in. jointer (the size is determined by the length of the knives) will easily straighten a 6-in.-wide by 8-ft.-long board, which is stock that's suitable for many projects. Shop space also is a consideration: An 8-in. jointer takes up quite a bit more room than its smaller brethren (primarily due to the longer infeed and outfeed tables). I have an 8-in. jointer in my shop and only occasionally benefit from the added width. Also, an 8-in. jointer often requires 220-volt power, something not always available in a small shop.

—Roland Johnson, contributing editor

Testing for sharpness

Q: Is there any way to test for sharpness while you are honing a blade without loading it in a plane and taking a cut?

—BILL WOODSON, Peoria, Ill.

A: YOU CAN QUICKLY TEST FOR sharpness by holding the tool lightly between your thumb and forefinger and lowering the edge gently onto the thumbnail of your other hand. A sharp blade will catch on the nail immediately. A not-quite-sharp blade will skid a little and then catch, but not very solidly. A dull one will slide.

If your blade fails the nail test, go back and start at the beginning of your honing process. Use a honing guide for quick, consistent results. Spend plenty of time on the coarsest stone until you feel a fine burr along the entire back of the blade. Then go through the abrasives again, one by one, lapping the burr off the back after you finish with the finest grit.

—Aimé Fraser, woodworking teacher and writer

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To contact us:
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The Taunton Press
63 South Main Street
PO Box 5506
Newtown, CT 06470-5506
Tel: 203-426-8171

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Photos, this page: Lynne Christiana (top); Michael Pekovich (bottom)

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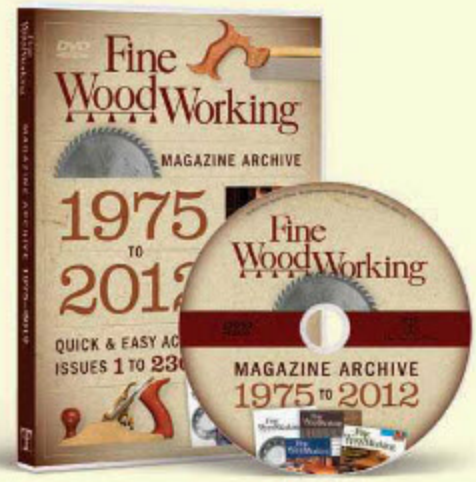

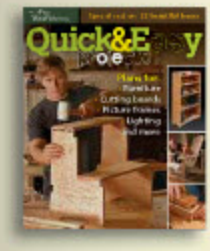

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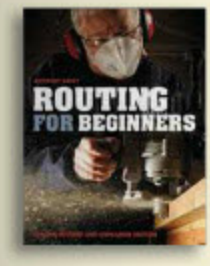

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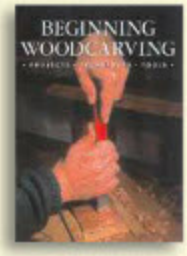

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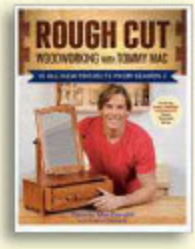

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Removing excess glue

Q: What is the best technique for removing excess white or yellow glue, so it doesn't hinder or discolor the finish that comes later?
—MARK NEWFIELD, Minneapolis, Minn.

A: SOAK A CLEAN RAG IN WARM water, then wring it out and wrap it around the blade of a flexible putty knife (see photo, left). The warm water loosens the glue, and the blade lifts it from the surface. Rewrap the blade with a clean section of the cloth as glue accumulates, and rinse out the rag frequently. This method allows you to restrict and focus the amount of water (and heat) being applied, so don't worry about excessive moisture penetrating the glue joint and causing failure. It works well for getting glue out of inside corners.

When the wood dries, you'll likely find the grain slightly raised in the area that was wet. Use a fine-grit sandpaper to smooth the raised grain.

—Mario Rodriguez, woodworking teacher

Preventing outfeed snipe

Q: I am experiencing snipe (a slight dishing of both sides of the wood surface at the end of a board) on the outfeed side of boards when I run them through the planer. What can I do?
—NICKIE PARNELLO, Chicago, Ill.

A: OUTFEED SNIPE HAPPENS when the roller on the infeed side drops down when the aft end of the board has left it. Whether or not your planer is well-tuned, there is a simple trick for preventing the problem.

Keep a sacrificial board on hand that's the same thickness as the rest of your stock. Butt the forward end of the sacrificial board to the aft end of the first board in midfeed. The sacrificial board will keep the infeed roller elevated while the aft end of the good board passes under the cutterhead.

—Steve Rowles, woodworker

Selecting a bench vise

Q: I am trying to choose a bench vise for my workbench. What is the advantage of a traditional wooden shoulder vise over a regular metal front vise?
—JOHN HINYARD, Orlando, Fla.

A: ADVANTAGES OF THE WOODEN shoulder vise are a less-restricted holding area and wooden jaws, which are less likely to mar the workpiece. On the downside, these vises usually open only 8 in. to 10 in. and aren't suitable for holding small metal or hardware parts.

Large metal vises usually open wider than wooden vises and often have dogs and quick-release mechanisms. To protect your work, add a softwood face to each jaw.

—Christian Becksvoort, contributing editor

Metal front vise vs. shoulder vise. *With a metal vise (top), you often need additional support to hold large pieces. The shoulder vise (bottom) allows the workpiece to extend downward to accommodate large pieces such as cabinet doors.*

Photos: Erika Marks (left); Marcia Ryan (right); Kelly J. Dunton (opposite page)

Solvents reveal planer marks

Q: Lots of times after finishing a project, I see planer marks that I missed when sanding. How can I spot these marks before the stain and finish are applied?

—BOB REDINGER, Shorewood, Ill.

A: BEFORE YOU APPLY A FINISH to a surface, wipe on a solvent such as naphtha, mineral spirits, or denatured alcohol, which, unlike water, will highlight planer marks without raising the grain. The solvent will evaporate quickly and won't interfere with any subsequent stains or finishes you might apply.

—Matt Berger, former FineWoodworking.com editor

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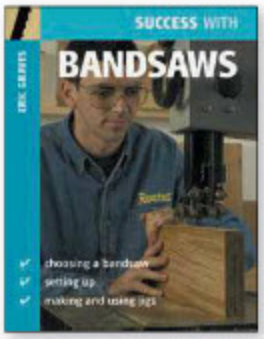

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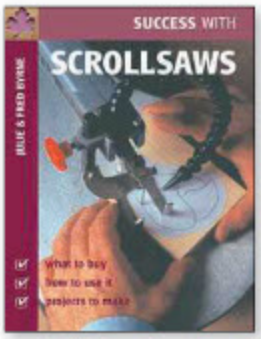

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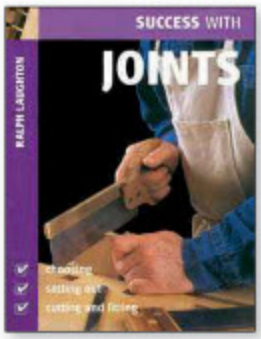

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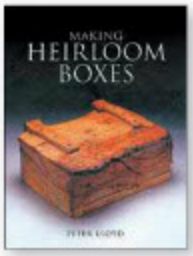

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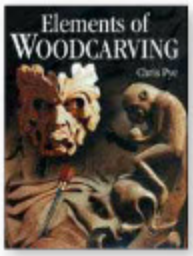

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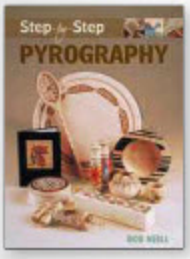

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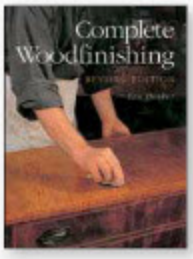

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How yellow glue works

BY CHRIS A. MINICK

You'd think that after 3,000 years scientists would know why adhesives stick things together. The truth is they don't: Different theories abound, but nobody really knows for sure.

These arguments are of more than academic interest to woodworkers. Knowing how glue works will help you get the best results when using it.

Why glue sticks: a brief chemistry lesson

Adhesion is an extremely complex process; no single theory can fully explain the phenomenon. Dozens of theories have come and gone through the years, but currently the most popular for polyvinyl-acetate adhesives (PVA) are the mechanical-interlocking theory and the specific-adhesion theory.

Mechanical adhesion is fairly straightforward: The liquid adhesive flows into the pores and crevices in the wood's surface, then dries. The resulting hard, little glue fingers hold the two boards together. While this lock-and-key effect undoubtedly occurs, the strength of the bond produced by mechanical adhesion is too low to explain the high bond strength (around 3,500 psi) in most joints bonded with PVA wood glue. Clearly, something else also occurs as the adhesive sets.

That extra something is explained by the specific-adhesion theory. Specific adhesion involves the interaction of the adhesive and the wood on a molecular level. A little chemistry is needed to explain this phenomenon: Cellulose molecules in wood contain an abundance of hydroxyl groups, the same chemical groups found in alcohols. PVA molecules are rich in carbonyl groups. During the curing process, the cellulose hydroxyl groups link with the adhesive carbonyl groups through a force known as hydrogen bonding. These bonds hold the boards together.

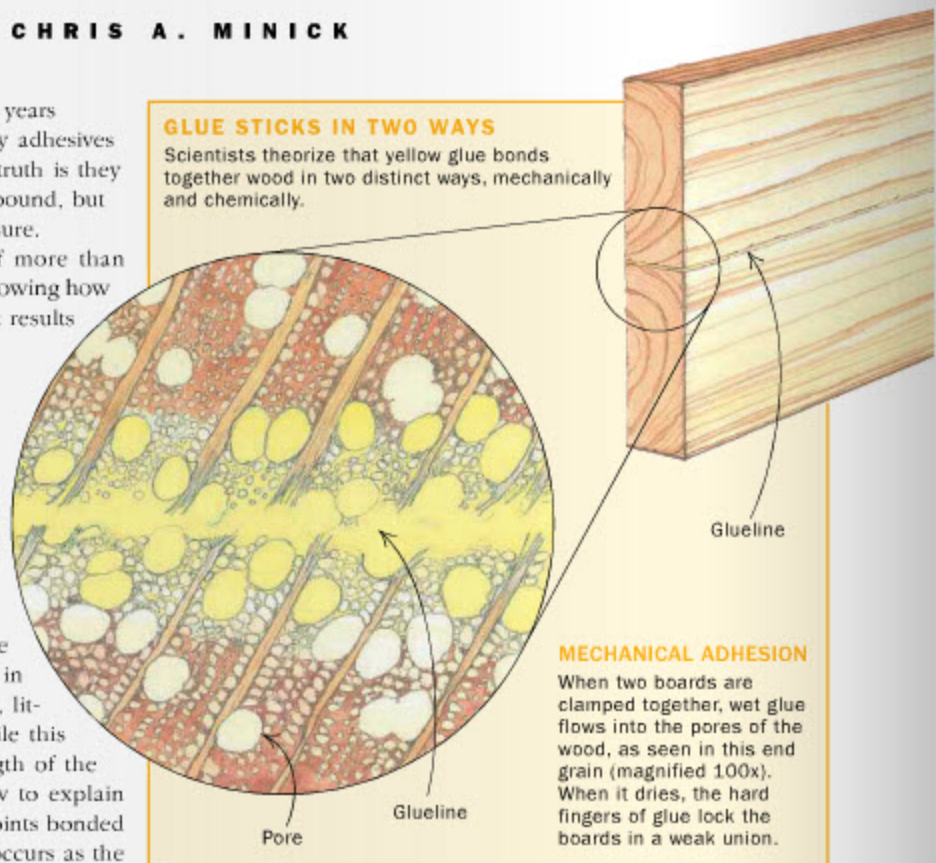
When yellow glue and wood combine

It is hard to imagine woodworking without adhesives. Furniture builders have been gluing together wood for several thousand years. For most of that time, animal glue of one sort or another was their only option. That changed about 50 years ago with the introduction of PVA adhesives. Among woodworkers, yellow, or aliphatic-resin, glue is the best-known variety.

To make yellow glue, vinyl-acetate monomer is mixed with water, a catalyst is added, and then the mixture is heated to produce PVA. Surfactants (which aid penetration), pigments, and specialty ingredients are added to produce a workable wood adhesive.

GLUE STICKS IN TWO WAYS

Scientists theorize that yellow glue bonds together wood in two distinct ways, mechanically and chemically.

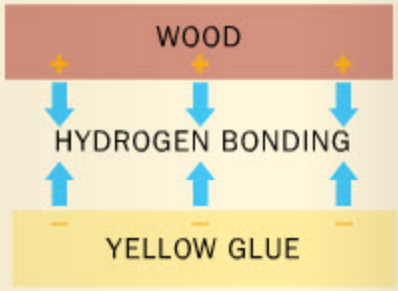


MECHANICAL ADHESION

When two boards are clamped together, wet glue flows into the pores of the wood, as seen in this end grain (magnified 100x). When it dries, the hard fingers of glue lock the boards in a weak union.

CHEMICAL ADHESION

Positively charged hydroxyl groups on the wood's surface are attracted to the negatively charged carbonyl groups in the yellow glue in a process known as hydrogen bonding. This is the main force that makes yellow glue a strong adhesive.

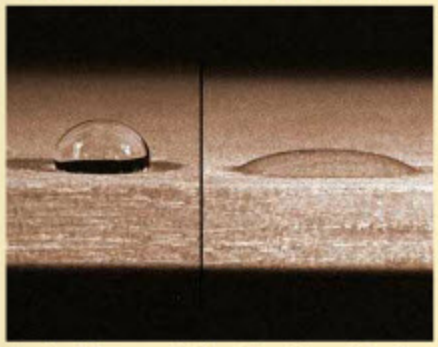


When a thin film of yellow glue is spread between two pieces of wood, a dramatic transformation takes place. Initially, the adhesive between the two boards is more water than polymer particles. Clamping pressure, coupled with the surfactant in the adhesive, causes the liquid glue to wet the wood, and the water quickly penetrates into the top layer of wood fibers. Capillary action continues to draw the water and polymer particles into the wood until the top cellular layers of the wood are saturated with glue. With the water drawn from the joint, the remaining polymer particles coalesce into a continuous adhesive film. The bond is

Drawings: Fred Carlson

SAND BEFORE GLUING

To achieve a good bond, the glue must penetrate the wood easily. If the components were milled several weeks before being assembled, lightly sand the areas to be glued to remove surface contaminants.



Testing for penetration. *Two drops of water were applied to this board and photographed after 30 seconds. The sample on the right had been lightly sanded recently.*

complete when all of the water in the adhesive film and the surrounding wood has evaporated, usually in about 24 hours.

Although joint design, the type of wood, and surface contamination all influence the strength of the adhesive bond, nothing has more impact than "wetting." Simply put, wetting is the intermingling of the liquid adhesive and the wood fibers on a molecular level. The wood and the glue must blend together, or no bond will form. Good joint design and proper surface preparation will guarantee failure-free adhesive bonds every time.

Strong joints start with surface preparation

Wood is not a homogeneous material but rather a conglomeration including cellulose, hemicellulose, lignin, resins, oils, minerals, and colorants. Most of these materials (called wood extractives in the adhesives trade) decrease the ability of the adhesive to wet the wood. Removing these extractives from the wood surface before gluing is necessary to achieve a strong bond.

Edge-jointing the boards or cutting the joints immediately before applying the glue is the best way to remove contaminants. Unfortunately, the extractives start to migrate back to the surface as soon as the board clears the jointer. The longer you wait between jointing and glue-up, the lower the bond strength. A two- or three-day wait is no big deal, but check for extractives if more than two weeks have passed. Place a drop of water on the edge to be glued, then time how long it takes to soak into the wood. If it takes more than 30 seconds, lightly sand the wood with 180-grit paper. Sanding removes the accumulated extractives without having to rejoint the board.

Oily woods are a special case—Oily tropical hardwoods like rosewood, teak, or cocobolo are difficult to bond with yellow glue. A common practice among woodworkers is to wipe the joint with solvent before gluing, in an attempt to remove the oils and allow the glue to bond to the wood. I have used this trick, but I never was satisfied with the joint strength. I believe that the evaporating solvent pulls more oil to the surface than it removes. This article gave me the excuse to test my theory.

I jointed a ½-in.-thick rosewood board, crosscut it into six 4-in. lengths, and left the strips in the shop for two days. The first pair was glued and clamped without any additional treatment. I wiped the second pair with lacquer thinner, let them dry for two hours, then glued and clamped them. The final pair was sanded lightly with 180-grit paper before gluing and clamping. The test results were interesting: It took nearly an identical amount of force to break the untreated first pair and the solvent-wiped second pair: 892 psi and 888 psi, respectively. As I suspected, wiping with a solvent had no effect on strength. Looking at both samples under a microscope, I found in each case the dry adhesive had peeled cleanly off the wood without removing any wood fibers.

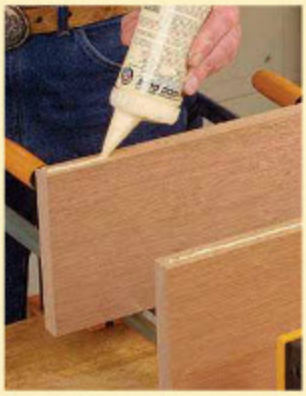
On the other hand, a force of 1,290 psi was required to break the sanded joint—about a 45% improvement in strength. Under the microscope it was clear that some fibers had been pulled out of the wood. To put this result into perspective, forces in the neighborhood of 3,500 psi are needed to break the bond of non-oily woods like oak or walnut. A few years ago, I switched to epoxy adhesives, which give a joint strength of 2,500 psi on oily woods, and have not had a joint failure since.

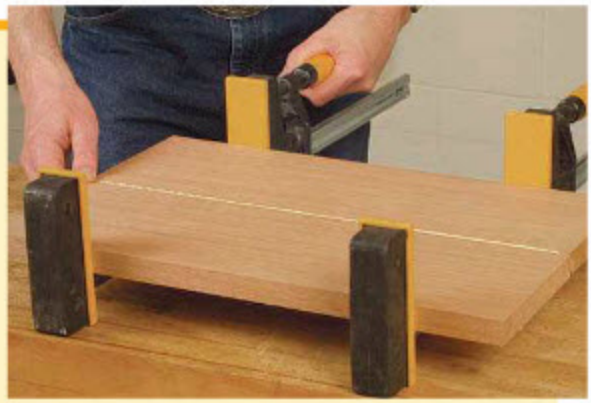
A few gluing tips

Keep these points in mind when gluing any kind of wood: Yellow glue is not a gap-filling adhesive; snug-fitting joints are required to achieve the best bond. The force needed to push

APPLY THE RIGHT AMOUNT OF GLUE AND PRESSURE

Sufficient glue. *Apply a thin, even bead of glue to both edges. You have about five minutes of open time before the glue skins over, hindering adhesion.*





Even pressure. *Each clamp is applying about 2,000 lb. of pressure. To give an even 200 lb. per linear inch of pressure over the length of the boards, space the clamps about 10 in. apart. You should produce a thin, consistent bead of glue squeeze-out.*

Photos, except where noted: Kelly J. Dunton; this page (top right): Courtesy of U.S. Forest Products Laboratory

Not the solution. *Wiping oily tropical woods with a solvent prior to gluing does not improve the performance of yellow glue.*

GLUING OILY WOODS

Yellow glue does not work well on oily woods such as teak or rosewood. Sanding the joint prior to gluing yields some improvement, but a better method is to use epoxy instead.

WOOD/TREATMENT	BREAKING POINT
Untreated oily wood	892 psi
Oily wood wiped with lacquer thinner	888 psi
Oily wood sanded prior to glue-up	1,290 psi
Oily wood glued using epoxy	2,500 psi
Non-oily wood	3,500 psi

a dowel into a hole with only your thumb, and then to pull it out with just a slight effort, indicates how tight dovetail and mortise-and-tenon joints should fit.

Edge-glued boards must be snug over their entire length. Don't rely on clamping pressure to pull together any boards that are warped; this puts undue stress on the glueline, which may result in joint failure. The best glue joints are formed when a thin, even layer of glue is spread on both mating surfaces. This ensures that both sides of the joint are wet with adhesive before clamping. A thick mass of glue results in a weaker joint. Clamping holds the pieces together and keeps the joint aligned while the glue sets. Proper clamping pressure comes with experience. Too little, and the pieces fall apart when the clamps are removed; too much, and the wood is crushed, nearly all of the glue squeezed out, and the joint left weak. Apply enough glue and pressure to form a small bead of adhesive along the joint, let the assembly dry, then scrape off the dry glue with a cabinet scraper.

End grain poses a problem when gluing miter joints: It is so porous that the liquid glue wicks away from the joint before it has a chance to set, and no bond is formed. The solution is to paint the end grain with glue diluted with one part to four parts of water. The diluted glue (sometimes called glue size) acts like a primer to partially seal the end grain, reducing wicking. Let the glue size sit for a minute or two, scrape off any excess, and then glue the joint following your normal method. □

Chris Minick is a former consulting editor for Fine Woodworking.

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How woodworkers tame tearout

ZERO-CLEARANCE TRICK APPLIES TO ALMOST EVERY TOOL IN THE SHOP

BY ASA CHRISTIANA

Wood is an amazing material, widely available in all sorts of colors, with beautiful grain patterns. It cuts easily with small machines and tools—products that are accessible to the home craftsman—and its strength-to-weight ratio rivals high-tech materials. But it *is* organic, and therefore comes with some strings attached.

One is movement, and there is no stopping it. The other is tearout. A budding hobbyist soon encounters splintered edges and pockmarked surfaces, damage that grows more obvious when finish is applied. It happens with almost every tool in the shop. The good news is that it can be stopped, in most cases easily.

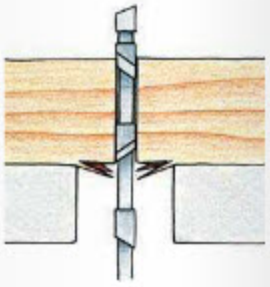
Tearout happens when wood is cut and its plant fibers aren't held firmly in place. There are two main types: One happens when wood is cut across its grain, and the other when the surface is planed. I'll start with crosscutting, which is the easiest to handle.

Crosscut with no worries

Ripping happens along the grain, and generally causes little to no tearout. The few long fibers involved simply shear away from each other. But crosscutting applies pressure across every fiber in a board. That's fine through most of the cut, but near the bottom or back edge, the last few fibers have nothing behind them and would much rather splinter away than be sliced through. On most tools,

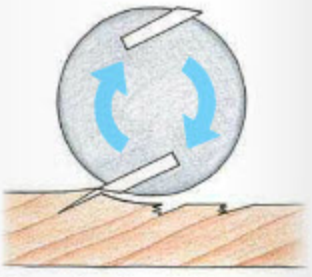
Two main types

TEAROUT FROM CROSSCUTTING



Chip off the old block. *At the bottom and back edge of a cut, unsupported surface fibers tend to splinter away, leaving a ragged surface.*

TEAROUT FROM PLANING



Scarred surface. *Jointers, planers, and handplanes can lift surface fibers and break them instead of cutting them cleanly, leaving pockmarks in the surface.*

Photos: Steve Scott; drawings, this page: John Tetreault

Zero clearance for tablesaws

Replace your tablesaw insert. *A zero-clearance throat plate helps control tearout by supporting the fibers on the bottom of a workpiece.*

Add support to your miter gauge, too. *A hardwood or MDF fence screwed to the front of the miter gauge will prevent the wood from splintering at the rear of the cut.*

CROSSCUT SLEDS

Also works on sleds. *Clamp a piece of ¾-in. MDF to the fence and tack down a sheet of ¼-in. plywood. Then cut a new slot to match the crosscut or dado you plan to make.*

there is nothing there to stop them.

Manufacturers build those tools to make both square and angled cuts, so the opening in the table or fence needs to be extra large to allow the blade to be tilted. Carpenters don't mind, because tearout doesn't matter on framing, and they usually can hide the bottom side of a trim- or deck board. But furniture makers can't always hide a splintered edge, and they quickly learn to close up that big gap with a "zero-clearance" plate, usually just a piece of plywood tacked or clamped onto the tool.

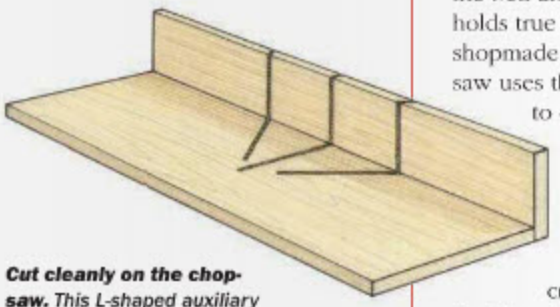
The principle is always the same: The blank plate is attached, and the sawblade is used to cut a kerf through it. Then, when wood is crosscut on top or in front of that plate, the lower or back edge is supported completely on both sides of the blade. Granted, that plate will need to come off or be replaced for angled cuts, but most cuts are at 90°.

Saws are simple—On tablesaws, you should replace the throat plate (the one with the big slot) with a blank plywood one for all square cuts. But you can use a zero-clearance plate on the miter gauge fence, too, to support the back edge of the cut. This is nothing more than some plywood or MDF (medium-density fiberboard) screwed to the existing fence.

The same goes for any crosscut sled you build for the saw: You can tape or tack sacrificial surfaces onto the base and the fence. Don't use thick pieces on the base; you'll steal too much of the blade's height capacity. Later, when the zero-clearance slots on these plates get beat up by angled cuts or different-size blades, you just attach new ones. On miter- and chopsaws, you can eliminate tearout on both square and

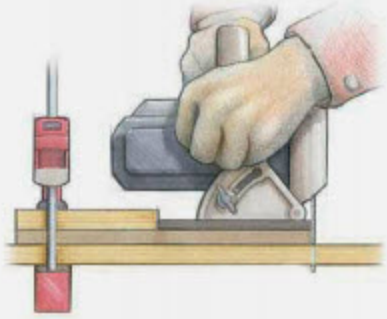
Zero clearance for other tools

MITER SAW



Cut cleanly on the chop-saw. *This L-shaped auxiliary table supports the bottom and rear of the stock when cutting small parts.*

CIRCULAR SAW



Get straight, square edges without splinters. *A shopmade cutting guide keeps a handheld circular saw on a straight line. The MDF base helps support the fibers on the top surface, where the blade exits the cut.*

ROUTER

Bury the bit in a sacrificial fence. *A clean cut is crucial for delicate joinery like these sliding dovetails. Attach an extra board to the fence, then pivot the assembly into the spinning bit.*

Torn fibers vs. a clean cut. *The zero-clearance fence supported the wood adjacent to the cut on the lower piece, preventing tearout.*

45° cuts by attaching similar plates to the bed and fence. The principle even holds true for handheld power tools. A shopmade straightedge jig for a circular saw uses the same zero-clearance idea to eliminate tearout on at least one side of the cut, where it matters most.

Same deal for drill presses and router tables— Although these don't exactly crosscut wood, they cut across the fibers in a similar way. And you use the exact same treatment.

Most drill presses have a big hole in the cast-iron table to accommodate the largest drill bits. Without a backer board under your workpiece, you'll get terrible blowout on the bottom side of the hole you are drilling. A simple piece of plywood or MDF prevents this. Just move it around to get a solid surface under each new hole.

On router tables, the force of the spinning bit is horizontal, so you will sometimes need a zero-clearance plate on the fence, but almost never in the table. There are a number of ways to do it: Make the whole fence sacrificial and replaceable, attach a thin blank plate to the fence, or design a fence with replaceable inserts.

Surface tearout is trickier

Jointers, planers, and handplanes all can create nasty tearout in wood surfaces, especially when they hit grain that changes directions. But the power tools require a different approach than the hand tools.

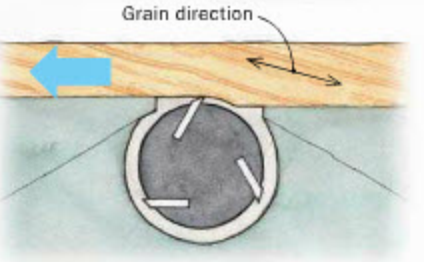
I don't believe there is a way to use the zero-clearance principle on the jointer and planer (it's difficult to get support close to the spinning cutterhead), but there are other ways to reduce tearout. Cut with the grain as much possible. If you are getting tearout, try reversing direction. Also, try replacing dull knives with sharp ones. Sometimes it also helps to dampen the surface with water before sending the board through. Handplanes, on the other hand, do benefit from the zero-clearance principle, or, more

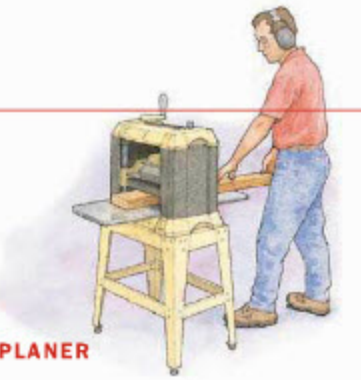
Drawings, this page: Bob La Pointe

Strategies for surface tearout

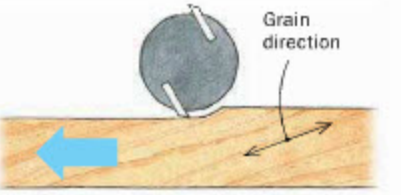
Pay attention to grain direction. *On the jointer, the edge grain should run downhill toward the rear of the board. On the planer, the downslope should point to the front of the workpiece.*

JOINTER





PLANER



accurately, the tight-clearance principle.

The force of the blade tends to pry fibers upward, while the plane's sole holds them down. A tighter blade opening puts the sole closer to the front of the blade and prevents the fibers from lifting during the cut. For the final, critical passes on a board, resharpen the blade, set it for a fine cut, and adjust the mouth to a very tight opening.

Depending on the plane, you either adjust the frog forward or adjust the toe of the sole backward to close the mouth. And on planes with a chipbreaker, it helps to place it as close as possible to the tip of the blade, so it applies additional downward pressure on the chip as it curls it, fighting its tendency to tear upward.

Last, when tearout is unavoidable, use scrapers and/or sandpaper to work past it and produce a flawless surface. □

Asa Christiana is editor of Fine Woodworking.

TIP

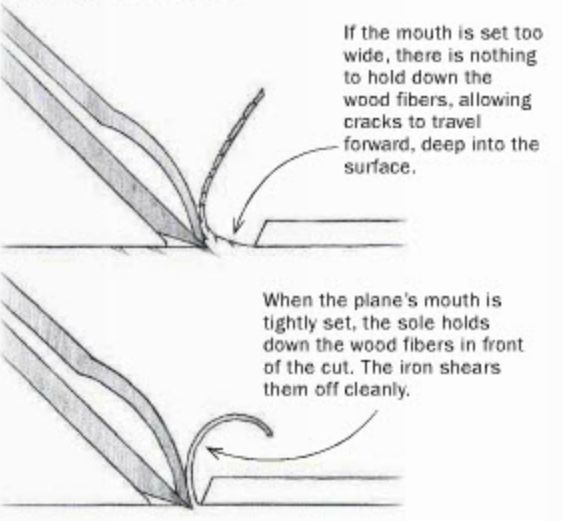
DAMPEN THE BOARD

Dampening the face of the board softens the surface fibers slightly, making them easier to cut and less likely to tear out.

HANDPLANES

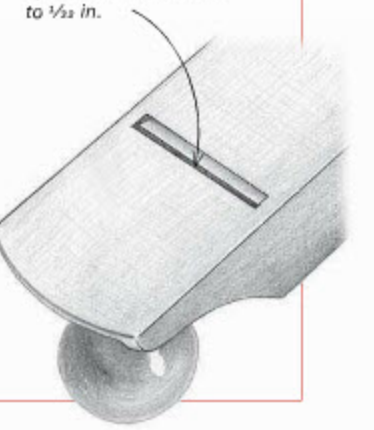
The goal. *A properly set up handplane with a sharp iron should produce thin, fluffy shavings like these and a glassy surface with no tearout.*

HOW TEAROUT HAPPENS



SET UP THE PLANE FOR A CLEAN CUT

Move the frog (blade carriage) forward to create a tight mouth opening. For fine cuts, open the mouth 1/64 in. to 1/32 in.



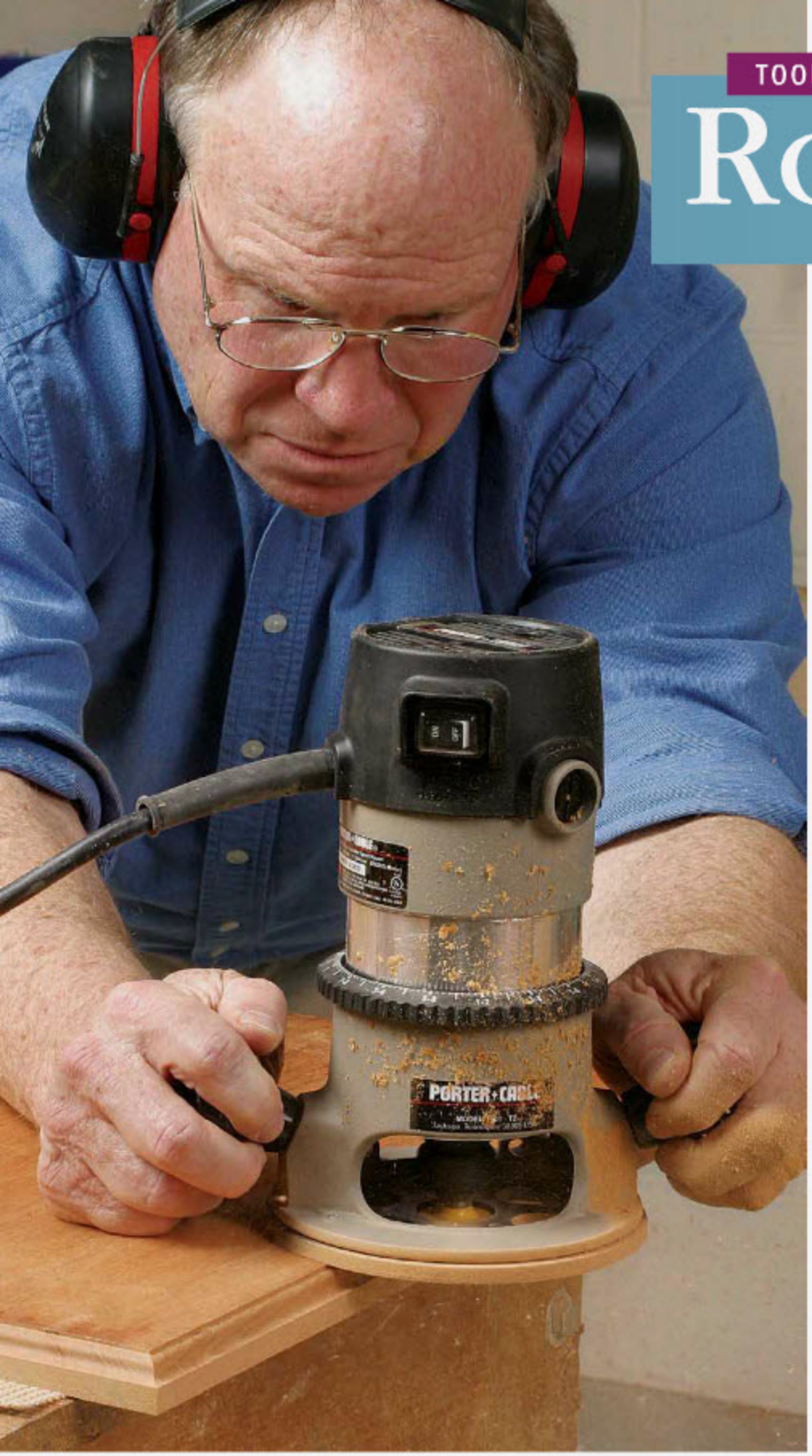
Drawings, this page: Jim Richey (top); John Tetreault (bottom)

TOOLS

Routers

Proper feed direction ensures safety and gives best results

BY GARY ROGOWSKI



Because a router bit does most of its cutting on its edge rather than straight down like a drill bit, feed direction is important. The direction in which you feed the bit can help to create or destroy a joint. Held topside on a board, a router bit spins clockwise as you look down on it. Mounted upside-down in a router table, a router bit spins counter-clockwise as you look down on it. Depending on how you move the router (topside) or the workpiece (router table), the bit will either pull itself into the cut, as it usually should, or push itself away.

Topside routing

Hand-held on top of a board, the router should move so the fixed workpiece is effectively feeding into the rotation of the bit. As it cuts, the bit will pull itself into the workpiece. When working on the edge of a board, move the router left to right. When working on a frame, move counter-clockwise around the outside of the frame. On the inside of the frame, move the router in a clockwise direction. With a ball-bearing guided bit, this feed direction will pull the bit into the wood right up to the edge of the bearing.

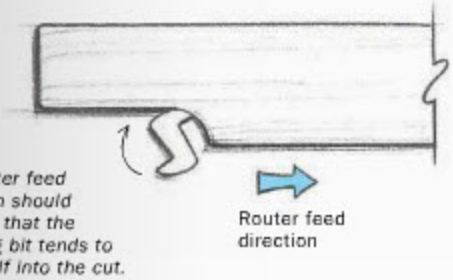
When using a straight fence to cut along

Photos: Kelly J. Dunton

Topside routing

As the name suggests, topside routing is done with the router on top of a workpiece. The workpiece is fixed in place while the router, held in both hands, is moved to make the cut. Depending on the cut, the router can be guided either by a straight fence, a ball-bearing guide, a guide-bushing, or an edge-guide. Viewed from above the router, the bit spins clockwise.

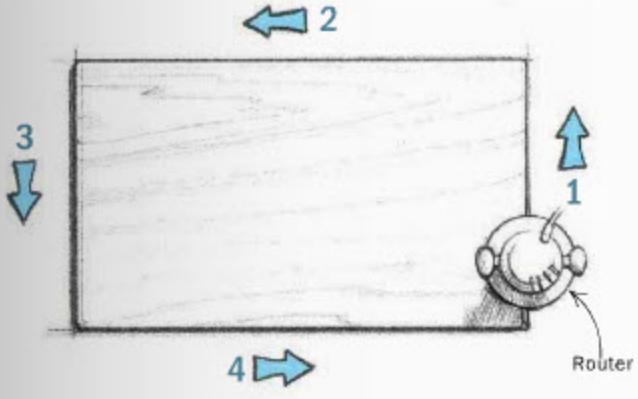
ALONG THE EDGE OF A BOARD



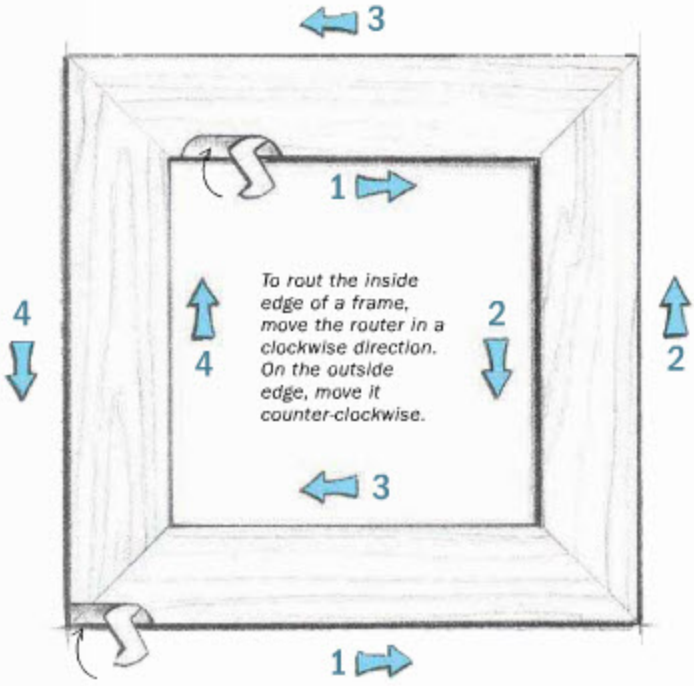
The router feed direction should be such that the spinning bit tends to pull itself into the cut.

AROUND THE EDGES OF A BOARD

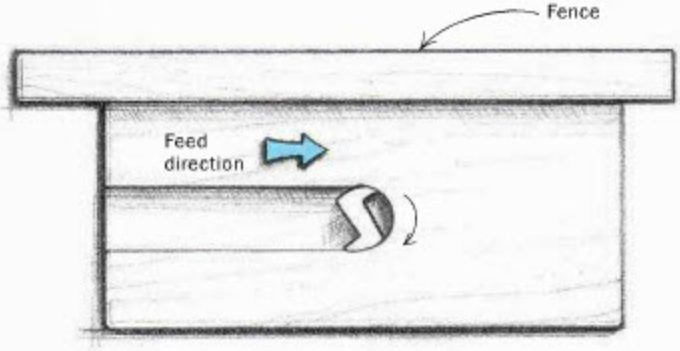
A cut made around the edges of a board should be made in a counter-clockwise direction. Start on an end-grain surface and follow with a long-grain pass to clean up any tearout that may occur.



AROUND THE EDGES OF A FRAME



IN THE CENTER OF A BOARD, WITH A FENCE

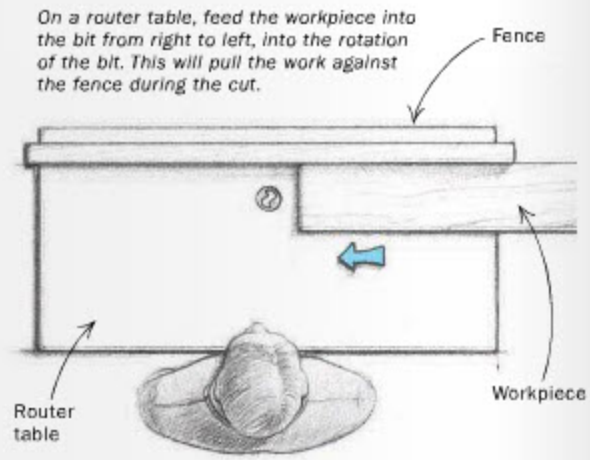


Drawings: Robert LaPointe

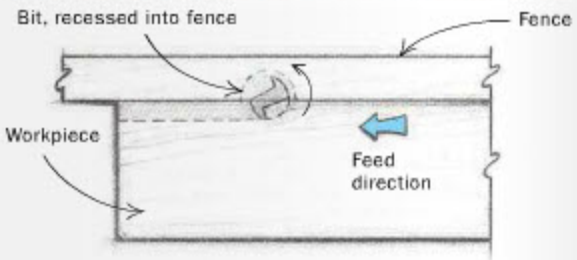
Table routing

Some cuts are easier to make when the router is mounted upside down to the underside of a table. A cut is made by pushing a workpiece into the fixed router. Generally, the workpiece is guided by a straight fence. Viewed from above, the bit spins counterclockwise.

PASS THROUGH A BOARD, BIT FULLY EXPOSED



PASS THROUGH A BOARD, BIT PARTIALLY EXPOSED



the edge of a board, feed in the exact same direction: left to right. This will pull the fence in tight to the edge. When making a cut set in from the edge, this feed direction, against the rotation of the bit, will do the same job.

When running the router base of a template guide against a fence, the fence can be placed on either side of the router, so it's tricky to decide which way to feed. Use the bit rotation as your key. Always move the router so the bit pulls the router toward the fence. This feed direction is opposite to the bit rotation.

What if you disregard these guidelines and feed in the same direction as the bit rotation? You'll feel the bit try to push itself and the fence away from the cut or skitter along an edge. If you cut in this direction, you will have to work to hold the fence tight to the edge.

Router-table cuts

When you flip the router over to cut in a router table, the bit spins counterclockwise as you look at it from above, so you have to reverse your feed direction (see drawing, above). On the router table, you feed the work into the bit from right to left, into the rotation of the bit, to push the workpiece into the fence during the pass or to pull the wood into the edge of the bearing. As you stand at the front of the table, the first contact the bit makes with the wood is at the front of the bit's cutting edge.

When cutting an edge, never position the workpiece between the bit and the fence. In that position, the back side of the bit would make the first contact with the workpiece. And because you feed the workpiece from right to left, you would be feeding with the rotation of the bit, not against it. On the router table, this can do one of two things. It can scare the heck out of you as the piece of wood shoots out of your hand following the bit's lead, or it could draw your hand into the cutter if you fight to keep a grip. Either way, it's dangerous.

Always be sure you know which side of the bit will be doing the cutting in a pass, especially when routing small pieces. Sometimes a first cut is made, and you follow that with a second pass. This can happen when a straight bit is too small for a cut. If you move the fence so that the far side of the bit is cutting, you will

be feeding with the rotation of the bit, and you could lose your hold on the workpiece.

When using bearing-mounted bits on the router table, be careful when you start a cut. Many commercial router tables use a starting post as a pivot point to begin a cut. Simple care instead will allow you to begin a cut safely without using the pivot point. Start your cut just back from the end of a board to prevent an unwanted cut or tearout, because it's difficult to hang onto a piece if it starts to run backward. If the bit catches the end grain as you begin the cut, it can kick the end of the board past the bit. For added safety, use a fence with a bit recess so there's never a chance of catching the end grain.

Feed rate: bogging vs. burning

Learn to recognize the normal sound of your motor under a load. Always pay attention to it as an indicator of how the cut is going. When you're moving the router or the workpiece at the proper feed rate, the sound of the motor should remain steady. When the feed rate is too fast, you'll hear the motor bog down or the router bit scream as you try to make the cut.

When the feed rate is too slow, the wood and the bit will start to burn. In end grain, which loses moisture quickly and is so much harder to cut than long grain, burning occurs quickly when the feed rate is too slow. Add a dull bit to a slow feed rate, and you'll have a shop filled with the aroma of burning wood. Try to move through end grain at a fair pace because a slow hand here will give you more to clean up. Burning also will occur any time you stop a cut with the bit touching the wood, because the bit is just spinning in one spot and building up heat.

Feed rates can also determine the quality of a cut. If the rate is too fast, the bit may chatter, yielding a poor cut. Tearout may also occur. Listen carefully as you make a cut. If you hear the wood splinter, slow down your feed rate. □

Gary Rogowski builds furniture and teaches woodworking (northwestwoodworking.com) in Portland, Ore. This article is excerpted from his book, Router Joinery *(The Taunton Press, 1997).*

Choosing the right bit

When it comes to choosing a bit, the most important factor is sharpness. Then, depending on your needs, you must decide whether more expensive ball-bearing guided bits with thicker shanks are worth the cost. If you do a lot of routing, you'll be well served by the better bits.

Solid-post guide can leave burn marks. *Unless you work carefully, a bit with a solid-post guide may leave a black stripe along the edge of the workpiece. A ball-bearing guide is a better choice.*

SHARP AND STURDY

A sharp bit cuts through wood with little effort, producing smooth, clean cuts. A dull one won't cut wood fibers as cleanly, so it's more likely to produce tearout.

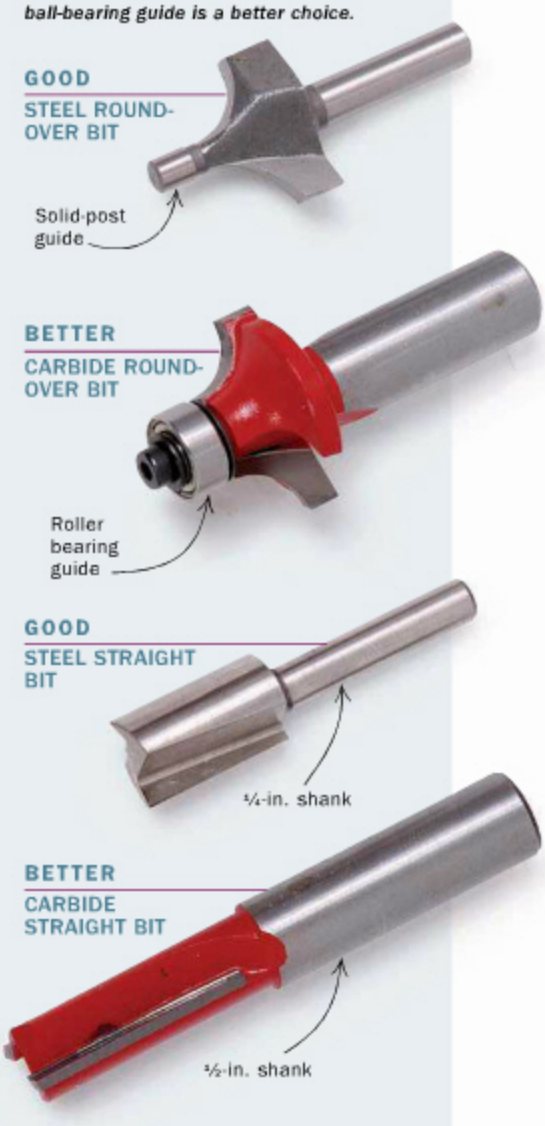
Router bits are made from steel, carbide, or a combination. Steel bits cost less than carbide, but dull faster. For a few short cuts, a steel bit is fine. But for long-term service, carbide is the better investment. As a bit cuts, it's subjected to a bending force. If the force is enough to make the bit bend, even slightly, it will chatter and won't cut smoothly.

A bit with a ½-in.-dia. shank will resist chatter better than one with a ¼-in.-dia. shank. If you expect to do light cuts only, the smaller shank is fine. But for any kind of heavy cut, use a ½-in. shank bit if your router accepts the larger size.

USE A BALL-BEARING GUIDE

Router-bit guides come in two types. One is simply an extension of the body in the form of a solid post. The other is a ball-bearing that mounts to the body with a machine screw. The solid post is found mainly on lower-cost ¼-in.-dia.-shank bits. It has one big drawback. Because the post is part of the body, it spins at the same speed —around 25,000 rpm—creating friction that can quickly lead to burning. Ball-bearing bits cost more, but the money is well spent because they won't burn the wood.

—Tom Begnal



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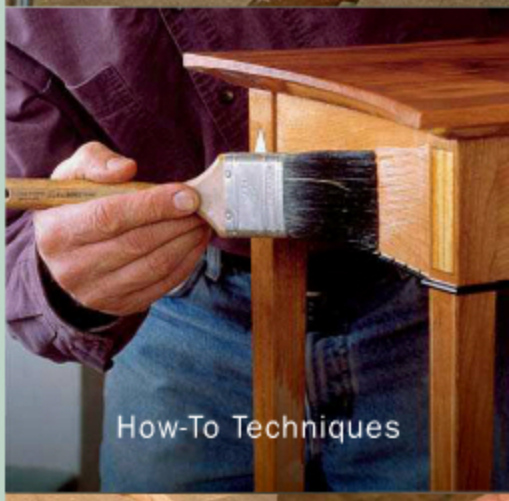


TOOLS

Chisels

Used correctly, a modest set covers all of your chopping and paring needs

BY GARRETT HACK

A few thousand years ago, someone clever hammered out a hunk of bronze into a narrow blade, fitted a handle to one end, sharpened the other against a stone, and produced a chisel. Generations of craftsmen since have tweaked the design: Tough steel replaced soft bronze, the shape and length of the blade were modified to suit various tasks, but in essence, chisels have not changed much. They are still simple in form and, when used effectively, one of the most useful tools in the shop.

Every week, catalogs arrive, full of a dizzying array of different chisels: long, fine-bladed paring chisels; stout mortise chisels; heavy and wide framing chisels; stubby butt chisels; intriguing Japanese chisels; and many sets of bench chisels. Few other classic hand tools are still available in such variety. Unless you work entirely by hand, all you really need is a good set of what I call bench chisels or, as some prefer, firmer chisels. These are chisels with blades about 4 in. to 6 in. long, available in a wide range of

The most versatile tool in your shop

No bench is complete without a chisel. Generations of woodworkers have come up with multiple uses for the chisel far beyond its original purpose. The five photos at right show a chisel replacing a hollow-chisel mortiser, a scraper, a handplane, a pencil sharpener, and tweezers.

Squaring up mortises. *When squaring up a machine-made mortise, a block of wood clamped to the workpiece can act as a guide.*

Cleaning up glue squeeze-out. *A scraper works best for large areas, but for small areas, a chisel offers more control.*

Paring pegs. *A chisel is more precise than a handplane and is neater than a sander when leveling a pin.*

Photos, except where noted: Michael Pekovich

widths from about ⅛ in. to 2 in. and with a wooden or plastic handle.

The only substantial differences between sets of bench chisels are the quality of the steel and the shapes of the blades. The blades on my everyday set of Swedish bench chisels are slightly tapered in length and beveled along the long sides. Tapering the blade yields a tool stout enough for the hard work of chopping a mortise yet light enough to pare one-handed. A blade with flat sides is stronger than one with beveled sides and is less expensive to manufacture. But a beveled blade can reach into tighter places, such as for cutting small dovetails.

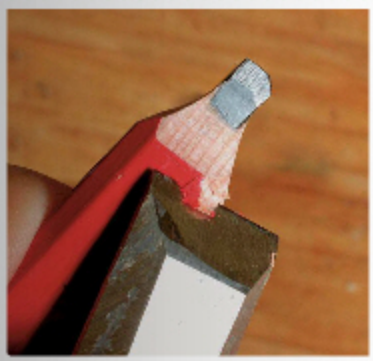
For best results, prepare the chisel

As with many other tools, the performance of a chisel is determined by how well it is tuned. The back of the chisel—the unbeveled side—must be dead flat for 1 in. to 2 in. behind the cutting edge (see photos, right). This flat plane guides and controls the cut; a curved back will rock and provide little control.

Another common problem is a slight rounding of the cutting edge on the back side. The back might be flat except for this tiny back-bevel. Sloppy technique, not keeping the back absolutely flat on a sharpening stone while honing, creates this rounding. The result is a chisel that will not cut while resting on its back because the rounded edge is in the air. Such a chisel must be angled forward slightly, thus losing the back as a source of control. Flattening the back of a bench chisel right to the cutting edge is tedious but important. Work through the range of grits until you get a bright polish on your finest stone.

Once you have flattened the back, choose a cutting bevel angle based on the type of work you do. The lower the bevel angle, the more easily the tool slices through wood fibers. A fine bevel of 15° to 20° is a little delicate, but works for a chisel reserved for light paring cuts in softwoods. To chop tough end grain, a stouter 30° to 35° bevel holds up better. But for everyday bench work, a 25° bevel is a good all-around cutting angle. This is a compromise between ease of cutting and the durability of the edge.

Lightly hollow-grinding the bevel every three to four sharpenings helps speed the honing process by reducing the area of steel in contact with the stone. I use a grooved block of wood that holds the chisel handle, set at a distance from the grinding



Handy pencil sharpener. *A test of a chisel's edge is how fine a point you can put on a pencil.*

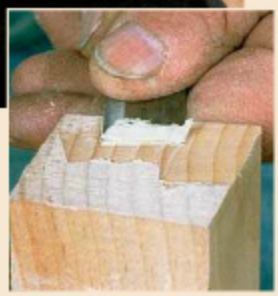
Better than tweezers. *Perhaps best not done in front of children, removing a splinter with a chisel works faster than tweezers.*

Photos, this page (top, second from top and inset): Mark Schofield

Honing a chisel

Flatten the tool's back. *The first 1 in. to 2 in. of the chisel's back should be perfectly flat. The back guides and controls the cut and ensures a fine edge.*

Grind and hone. *After hollow-grinding a 25° bevel on the grinder, the author hones the bevel on a medium and then a fine oilstone. The author guides the chisel freehand, but a honing guide can help until you master the technique.*

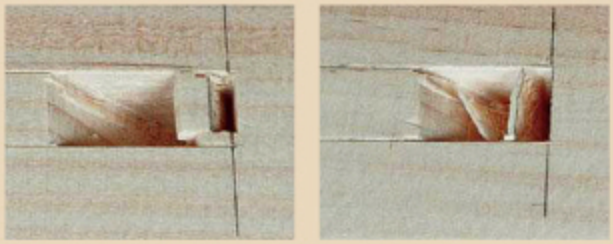


Ready to cut. *The tuned chisel should have a flat back and a narrow band of honed steel along the cutting edge, with a slightly concave ground surface just behind. If you can leave a clean cut on pine end grain, your chisel is ready for action.*

Vertical chopping and paring

The right angle for chopping. *With experience you will be able to hold the chisel at the correct angle merely by sighting across and down it (left). A square set on end can be used as a guide when squaring up the end of a mortise (right).*

Lighten up as you near your mark



Particularly in softwood, chopping too much waste at once makes the bevel push the chisel back over the line (left). It is better to take small cuts (right) and sneak up to the line.

wheel to achieve the desired bevel angle. I then hone the edge on a medium India stone and a fine black Arkansas stone using kerosene as a lubricant. I try to hone at a consistent 25° bevel with little or no microbevel along the cutting edge. The only exception is when I need a slightly tougher cutting edge for an extremely hard wood, such as rosewood, where I raise the tool handle to hone a microbevel of 30°. For a final polishing, I use some 0- to 2-micron diamond paste smeared on a piece of Baltic-birch plywood. I prefer plywood to a leather strop, as a strop increases the risk of rounding over the bevel.

How to tell if your chisel is sharp

A chisel must be very sharp to work well. A dull edge takes far more power to drive through the fibers and, more importantly, is harder to control. Everyone has a special way to test the sharpness of an edge: dragging it against a fingernail, shaving arm hair, or plucking the edge with a finger. The problem is that these tests are all a bit subjective.

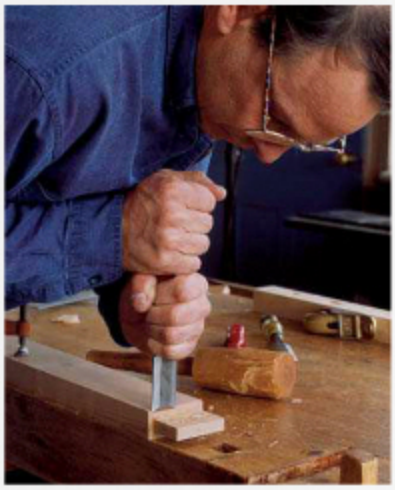
I test the sharpness of a chisel by paring a block of end-grain pine and then looking at both the shaving and the cut surface. Because softwood fibers are weak and easily torn from the surface, only a really sharp edge will cut a thin and whole shaving. Look at the end grain; it should be uniformly polished. You'll know you need to do more sharpening if you see light flecks in the surface where fibers were torn away, or fine tracks where tiny nicks in the chisel's cutting edge scraped across the wood.

Next lay the chisel with the back flat on one of the long-grain sides of your block. If you can pare a shaving without lifting the chisel, the back and cutting edge are flat. If you have to lift the chisel to get it to cut, either the back or cutting edge is rounded.

Proper technique ensures good results

For most of us, the days of working with hand tools alone are long gone. Whereas chisels once would have been our primary tools for cutting all manner of joints, today we typically use them to adjust joints cut on a machine.

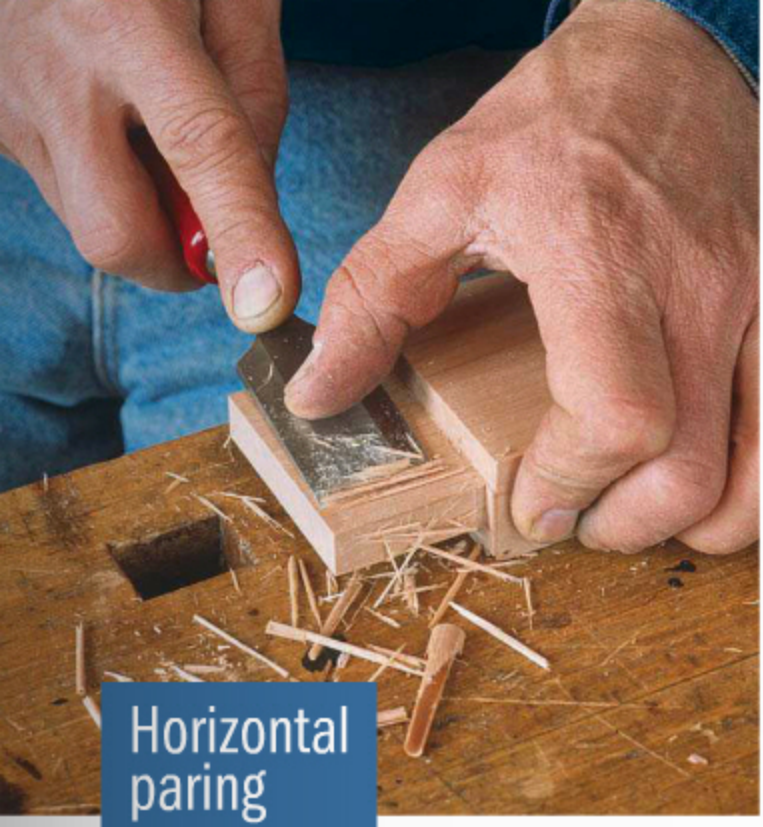
Chiseling tasks can be simplified to chopping, paring, or some combination of the two. Cutting end grain, such as excavating a mortise, is chopping. A mallet usually delivers the driving force, so everything works best when you chop vertically, down against your bench, preferably directly over a leg. Paring is often a hand-powered operation, using the chisel horizontally or vertically to slice away a thin shaving. This can be against the end grain or along the grain. I also pare with the chisel in one hand and use my thumb as a lever, much the same way you would use a small knife.



Chop, then pare. *Lightly chopping all the way around defines the shoulder of a tenon (left) before a final paring with hand power (above).*

Chopping to a line vertically— Cutting with a chisel held plumb is an acquired skill. Finding the right angle is easiest when you are only slightly above the work and looking

Photos, this page (top row, middle row): Mark Schofield



Horizontal paring

When cutting horizontally, the smoothest cuts are made with a slight shearing action, cutting both forward and sideways. The need for a perfectly flat chisel back is apparent when fitting a tenon.

across the chisel. Sighting against a square set on end helps, as does good light shining toward you and the work. If you find it hard to hold a chisel plumb or if you have to cut an angled mortise, saw a waste block to this angle and clamp it in place to guide your chisel. For heavy chopping, driving a chisel with a mallet allows you to focus your efforts on directing the tool.

Light cuts yield more accurate results. Think about the cutting edge sinking into the wood. The back is trying to guide the chisel plumb while the beveled side of the cutting edge presses the chisel against the back. With a light cut, this pressure breaks out the chip and holds the back right to the line. Try to chop too large a chip, especially in softwood, and the pressure will push your chisel beyond your line. Take little bites on the waste side of the line and then take a final light cut right on the line. Because I have a good selection of chisel sizes, I waste as much wood as I can with a chisel narrower than the mortise. The final cut is with a chisel fitting snugly in the mortise width and right on the line.

Paring to a line vertically—Paring end grain gives you a whole new appreciation for the toughness of wood. Good paring takes both muscle and a feel for controlling the cut. A sharp chisel and a light cut give you the best chance for doing accurate work.

After you have removed the bulk of the waste using a mallet, switch to a light paring cut right on the line. This provides greater accuracy and control and allows you to undercut slightly. Also, it's just plain quicker than reaching for the mallet after moving the work. If paring a tenon, for example, work around all four sides to establish the shoulder line and to give you something to sight against when paring. Position your body above the work for paring the final shaving or two, using the weight of your upper body to drive the chisel and both hands to guide it.

Paring to a line horizontally—Given a choice, I prefer the control of a plane to shave a surface. But there are plenty of times when I don't have the right plane close at hand or when it's simply quicker to pare a few shavings with a chisel. Long and thin-bladed (for flexibility) paring chisels are the tools of choice here, but a well-tuned bench chisel will work almost as well.

For maximum control, I find it's best to have one hand on the chisel handle and the other as close to the work, or cutting edge, as is practical. This way, you can raise or lower the handle slightly to control the depth of cut, while the hand close to the cutting edge holds the chisel steady and helps guide the cut. This hand also acts as a brake, smoothing out the pressure delivered by the hand on the handle. The smoothest and easiest cuts are made with a slight shearing action, slicing both forward and sideways.

Paring while using the thumb as a lever—Holding the chisel like a penknife or a potato peeler, with the blade cutting toward you, takes some getting used to. Once mastered, this technique allows for fine controlled cuts, even in end grain. I use it to pare the end of a table leg, to shorten a tenon, and to chamfer its ends.

Cutting bevel-side down—When paring the bottom of a groove, the flat back of a chisel can no longer be used as a guide, and the natural inclination of the chisel is to dig in. Turn the chisel upside down and use the bevel to guide the cut, raising or lowering the handle to adjust the depth of the cut. This method is useful to deepen a mortise or dado (or shape a curved one) or to smooth the bottom of a recess for an inlay.

As with all tools, there are many paths to accurate and satisfying results. Sharpen a few chisels and practice these basic techniques. Some of them might not feel comfortable at first, but everyday use at your bench is the surest way to master them. □

Garrett Hack is a furniture maker in Thetford Center, Vt.

Delicate cuts

Using the chisel as you would a penknife allows you to make delicate cuts such as slicing end grain or beveling a tenon.

Photo, this page (bottom): Mark Schofield

TOOLS

Block Planes

Five common tasks for the handiest plane in the shop

BY CHRIS GOCHNOUR

One of the tools I reach for most often is a block plane. With its compact size and comfortable palm grip, it is an extension of my hand. I almost always have a block plane within reach as I navigate through the diverse tasks of custom-furniture building.

A finely tuned block plane is a pleasure to use. Quiet, efficient and precise, it can slice tissue-thin shavings off end grain, leaving a crisp, clean surface that no other method can rival. I use a block plane for many tasks, such as eliminating mill marks from board edges and ends, shaping a radius or a chamfer on a board's edge, and fine-tuning and cleaning up joinery. Over the years, I've refined the way I tune and use this plane, based on the tool's unique geometry and features.

Typically made of metal and varying in length from 4 in. to 7 in., block planes are ideal for planing small parts and reaching into tight areas. They can be used one- or two-handed, either pushed or pulled. The blade is bedded at a low angle—between 12° and 20°—but the bevel faces upward, creating an actual cutting angle of 37° to 45° (if the blade is sharpened at 25°). The low blade angle allows for a palm-and-finger grasp and a low center of gravity, creating a more sensitive feel and greater stability. It also puts the

Low-angle vs. standard block plane

Years ago, when I first tried my hand at planing, I used a low-angle block plane to level the front edges of a figured mahogany dresser. I was puzzled by the torn grain that resulted, because I knew my plane was well tuned and razor sharp. After further experimentation, it became clear that I had not chosen the right plane for the job.

Understanding cutting angles will help you select and tune a block plane that will handle the task at hand effectively. The cutting angle is the angle formed by the workpiece and the top of the blade. A low cutting angle requires less energy, reduces friction (enabling the blade to stay sharp longer) and minimizes blade deflection and chatter, allowing the blade to slice through long grain or end grain with less effort. However, a low-angle blade has more trouble on figured or changing grain because the low angle produces a knifelike cut that tends to lift and pry, tearing the grain.

Conversely, a standard block plane with its steeper cutting angle requires more energy to use, generates more friction, and dulls more rapidly. It also is more susceptible to chatter. However, that steeper cutting angle makes a standard block plane more valuable on long grain, where its wedgelike cut will not lift, pry, and tear the grain.

Photos: Asa Christiana

1 REMOVING MILL MARKS

With its low center of gravity, the block plane excels at slicing machine marks off the edges and ends of boards.

Edge vs. end grain. *To plane edge grain (left), check the grain direction and use a standard-angle plane. For end grain, use a low-angle plane, if possible, and chamfer the far edge (above) beforehand to avoid splintering. Skew the plane to create a shearing action (right), and wet the wood with paint thinner or water if you encounter stiff resistance.*

blade in more direct alignment with the thrust of the cut, reducing blade deflection and chatter.

Another nice feature of a block plane is that the upward-facing bevel is supported by the bed all the way to its cutting edge. This further stabilizes the blade, so it gives rock-solid performance even while you are planing harsh end grain. A final attribute of many block planes is an adjustable throat. This enables you to fine-tune the plane's throat from a wide opening that accommodates a free flow of coarse shavings to a narrow slit that's capable of supporting the finest cut, leaving a smooth, tearout-free surface.

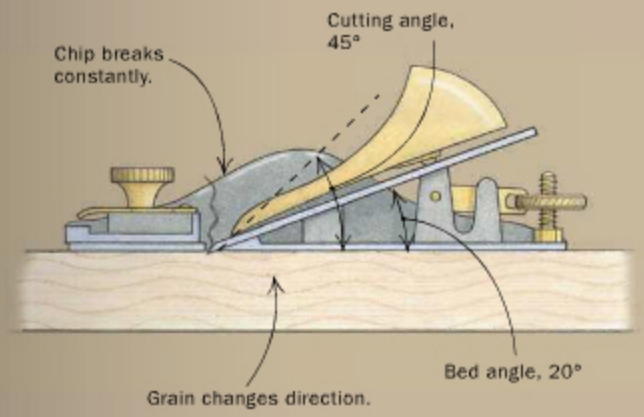
With a sharp, well-seated blade in your plane (for more on tuning up a block plane, see "Tune up the plane for best results," p. 36), you are ready to tackle many tasks. There are five crucial woodworking operations that a block plane handles easily. A standard-angle plane works better for some of these tasks; for others, a low-angle plane is preferable (see drawings, below).

Clean up saw and mill marks

Due to their compact size and stable footing, block planes are ideal tools for eliminating mill marks from edge and end

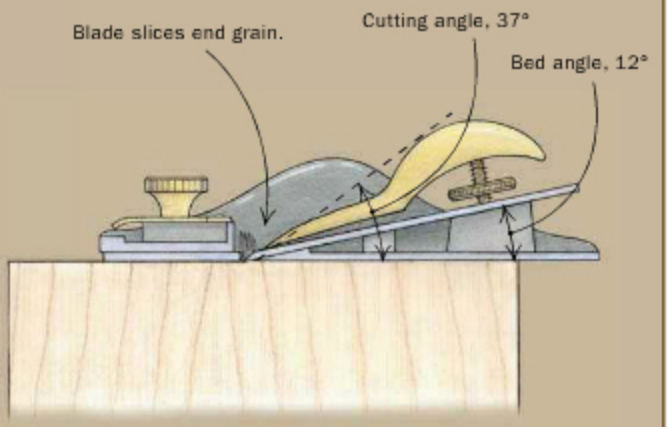
STANDARD ANGLE FOR LONG GRAIN

A 45° cutting angle is harder to push through the wood and causes the blade to dull more quickly, but it breaks the chip aggressively for a cleaner cut in long grain.



LOW ANGLE FOR END GRAIN

A low cutting angle requires less force to slice through tough end grain, and the blade doesn't dull as quickly.



Drawings: Vince Babak

2 CHAMFERING AND ROUNDING EDGES

The block plane excels at working the edges of a workpiece, from just lightly breaking an edge (left), to roundovers (two center photos), to wide bevels (right).

Chamfers and roundovers. *Draw reference lines on the edges and ends of the workpiece. For roundovers (above), stop short of the lines with the first bevel and then bevel the new corners. Finish with fine sandpaper.*

Large bevels can start on a machine. *The wide bevels on this drawer bottom were roughed out on the tablesaw, but they were finished and fitted to the drawer with a few passes of a block plane.*

grain (see photos, p. 33). Secure the board and use a light cut. Generally, you should push the plane, but if the grain direction changes, it's easy to turn around the plane and pull it toward you.

It is important to keep the edge of the workpiece square. If your machinery has been set up squarely, you can use the mill marks as a reference, planing until the marks disappear evenly. Pencil marks across the board edge also will serve as a reference. In time you will develop a feel for the job, and you'll be able to maintain a square cut without having to use any reference marks.

Removing mill marks from the ends of a board can be a bit more challenging because of the tough nature of end grain and its tendency to splinter at the unsupported edge of the cut. For this job, a low-angle plane is better than a standard block plane. Set the plane for a very light cut and make sure the blade is sharp. I have found that skewing the plane is very effective on end grain, producing a shearing action that contributes to a smoother, cleaner cut. Skewing the blade also lowers the effective cutting angle. For example, if the plane has a 37° cutting angle and is skewed 45°, the effective cutting angle becomes a low 28°.

Generally, I plane board ends with one continuous stroke from edge to edge. To

3 CLEANING UP JOINERY

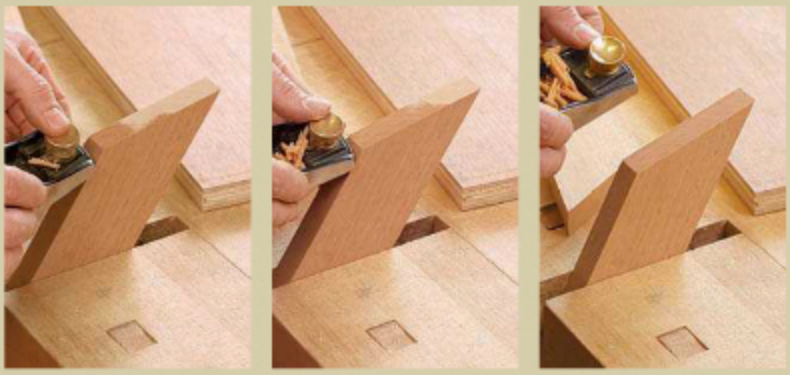
For a perfect fit, make joints proud and then plane them flush with a block plane.

Plane dovetails in two directions. *First remove the bulk of the excess stock by planing along the row of pins or tails (left) with the nose skewed inward to avoid splintering the end grain. Then work inward from the edge (above) for the last few passes.*

Plane pegs flush. *Plane in a tight circular motion to work toward the center of the peg.*

4 FINE-TUNING MITER JOINTS

Angled cuts from a machine tool aren't always perfect, but a block plane can adjust the fit of miters quickly.



Closing the gap. *This solid-wood edging for a plywood panel has loose-fitting miter joints (left). A series of cuts makes the adjustment. The first cut (above left) changes the miter angle, and successive cuts carry that new angle across the entire joint.*

prevent a chipped edge at the far end of the cut, there are several different things you can try: Plane a small bevel on the far edge to reinforce the fibers, or clamp a piece of scrap wood to the back edge to support the edge. You can also try planing toward the center of the board from both edges.

Certain woods have harsh end grain that will dull the blade of a block plane pretty quickly. Unless you enjoy sharpening, it's a good idea to dampen the end grain with water or paint thinner to make the wood more supple and preserve the blade's edge.

Round and chamfer edges

Block planes excel at lightly softening a hard edge, milling a crisp chamfer, or fully rounding an edge.

To soften an edge, make several light passes, rolling the plane slightly with each pass. To make a roundovers from a 1/32-in. radius to 1/4-in. radius, lay out the profile on the board edge and end. Because the shaping is freehand, a diverse range of contours can be shaped simply by working to your layout lines.

Begin the radius with a few bevel cuts. Then bevel the bevels, gradually shaping the intended profile. Finish with a very light cut and multiple passes, rolling the plane continuously. Final touch-ups can

5 FITTING A DOOR

After installing the hinges, use a block plane to adjust the fit of a door. Start by putting a back bevel on the door stile.

A back bevel (left) will make the next step easier. *It leaves good clearance for closing and only a small amount of wood to be removed during final fitting. Next, install the door and fine-tune the fit (above left). Check your progress frequently, creeping up on a fine, even gap (right).*

be made with a contoured card scraper or sandpaper.

To chamfer or bevel an edge, begin by laying out the cut with pencil lines on the board's edge and ends. Then plane to the layout lines, making sure the cut stays in the center of the two lines. If you stray off course, make corrections now rather than waiting until you've reached the pencil lines.

When chamfering end grain, you should skew the plane's nose off the edge of the board so that the blade is cutting the grain downward. This will result in a smoother finish.

Clean up joinery and adjust miters

I frequently use a block plane to clean up joinery after gluing. I'll trim tenon pegs flush, moving the plane in a tight swirl and working until the blade skims the surface surrounding the peg. Through-tenons, dovetails, and bridle joints also can be trimmed flush with a block plane.

When making a dovetail joint, for example, leave the pins and tails a bit long. After the glue dries, remove most of the extra material by planing along the row of pins or tails, in line with the edge. Skew the plane nose inward to support the cut and prevent chipped edges. When the joint is nearly flush, start planing in from the end, cutting lightly until the joint is flush and clean.

Frequently, miter joints require slight adjustments after being cut. A block plane is

Tune up the plane for best results

Whether you choose a low-angle or standard plane, an initial tune-up makes all the difference. Each time I tune up a plane, I follow a sensible order of refinements, beginning with the sole of the plane and progressing to the bed, the lever cap, and finally the blade.

1. FLATTEN THE SOLE

A convex or concave sole will leave the cut unsupported, causing unpredictable results, so I always check to see whether the sole is flat. Before lapping the sole flat, I also check that the adjustable throat seats well in the plane body. Remove the throat plate and check for any burrs or debris and then use a file to eliminate any trouble spots. Reassemble the plane, making certain the throat plate seats properly and moves freely.

I flatten planes by putting abrasive paper on a flat surface (plate glass, a slab of granite, or a jointer bed) and lapping the bottom of the plane. I always keep the blade in the tool, properly tensioned but raised above the sole. Begin with 80-grit and then follow with 150 and 220. You can stop there and let actual use further polish the sole, or go one step further to 320-grit.

Lap the sole. *Attach coarse- and medium-grit sandpaper to a flat substrate and flatten the bottom of the plane until the sandpaper hits the entire sole. The area around the blade is the most critical to get flat. The scratch pattern will tell you how much more steel to remove.*

the perfect tool to accomplish this task. For example, if I'm mitering a solid-wood border around a center panel, and a corner has a slight bird's mouth, I first assess where the material needs trimming. Then, using a series of overlapping cuts followed by one continuous pass, I make the adjustment with a block plane and check to make sure the fit is right.

Even if the joint has been cut accurately, one light cut on each miter will quickly eliminate any irregularities caused by sawblade deflection, ensuring an invisible glueline.

Fine-tune gaps on doors and drawers

Nothing works better for getting consistent gaps on cabinet doors and drawers than a block plane. Its compact size allows a one-handed grip, freeing the other hand to steady the work. Depending on the location of the door or drawer, sometimes I push the plane; other times I pull.

To ensure that a door stile has enough clearance and doesn't hit when opened or closed, I recommend a slight bevel from the door's front to back. This bevel is shaped easily with a block plane, even with the door in place. Another reason for this back bevel is that you will have to remove only a small amount of wood during the subsequent final fitting. □

Chris Gochnour builds custom furniture in Murray, Utah, and teaches around the country.

2. TUNE THE LEVER CAP AND BED

The blade must have a snug fit with the lever cap and the bed of the plane. First remove any rough burrs or sizable drips of japanning (black paint) that prevent a stable fit between the cap and blade. Then check that the bed of the plane is free from rust, paint globs, grime or coarse machining. The blade must have a solid footing to remain still under pressure.

Eliminate any imperfections with careful filing, being cautious not to make matters worse by being reckless with the file.

Tune the lever cap. *While protecting the back of the cap assembly with a piece of paper, sand the paint off the front edge for a snug fit with the blade.*

Level the bed. *Insert a small wood block into the back of the plane body (right), to raise the file to the blade angle. Don't over-file.*

3. LUBRICATE THE PARTS AND HONE THE BLADE

The plane's vertical adjuster and adjustable throat will work more smoothly with a light drop of machine oil on each part. A little paste wax on the sole of the plane will keep it gliding freely and prevent rust.

Sharpen the blade as you would any other, remembering that the sharpening angle of a block plane impacts performance. Because a block plane has its bevel up, its cutting angle is the sum of the bed and the sharpening angle. I sharpen my standard (20° bed) and low-angle (12° bed) planes with a 25° bevel, producing 45° and 37° cutting angles, respectively.

I use a honing guide because it helps maintain the desired bevel angle. There are two sides to a sharp edge: the bevel and the blade's back. I take both surfaces to 6,000 grit on my waterstones.

Adjust the throat. *A small gap in front of the blade supports the finest cuts; a larger gap is required for heavier cuts.*

Wax the sole. *This protects the plane from rust and makes for smooth sliding action.*

JOINERY

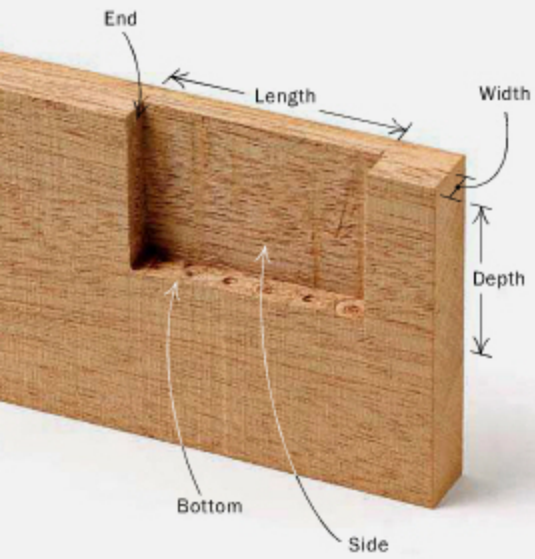
Mortises

With little more than a drill bit and chisel, this time-tested technique gets you a mortise in minutes

BY TOM BEGNAL

MORTISE TERMINOLOGY

When describing a mortise, it helps to use words that everyone understands. Some common terms are shown in this cutaway view of a typical mortise.



The mortise is the first half of a venerable woodworking team—the mortise-and-tenon joint. Reduced to simplest terms, a mortise is a flat-sided, flat-bottomed cavity cut into a piece of wood. The end of a mating board, cut to fit snugly inside that cavity, is the tenon. Glue the two parts together and you have an exceptionally strong woodworking joint that has an endless number of good applications.

Over the years, woodworkers have devised all sorts of ways to cut a mortise. Some use a dedicated machine to get the job done quickly, but you would have to reach pretty deep into your wallet to ride in that fast lane. Some use a router and a straight-bit, although that process usually requires a somewhat fussy setup. A mallet and bench chisel will get you a mortise on the cheap, but it's a relatively slow and labor-intensive procedure.

Then there's the drill-and-chisel method. That's the one I used when I started woodworking some 30 years ago. It's nearly foolproof, doesn't require fancy machinery, and can produce a mortise in about the time it takes to make a pot of coffee. You simply drill a series of holes to remove most of the stock from the mortise, then finish the job with a chisel.

A mortise has four flat, square walls and a flat bottom. You can make it any size by changing the dimensions of the walls. Typically, to describe the size of a mortise, you specify the width first, followed by the length and depth—for example, ⅜ in. wide by 2½ in long by 1¼ in. deep.

To determine a suitable width for the mortise and tenon, divide the thickness of the board by three, then round off that number to the nearest common drill-bit diameter. That means a 1¼-in. thick board would have a 7/16-in-wide tenon, a 1-in.-thick board would have a 5/16-in-wide tenon, and so forth. This rule of thirds provides an adequate tenon while ensuring a thick enough wall between the sides of the mortise and the face of the board.

With a well-cut mortise in hand, you're halfway to a strong mortise-and-tenon joint. The tenon is next. See pp. 42-49.

Photos, except where noted: Tom McKenna; this page (bottom): Kelly J. Dunton

Lay out the mortise

Mark the length. *Use a rule and a pencil to establish the two ends of the mortise (1). Then, using a combination square as a guide, scribe the ends of the mortise with a marking knife (2).*

Before you can start cutting the mortise, you need to know where to cut. First, lay out, mark, and scribe the length and width of the mortise on your stock. When I need to cut one or two mortises, I usually lay them out using only a pencil, a rule, a marking knife, and a square.

When scribing, a marking knife has a few advantages over a pencil. Even a well-sharpened pencil produces a relatively wide line. A knife line is much sharper. And, because the knife makes a line by cutting slightly into the wood, you can align the chisel perfectly at the start of a cut simply by placing the tip into the cutline. I use a woodworker's marking knife, but a sharp pocketknife or an X-Acto knife also will do the job.

To begin laying out the mortise, use the rule and pencil to mark the end points. Then use a combination square and marking knife to scribe each end (1 and 2).

The square and marking knife also establish the width. First, though, adjust the square so the blade extends an amount equal to the shoulder width of the tenon. Then, with the square on the workpiece, place the tip of the knife blade against the end of the square. Slide the square and the knife in unison along the workpiece. Then, do the same on the other side. The pair of knife lines will represent the width of the mortise (3).

A mortise gauge is a handy tool for laying out and marking the width of a mortise. It's especially useful when you have a lot of mortises of the same size. You just set the two marking pins on the gauge to establish the mortise width, making sure the pins are the correct distance from the face surface of the stock. Then use the gauge to scribe the width. Use a rule to locate the length of the mortise, and scribe the two ends with the square and marking knife.

Scribe the width. *With the blade of a combination square extending an amount equal to the tenon shoulder width, and the marking knife butting against the end of the blade, slide both the square and the knife across the surface of the workpiece (3) to make a mark. To make the second line, flip the square 180° and repeat.*

MORTISE GAUGE OPTION

If you have a lot of mortises to scribe, a mortise gauge can mark the side lines in short order.

Drill a series of straight holes

1

Add a shopmade fence. *Make a drill-press fence and position it so that the drill bit is centered along the width of the mortise, then clamp the fence to the table of the drill press.*

2

Drill the end holes. *With the drill press adjusted to the desired mortise depth, drill a hole at each end of the mortise. The edge of the hole should just touch the end line.*

3

Connect the two end holes. *The waste stock between the end holes is removed by drilling a series of holes that almost, but don't quite, overlap.*

With the mortise location marked, you can start creating the cavity. Here's where the drill bit shines. Drill a series of side-by-side holes equal to the depth of the mortise. Don't expect the bit to do all the work, though. Once you have drilled out most of the waste, you'll have to clean out the relatively small amount of remaining material and smooth all the sides with a bench chisel.

It's easiest to drill the holes with a drill press, which excels at keeping the drill bit square to the surface of the workpiece. To keep your workpiece square to the table when using the drill press, it helps to add a fence. A couple of flat, straight boards screwed together and clamped to the table will work fine.

Use a drill bit with a diameter equal to, or slightly less than, the thickness of the mortise. For example, use a 5⁄16-in.- or 3⁄8-in.-dia. bit for a 3⁄8-in.-thick mortise. If possible, avoid twist bits (the kind made for cutting either wood or metal) as they tend to wander during deep cuts. Brad-point bits or Forstner bits, though more expensive, are better at staying straight and true.

Clamp the fence to the drill-press table so the bit is centered across the width of the mortise. Then, set the depth stop on the drill press so the bit stops at a point equal to the mortise depth. Locate the workpiece so the outside edge of the bit just barely touches one end of the marked mortise. Drill the first hole at this point, then shift the workpiece to drill a second hole at the other end of the mortise.

After the two end holes are completed, drill a series of holes from one end of the mortise to the other. As you position the bit, don't overlap any of the holes. When holes overlap, the bit is more likely to wander away from a square cut. Such wandering is much less of a problem with Forstner bits, but even so, you're better off leaving a thin web of wood between each hole.

When making a mortise-and-tenon joint, be sure to leave space (about 1⁄16 in. is usually enough) between the bottom of the mortise and the end of the tenon. If you don't, and enough glue gets squeezed into the space when the tenon is assembled, you won't be able to close the joint fully.

Chisel away the waste

The wood that remains after you've drilled the holes is best cleaned up with sharp bench chisels. Clamp the workpiece in a vise, mortise side up. Starting with the ends of the mortise, position the edge of a chisel on the knife line you marked earlier, making sure to hold the chisel vertically with the bevel toward the center of the mortise.

Begin tapping the end of the chisel handle with a mallet. Keep in mind you'll be cutting across end grain, which is harder to cut, so it's especially important to have your chisel good and sharp. Typically, I'll drive the chisel only ¼ in. to ⅜ in. at a time, but that can vary depending upon the hardness of the wood and the amount I need to remove. After the chisel has gone a comfortable distance, give the handle a gentle twist in both directions to break away the wood fibers. Continue working in this manner until both ends of the mortise are reasonably flat from top to bottom.

Chisel the mortise ends. *Slip the tip of the chisel into the knife-cut line at the end of the mortise (above), then hold the chisel vertically and tap it with a mallet to begin squaring the ends of the mortise (right).*

When the two ends are done, it's time to work on the mortise sides. I typically use a wider chisel for the sides, anywhere from ½ in. to 1 in. wide, depending on the length of the mortise. A wide chisel cuts faster and makes it easier to produce flat sides. When chiseling the sides, though, avoid following the path of any drilled hole that has cut too deeply into the walls of the mortise. That's a sign the bit has wandered out of square. Also, because side grain is easier to cut than end grain, I have more control of the chisel if I forgo the mallet and use hand pressure to pare the wood.

The final step is to flatten the bottom of the mortise. That can be a challenge, mainly because the bottom is often well below the surface of the wood. The trick here is to angle the chisel in the mortise and use it to smooth as much of the bottom as you can. Then, reverse the direction and work from the other end. As you work on the bottom, be sure to clean out the waste material at each of the four corners.

Sometimes, the angled chisel won't reach the middle area. When that happens, it's generally best to hold the chisel vertically and use it like a scraper to smooth the wood. Don't fuss too much over the smoothness of the bottom. The space you allowed earlier between the bottom and the end of the tenon means those two surfaces won't produce significant glue strength. Mostly, you want your smoothing efforts to ensure that the bottom won't interfere with the end of the tenon when it's time to close the joint.

Chisel the mortise sides. *After placing the tip of a wide chisel in the knife line that marks the side of the mortise, use hand pressure to clean away the waste stock from the mortise sides.*

JOINERY

Tenons

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. The job of 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 a tablesaw or router; others prefer the more contemplative whoosh of a backsaw and handplane. Fortunately, when it comes to cutting tenons, there's a method to satisfy every inclination.

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.

I never cut mortises or tenons without 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 the 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 time it takes to set up 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 layout (see photos, p. 44). Your method may involve using a marking gauge and square, a mortising gauge, or a pencil and square. But whatever method you choose, be consistent with your approach and always be dead-on accurate. Even if you are using machines to cut tenons, the same guidelines for marking 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 ½-in.-thick mortise in the center of a door stile, for example, lay out a ½-in.-thick tenon centered in the thickness of the door rail.

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.

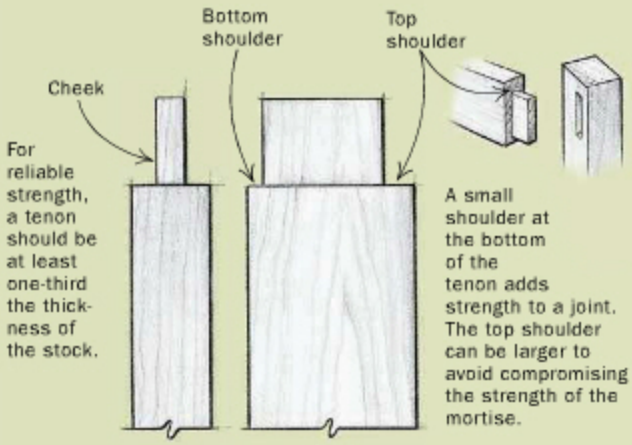
Use a backsaw to establish the shoulders. You want to cut right down to the cheek lines, but be careful not to saw past these marks. Next, cut the faces of the cheeks. Placing the work in a vise allows you to see both the top gauge line and the cheek line nearest you. For a short tenon, cut straight down these lines until you reach the shoulder. For a longer tenon, angle the workpiece so that you can easily see both the top gauge line and 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.

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).

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. Use the same methods to cut any haunches or other shoulders. Then grab a chisel and

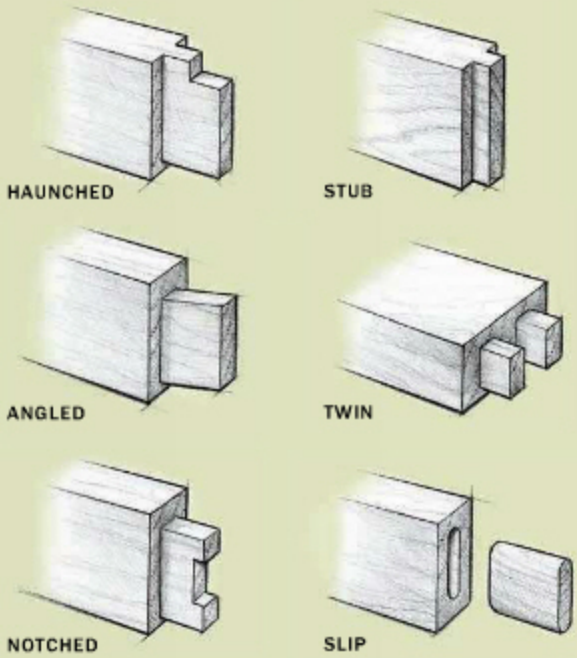
THE BASIC TENON

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



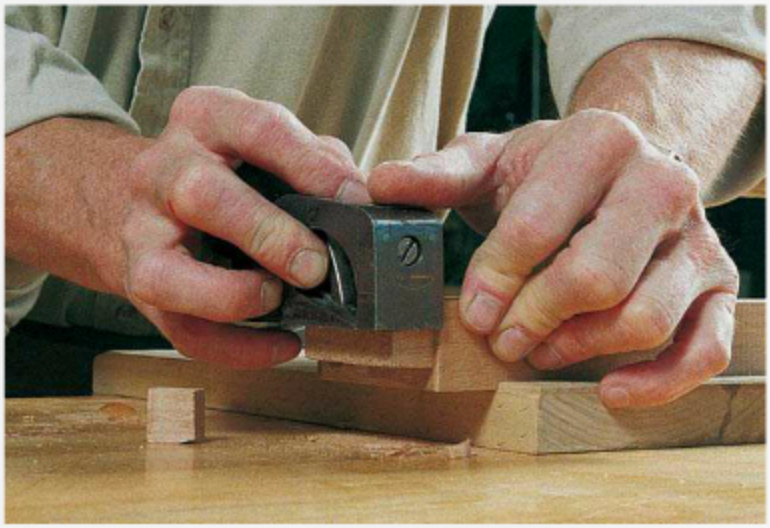
FOR A FEW SIMPLE JOINTS, CUT TENONS BY HAND

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 backsaw 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).*



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 bandsaw 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, 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 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

Photos, except where noted: Matthew Teague

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

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

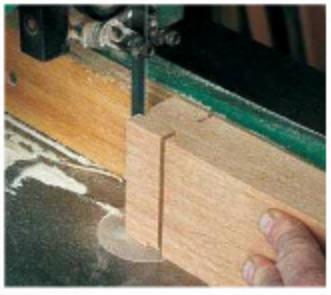
Make the passes for one side of all of the boards first. If your blade cuts well, you'll need to clean these cheeks very little;

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.

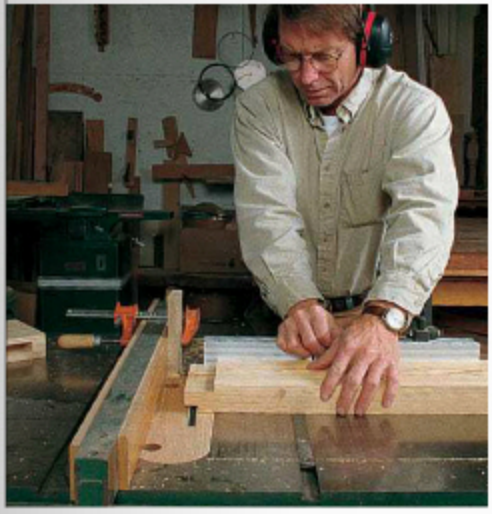
Method 1 CUTTING TENONS ON THE RADIAL-ARM SAW AND BANDSAW

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.*



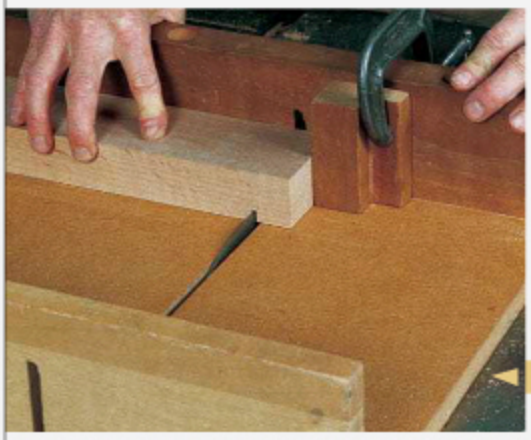
A bandsaw trims the cheek. *With the fence set in place, a quick pass cuts to the shoulder line. After adjusting the fence, another cut establishes the top and bottom of the tenon. A backsaw and chisel are used to clean up the shoulders.*

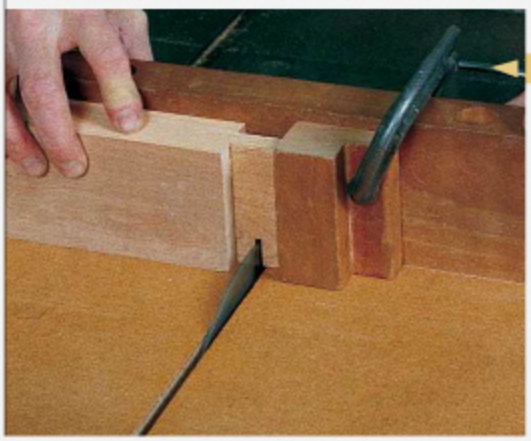
Method 2 CUTTING TENONS ON THE TABLESAW



A dado blade hogs off the waste. *A stop block clamped to the fence sets the length 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





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).*

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.*

but if your blade cuts like my dado blade, you will have to take some extra 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 intended thickness, you can 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). First, I cut the shoulders with a crosscut jig and rough-cut the cheeks on the bandsaw. Then, I trim the tenons to fit perfectly by holding them vertically on the tablesaw and pass 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 builds up between the stop and the board, it won't cause the tenon to be cut too long. A too-short tenon 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 ½-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 will 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. If it covers the mortise wall so you can't see it all, you'll need to glue on one of those tenon offcuts 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 cut depth. 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

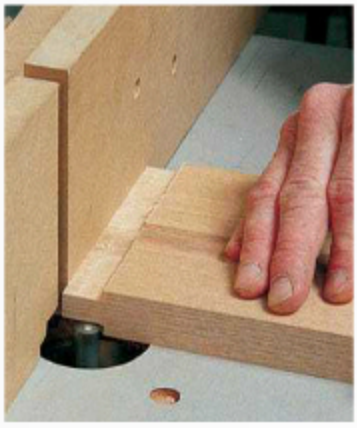
Given the proper amount of patience and setup time, tenons can be cut successfully using a router table, and this setup really comes in handy if you have quite a few tenons to cut. This tenoning method is similar to the dado-blade setup on the tablesaw in that you need to set the bit height for a perfect cut. But with a good bit in the router, you get a much smoother cut than you

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.

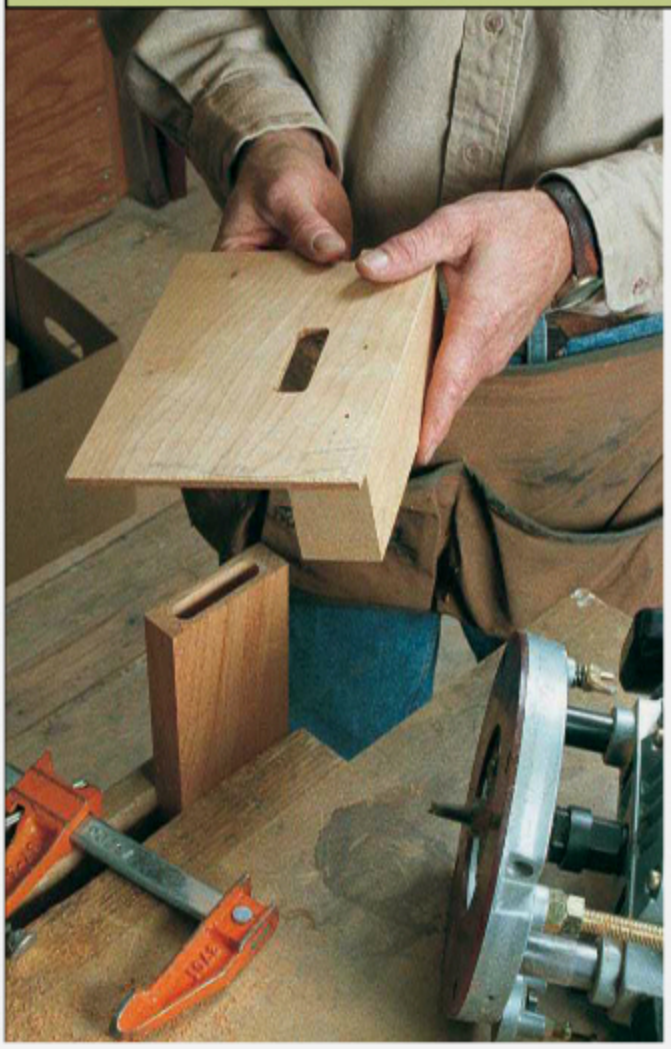
Method 1 ROUTER-TABLE TENONS

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).*



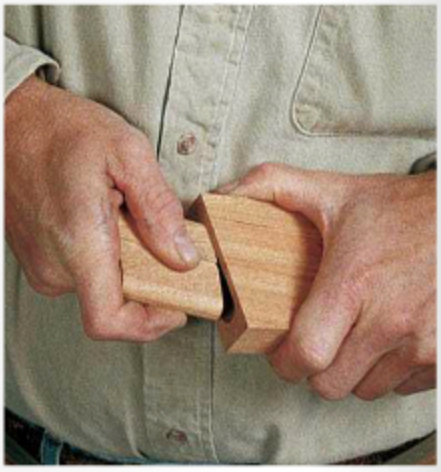
Method 2 PLUNGE-ROUTING WIDE TENONS

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 SLIP TENONS

Slip tenons for long stock. *Sometimes lengthy boards are difficult to muscle around machines, but using slip 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).*



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, p. 47). I also like to 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 rounded ends of the mortises or round over the tenons. When I opt to round over the tenons, a chisel and file get the job done quickly. First, I pare the square edge with the chisel, then I use the file to round it over. A simple, shopmade gauge, (just 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, p. 47). A breadboard end with multiple tenons is the perfect situation to use this method, but it also works well for narrow boards. You will 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 bandsaw 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 slip tenons on long stock

When your stock gets too long to cut tenons, you can use slip tenons (see Method 3, 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 slip-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 tablesaw). 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 tablesaw before crosscutting it to length. When cut to length, the slip 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 can save you a lot of time and work (see 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 prices starting at around $1,500, you have to be able to justify the cost of the machine.

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.*

Start your tenon cuts by making a right-angle fence to locate all of the tenon pieces. With a simple, shopmade end stop, you can set each tenon board in exactly the same location 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 should have no trouble cutting it quickly by hand. If you're cutting hundreds of tenons, though, 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. □

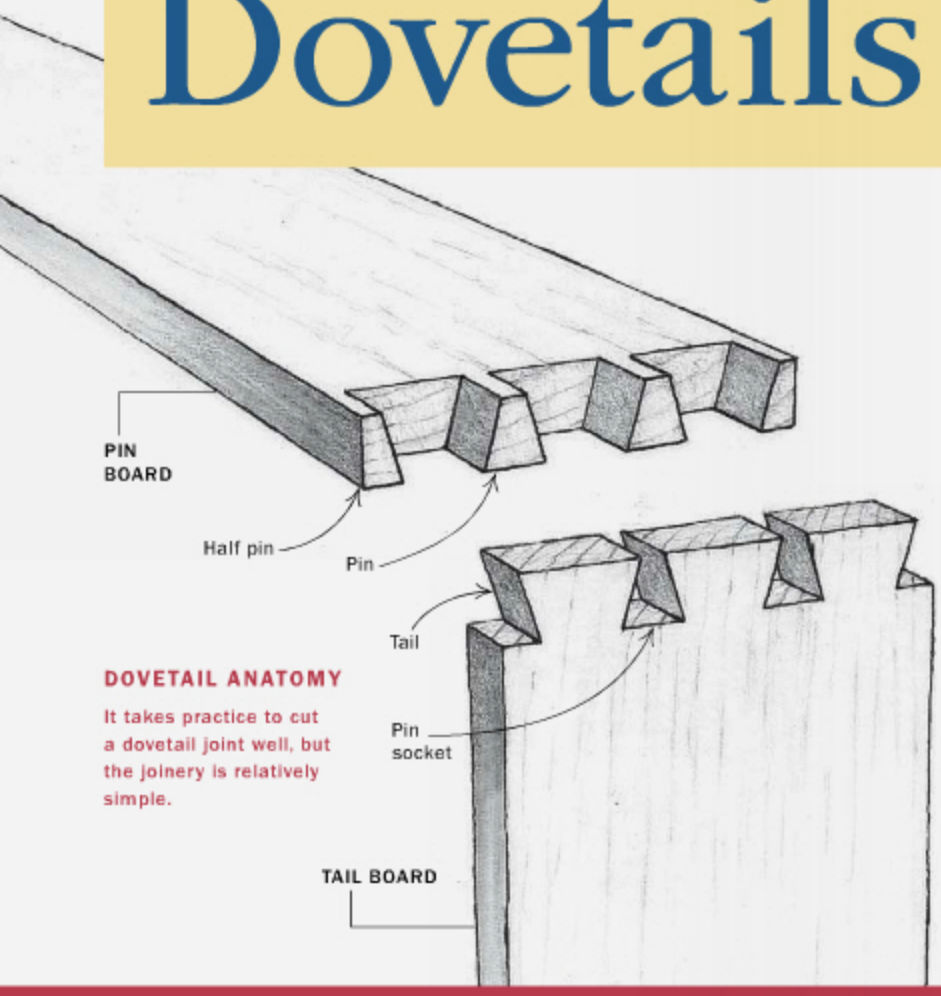
Gary Rogowski builds furniture and teaches woodworking (northwestwoodworking.com) in Portland, Ore.

JOINERY

Dovetails

Step by step: How to make this classic joint

BY CHRISTIAN BECKSVOORT



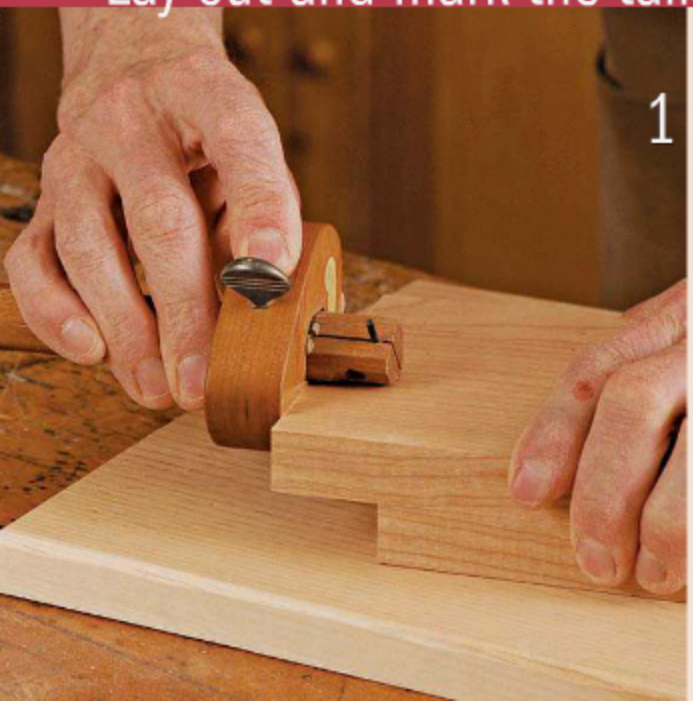
DOVETAIL ANATOMY

It takes practice to cut a dovetail joint well, but the joinery is relatively simple.

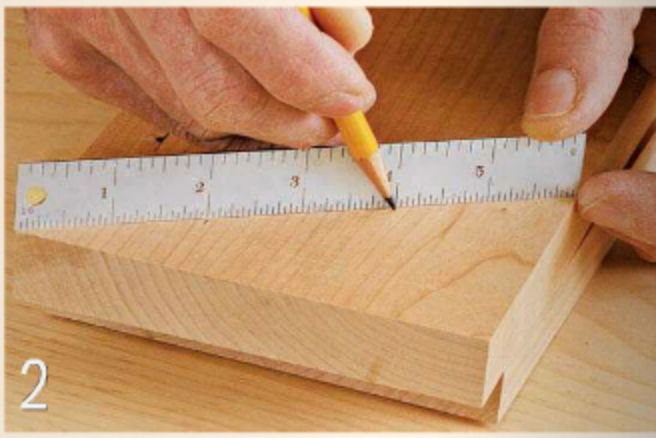
Woodworkers have dozens of ways to join boards together, but few of them offer the eye-appeal and strength of a through-dovetail joint. Perhaps more than any other joint, the through-dovetail is the one most associated with fine woodworking.

A lot of woodworkers shy away from through-dovetails, thinking they are too time consuming and difficult to make. Certainly, there's no getting around the fact that it's faster to make a butt, rabbet, or

Lay out and mark the tails



Use a marking gauge to scribe a baseline on both sides of the boards. *If you are joining boards of the same thickness, you need only one setting—the thickness of either board. When the pin board and tail board are different thicknesses, the thickness of one determines the baseline for the other.*



Lay out centerlines for the pin sockets on the tail board. *For a board with two pins, Becksvoort divides the board into thirds, as shown. There's also a half-pin at each end.*

Drawings: Christopher Clapp; photos: Tom Begnal

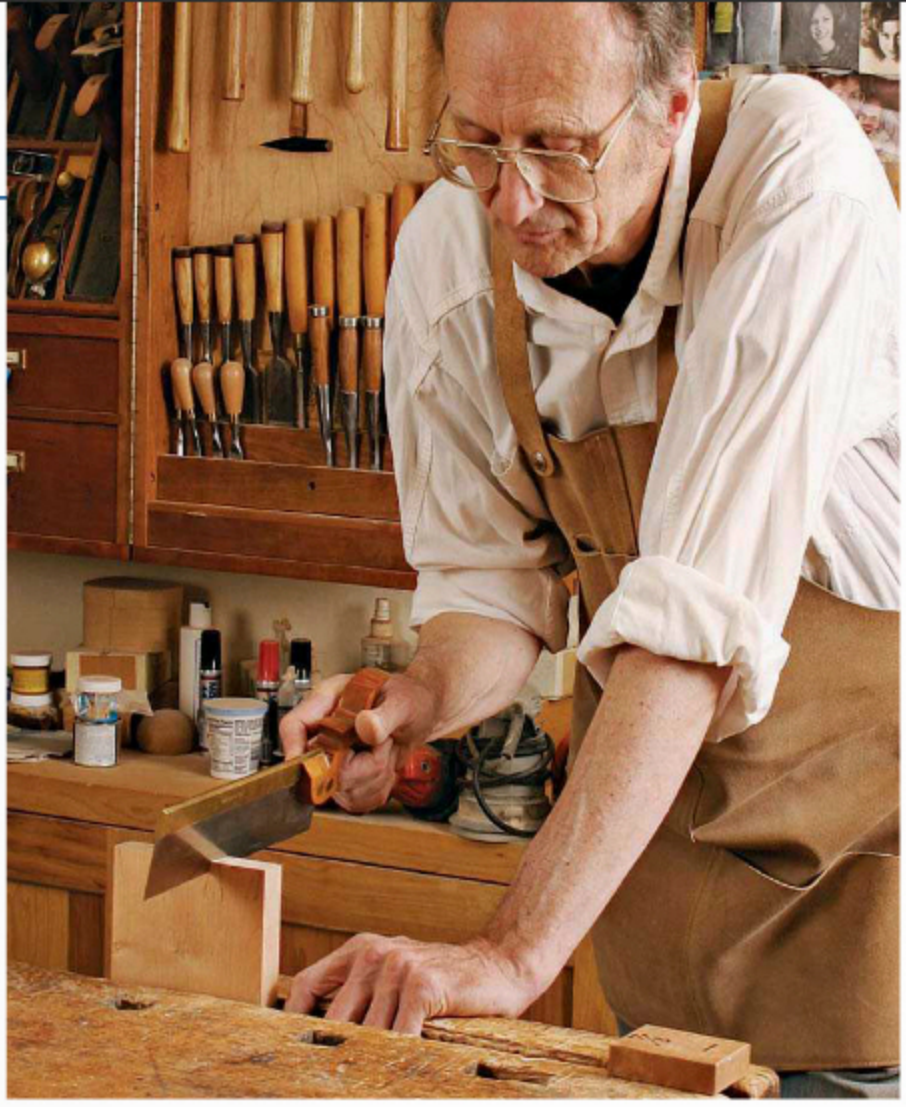
splined joint. And a through-dovetail exposes lots of cut lines that must be straight and tight-fitting, so the fear factor is easy to understand.

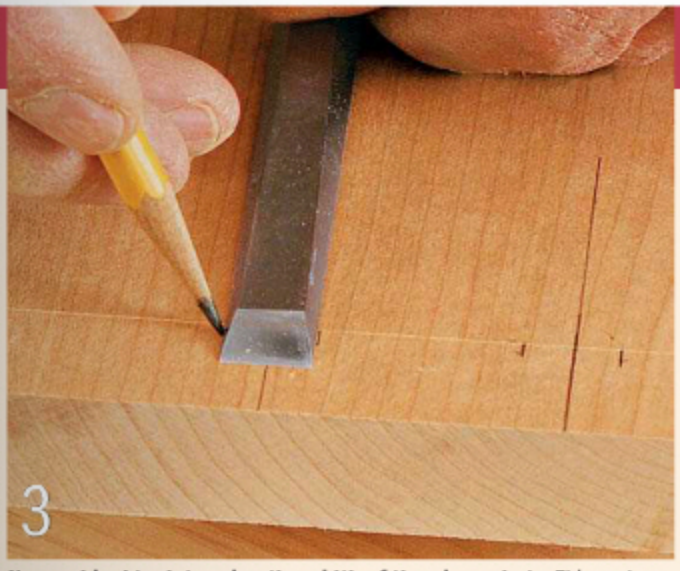
But the dovetail need not be an impossible dream. Using the technique shown here, you'll be making dovetails as routinely as any other woodworking joint.

It takes only two types of tool to cut dovetails, a dovetail saw and a few chisels. The sawblade should be thin and stiff. For most dovetails, I use one with 14 teeth per inch (tpi).

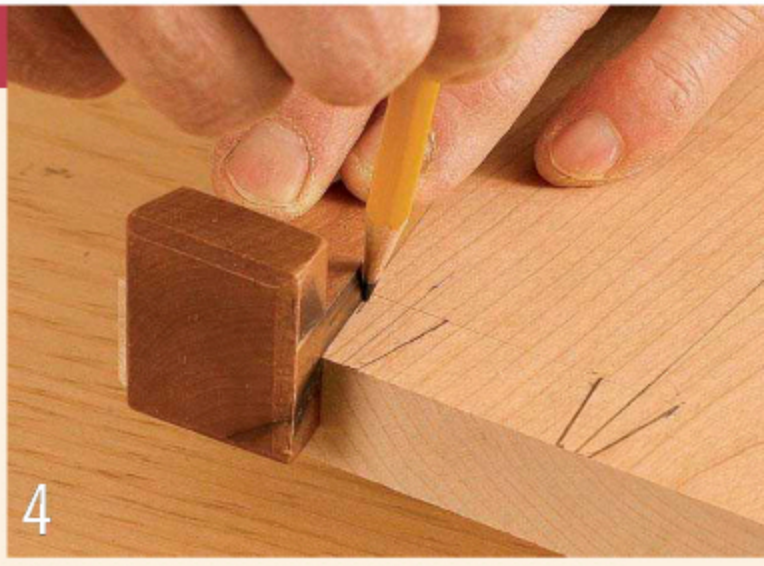
Before committing project stock to any dovetail cuts, it's a good idea to practice the process on scrap wood. It will help you get a better feel for the tools and the way they cut. And you'll begin to recognize the special satisfaction that results when tails and pins slip snugly together to create a perfect joint.

Christian Becksvoort builds custom furniture in New Gloucester, Maine (chbecksvoort .com). Vincent Laurence and Tom Begnal also contributed to this article.





Use a chisel to determine the width of the pin sockets. *This makes chopping the sockets much more efficient. Place the chisel over the centerline, and use a pencil to mark each side. Then mark out the half-pin sockets on the ends.*



Mark the angles of the pin sockets with a dovetail gauge or a bevel square. *Then transfer these lines across the end grain. After that, tape the two tail boards together, so you can cut pin sockets on both at the same time.*

Cut and chop the tails

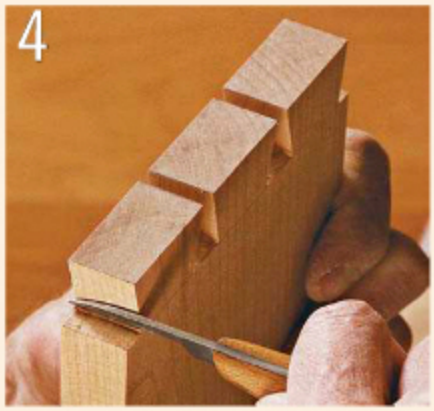
Cut the tails. *Use a handsaw with a fine blade to make cuts to the baseline. Remember to cut on the waste side of the line. Also, cut the two half-pin sockets during this step. Clamping two boards together allows Becksvoort to cut two sets of tails at once.*

Chop out the waste with a chisel. *Start by creating a small groove on the waste side of the baseline. Then chop alternately downward at a slight angle (2) and in at a sharp angle (3).*

Mark and cut the pins

Use the tail board to lay out the pins. *Clamp the pin board into a vise, and set the tail board perpendicular to it. Make sure the edges of both boards are flush, and be sure the inside edges of all the sockets align perfectly with the inside corner of the upright board. Apply pressure to the top board, and mark the dovetails with a sharp knife (1). Extend the pin marks down the side of the pin board using a pencil and a small square (2). Cut down to the baseline on the waste side of the line (3).*

Cut halfway through, then flip the boards. *Don't chop in from the end of the board yet. Keeping the corner intact prevents tearout when the waste is removed from the center of the socket. Once you've chopped about halfway through the joint, flip the boards over and repeat. This time, though, chop from the end.*



Clean the corners. *Use a knife to clean the corners in each of the sockets.*

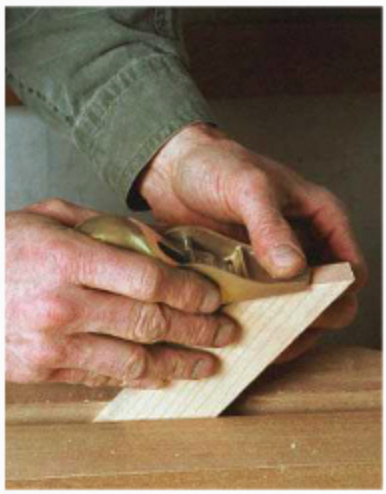
Chop out the waste between pins. *Clamp the boards so that their inside faces are up (4). This prevents the chips from becoming wedged between the pins when you finish chopping out the waste from the other side. When you're about halfway through, turn the boards over and re-clamp. As with the tail boards, once you've flipped the boards over, you can chop in from the end. Pare to the line with a knife (5).*

Test-fit the joint. *If you've cut and pared right up to the lines, the parts should fit like they were made for each other, a snug friction fit that comes together with a light tapping of your fist.*


Power
Tools

JOINERY

Miters

How to cut, trim, glue up, and reinforce this multipurpose joint

BY GARY ROGOWSKI

When connecting parts that meet at an angle, woodworkers can choose from several joints. My first choice is often the miter joint. The mating parts of a miter joint are cut on a bias, so the end grain—usually the least attractive surface on a piece of wood—is hidden. The resulting joint has a simple elegance, and it can be made in a manner that's reasonably straightforward.

Whether you are building the frame for a veneered panel, applying wrap-around molding, or constructing a simple picture frame, a miter joint will serve your needs. But, as the saying goes, the devil is in the details. The very visibility of the miter joint means that errors in machining or assembly are hard to conceal. But with a little patience and lots of practice you, too, can master the miter joint.

Generally, the miter is used to join two boards of equal thickness and width at right angles. A glued miter joint is relatively weak, so if the joint is expected to get any more than minor stress, plan to add some reinforcement. Fortunately, woodworkers long ago figured out ways to beef up miter joints. That beef comes in the form of biscuits, splines, or keys.

Use a clean, sharp sawblade

You can cut a miter joint with either a chopsaw or tablesaw. Just make sure the saw has a sharp, clean blade. Generally, the more teeth to a blade, the smoother the cut, but no blade will cut well if it's dull or covered with pitch. Every cut will be 45° across the width of a board and 90° across its face. For a miter to close up well, both angles must be set precisely. Make rough adjustments using a plastic 45° drafting triangle, then take several practice cuts, checking the results with a combination square.

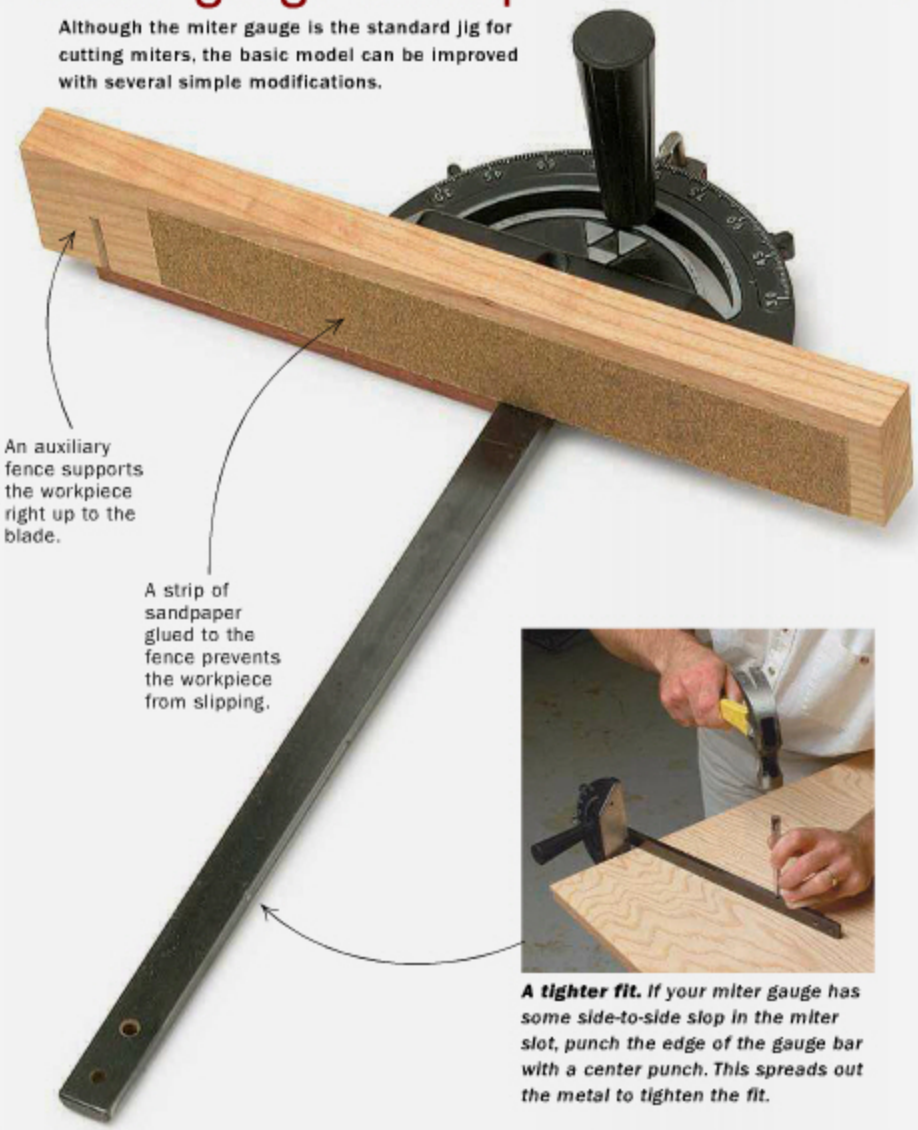
A chopsaw works great at cutting miters. Just make sure the fence is flat and straight. If necessary, add an auxiliary fence and shim it to make it square to the table. Frame parts can lie flat on the chopsaw table. Angle the blade 45° to the fence to make the cuts. Clamp stops onto the auxiliary fence to index matching cuts.

When cutting miters on a tablesaw, you'll get the best results using a jig that holds

Photos, except where noted: Mark Schofield

Miter-gauge tune-up

Although the miter gauge is the standard jig for cutting miters, the basic model can be improved with several simple modifications.



A tighter fit. *If your miter gauge has some side-to-side slop in the miter slot, punch the edge of the gauge bar with a center punch. This spreads out the metal to tighten the fit.*

your work to move it past the blade. The miter gauge is, of course, the standard jig used for cutting miters. Be sure to check your settings for the angle of cut (see photos, below). Attach an auxiliary fence to the miter gauge to support the workpiece near the blade.

When cutting frame miters, angle the gauge down and away from the blade. This way, if the workpiece slips, it will slide away from the blade. A piece of sandpaper glued to the fence will help prevent slipping. Make certain that your gauge is cutting a true 45° angle, then cut one end of each matching part. Measure and mark off the required length and clamp a stop onto the auxiliary fence to index the cut so matching parts are the same length.

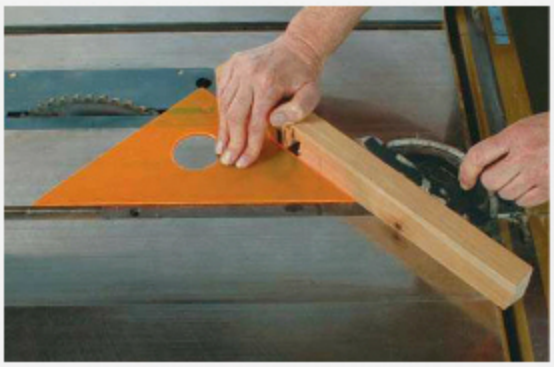
Picture-frame jig saves time

If you plan to cut a lot of miters, a picture-frame jig can save setup time. It has only a few parts: a flat base, two runners, a fence, and clamping blocks. The base can be made of any flat, ½-in.-thick sheet stock. Make the runners out of quartersawn hardwood, so seasonal movement won't affect their fit. Cut the corner of the fence at a right angle, then screw it to the base. It won't matter if it's mounted a little off a true 45° angle as long as you always cut one piece of the miter joint on the left side of the fence and the other on the right side. The cuts will mate perfectly. Put on the clamping blocks last. You can clamp a stop block to them to make cuts of uniform length.

Fine-tune the fit before glue-up

After cutting the miters, do yourself a favor and take some time to prepare them for

MAKE A TEST CUT AND CHECK FOR SQUARE

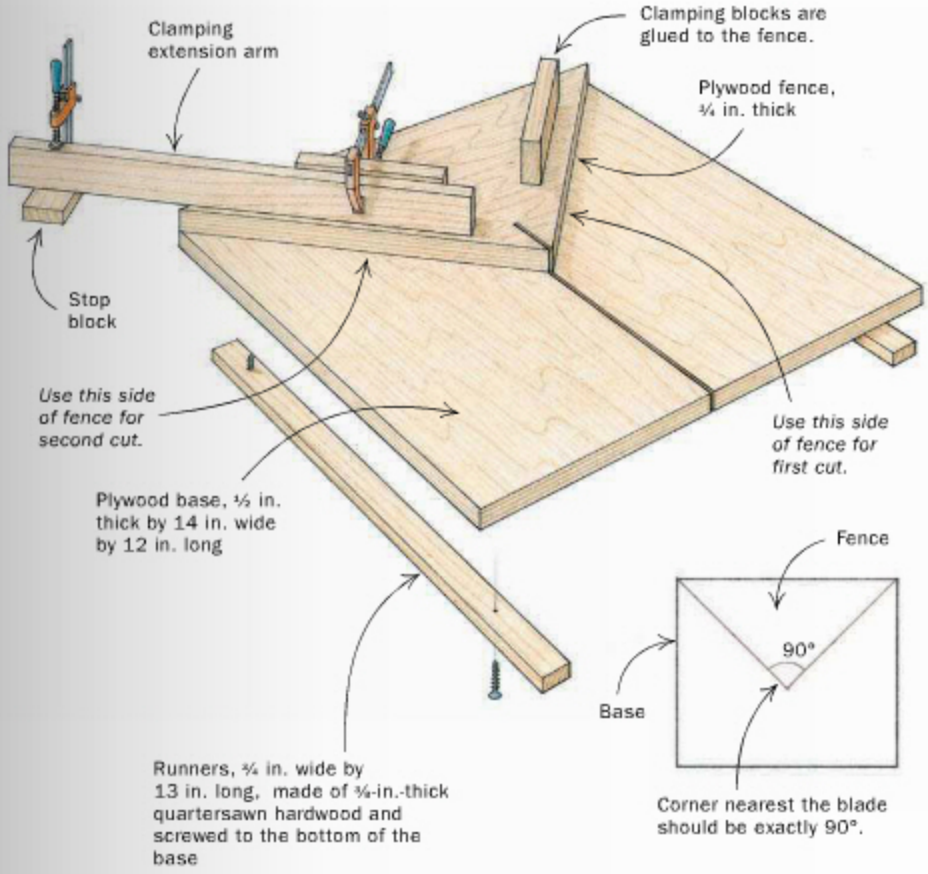


To set the miter gauge at exactly 45°, first align a drafting triangle against the miter slot in the tablesaw (left). *Make a cut in a piece of scrapwood (center). Flip over the cut-off piece and hold both pieces tightly against a square (right). Adjust the miter gauge until there is no gap, and you are set to cut perfect miters.*

Photos, this page: Michael Pekovich

Picture-frame jig

Cut adjoining parts on opposite sides of the jig to guarantee a 90° joint.



The first cut is made on the left-hand side of the jig. *If the work slips, it will do so away from the blade.*

Uniform length. *Mark the length on the workpiece and on the right-hand fence. Clamp a stop block against the mitered end.*

Make the second cut on the right-hand side of the jig. *With the stop block in place, you are assured of consistent cuts.*

gluing. First, check your cuts to see how well your saw performed. There are several ways to remedy a cut that is less than smooth. One option is to trim the miter with a low-angle block plane with a sharp blade. Put the workpiece in a vise and take a few light passes off each mating face, but don't change the angle. Check your results with a combination square.

A disk sander outfitted with a miter-gauge jig can also be used to fine-tune miters. This jig rides in the slot in the sander table and has a plate on it cut at 90° but positioned 45° to the sanding disk. Work on both sides of this fence to ensure that mating pieces get complementary cuts, but always work on the left side of the moving disk. This way, your work will always get pushed down into the supporting table. Take only light passes, and try to move the work past the disk so you don't burn the wood or load up the disk in one spot. Before starting, double-check that the sander's table is exactly 90° to the disk.

A third method is to use a shooting board. A stop angled 45° on both sides is screwed to the base. Used with a square-sided plane, this jig will trim the miter at 45° across its width and at 90° to its face.

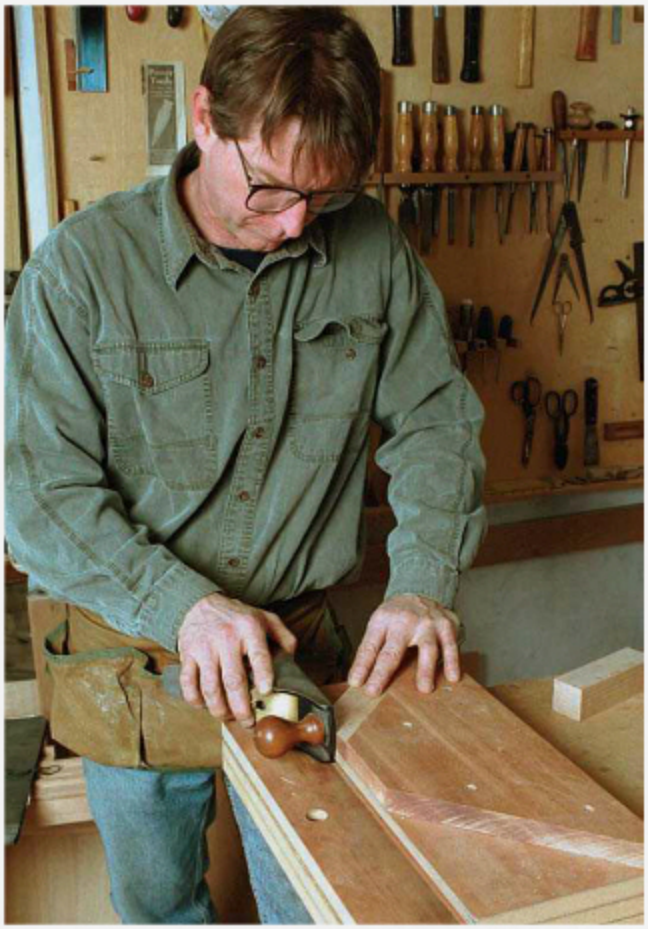
A sizing coat of glue is critical

Crosscut or miter the end of a board, and you expose the end grain of the wood. Apply glue to end grain and most of it immediately soaks into the pores, meaning you end up with hardly any glue on the surface. Unfortunately, you won't get a strong bond unless the mating surfaces have adequate glue. The solution here is to apply two coats of yellow glue to the miter joint. The first coat, called a sizing coat, seals most of the end-grain pores and serves as a base for the second coat. Just be sure to scrape off any excess glue before the sizing coat dries. The normal warning not to apply glue to an already glued surface does not apply in this case; sizing will strengthen the joint. Dry-fit and clamp everything

Drawings, except where noted: Vince Babak

Trimming miters

A light plane. *A few passes with a well-tuned block plane will clean up the surface and alter the angle, if necessary.*



Accurate shooting. *This shooting board, when used with a square-sided plane, trims the wood at 45° across its width and at 90° to its face.*

Sand to fit. *Another way to fine-tune a miter joint is to use a jig that holds the workpiece at 45° to a sanding disk.*

before the final glue-up. You'll thank yourself later for your calm demeanor and slow heart rate.

Band clamps fit around a box or a picture frame to apply even pressure to the miter joints. Practice locating and tightening the band clamp in place right over the joint. Use several clamps for wider glue-ups, and stagger the clamp heads so they're not in each other's way.

You can put clamping corners over the joint to help spread the pressure. Some band clamps come with self-adjusting corners suitable for any angle; you can also buy aftermarket versions. Again, practice with these systems before gluing.

When gluing up miters with splines or keys that would interfere with a band clamp, I use shopmade clamping blocks clamped right onto the frame side. These blocks have a notch cut into them where you can place another clamp to apply pressure directly across the joint. If your clamping blocks slip too much, glue a piece of sandpaper to them on the side that rests against the workpiece.

How to strengthen miters

Reinforce miter joints with splines or biscuits, which are inserted before the joint is glued up, or keys, which are added after glue-up. The method you use will be determined by several factors, the most important being aesthetic considerations. Do you want to conceal the reinforcement for a seamless look, as with a gilded picture frame, or do you prefer to emphasize it, as with face-frame keys? Another factor is the difficulty and length of time involved.

Splined miters in frames—Through-spline cuts are made along the length of the miter. They're most easily made on the tablesaw. Use a spline-cutting jig to support the workpiece at a 45° angle to the blade. Make this jig from a straight piece of ¾-in.-thick plywood with a support piece glued and screwed on at a 45° angle. Make sure your fasteners are higher than the tablesaw blade at its highest setting.

With your frame piece in the jig, set the fence so that the sawkerf is centered in the thickness of the stock. If it's not, the faces of your frame members will not be flush. One way to prevent this is by having a miter jig with two fences on it for each side of the miter (see photos and drawings,

Gluing and clamping miters

Sizing the joint. *The open grain on the face of a miter should be sealed with a thin layer of glue and allowed to nearly dry. The sealed end grain won't starve the joint when glue is applied to connect the miter.*

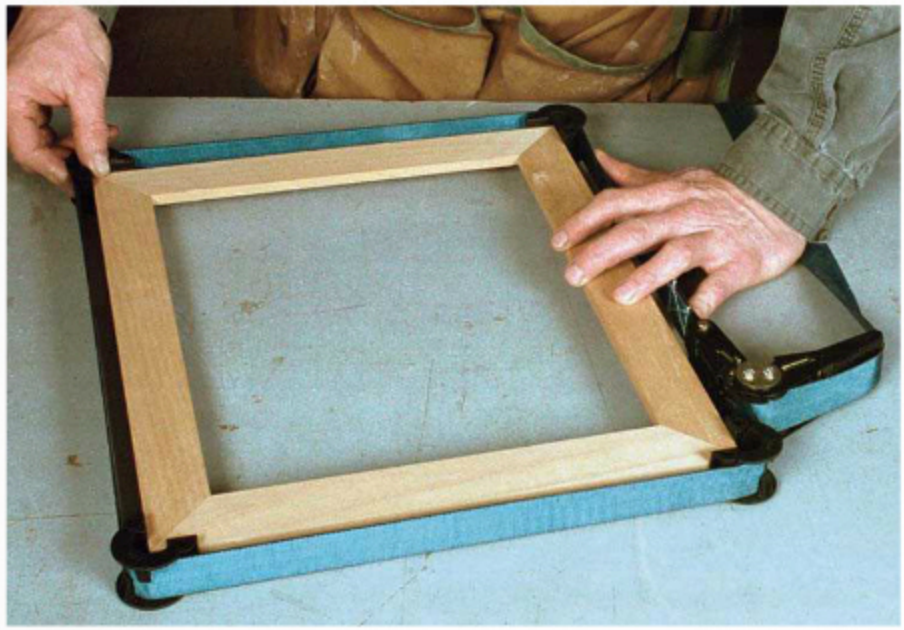
p. 60). The jig is rotated 90° to cut the spline in the adjoining workpiece.

Set the blade height for a ¼-in.- to ⅜-in.-deep cut, but no deeper. Because the grain direction of a spline in a solid-wood frame has to run in the same direction as the frame members, too deep a spline cut makes for a wide and fragile spline. Hold or clamp the work firmly in the jig. Place your hands well out of harm's way and make a pass. Use a flat-grind blade to put a flat bottom on the cut.

Mill the spline out of a contrasting wood to create a more dramatic visual effect. Using a tenoning jig, hold the board vertically and run it past the blade to trim your spline to thickness. Then cut the spline to length. If your spline doesn't quite fit, use a block plane to trim it to thickness. Be careful not to snap the short grain of the spline as you plane. You're looking for a snug fit, not one that's overly tight.

Fit one side of the spline and check to see that it will let the joint close up nicely. Trim its end grain with a block plane, if needed. Size the end grain of the miter, then put glue in one of the spline cuts with a thin piece of wood. Set the spline in place all the way to the bottom of the groove. Then put glue on the rest of the joint and clamp it up. If the fit is loose, clamp across the face of the joint.

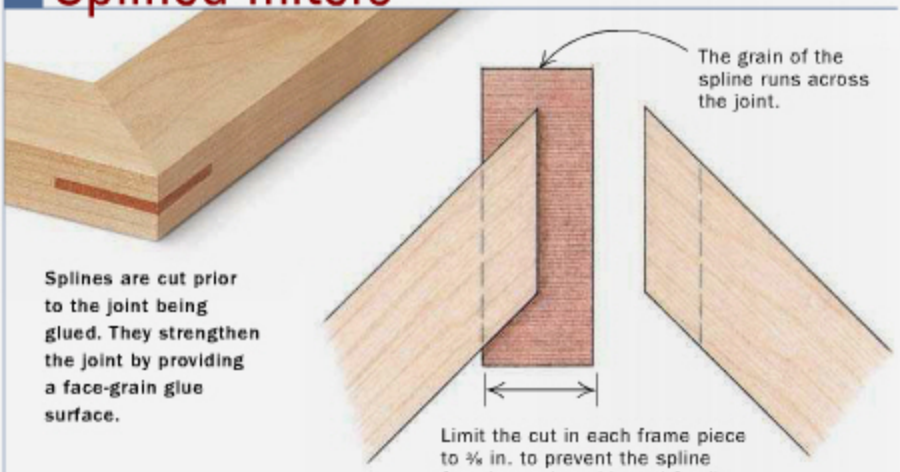
Biscuit splines—You can also strengthen a miter with a biscuit joint. Mark the frame members across their faces with a pencil at the center of the joint or, if necessary,



A better band clamp. *Plastic corner blocks added to a band clamp reduce the risk of crushing the corners of the workpiece.*

Bar-clamp techniques. *Shopmade clamping blocks distribute pressure across the joint and won't mar the workpiece.*

Splined miters



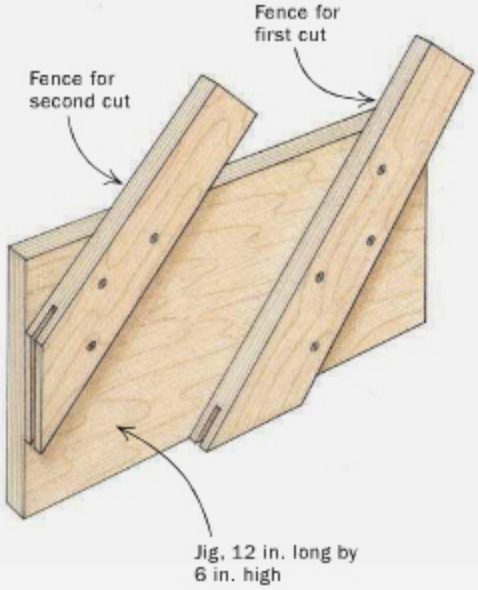
Splines are cut prior to the joint being glued. They strengthen the joint by providing a face-grain glue surface.

Cutting the spline. *Use a tenoning jig to trim the spline to thickness.*

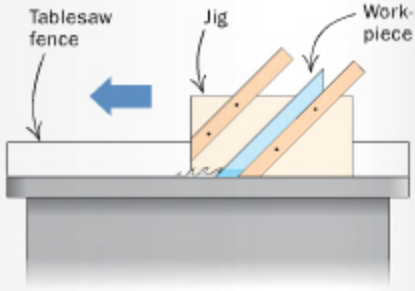
No band clamps here. *Because the spline extends beyond the outside corner, it is necessary to use block clamps.*

SPLINE-CUTTING JIG

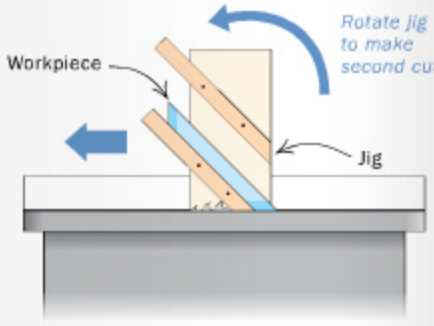
This jig has two 45° fences, which allow spline slots to be cut on both ends of the workpiece while keeping the same face registered against the jig. All parts are made of ¾-in.-thick plywood.



Cut one end. *Hold the workpiece firmly in place and register the jig against the tablesaw fence.*



Then cut the opposite end. *Rotate the jig and register the workpiece against the other fence.*



closer toward the inside corner of the joint so that the cut won't show at the corners. Center the biscuit joiner in the thickness of the stock. Support or clamp the frame members securely, and hold the joiner tight to the miter as you cut.

Keys can reinforce miter joints

Mitered frames may also be reinforced after glue-up using exposed keys. These keys, either straight or face, are inserted into mitered corners from the outside after cutting the appropriately sized slots. Slots may be cut on a tablesaw or on a router table.

Cutting straight keys on the tablesaw—A keyed miter jig works great for holding a glued-up frame in place while you pass it through the sawblade (see photos and drawings, facing page). Set the blade height for the full depth of cut, and use a flat-grind blade if you have one. Cut each corner, holding the same face of the frame to the jig.

Mill up key stock wider than the depth of the key cut. Trim the stock to thickness on the tablesaw. You should use a thin push stick to help you move the work

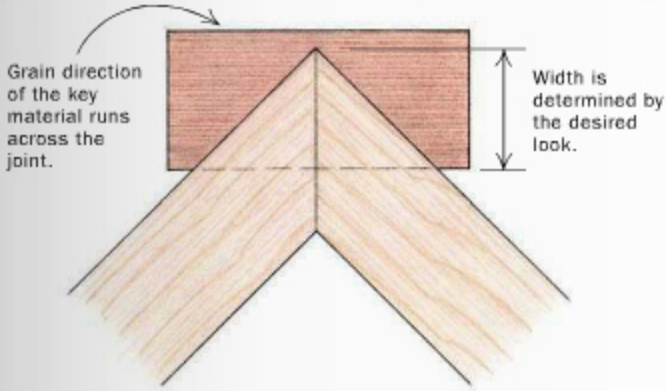
Drawings, this page (bottom right): Michael Pekovich

Keyed miters

STRAIGHT KEY

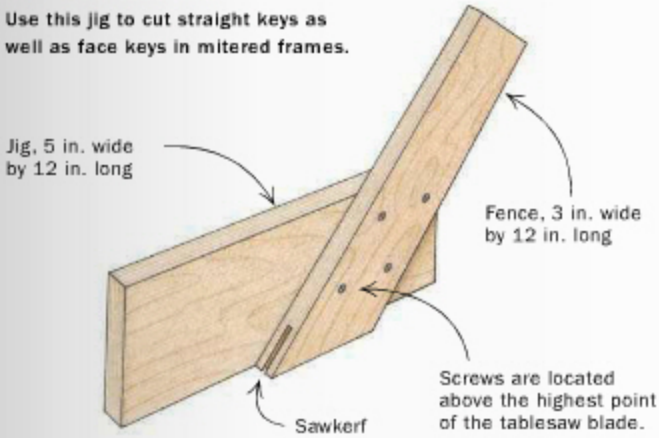
FACE KEY

Keys are added after the joint has been glued. Both face keys and straight keys add to the glue area of the joint.



KEY-CUTTING JIG

Use this jig to cut straight keys as well as face keys in mitered frames.



One jig cuts two keys. *Simply by adjusting the fence of the tablesaw, the key-cutting jig can cut either straight keys in the center of the frame (above), or face keys on the front and back of the frame (right).*

safely past the blade. Use a handplane to trim the key exactly to thickness, then cut it longer than necessary.

Fit keys in their cuts so that they're snug and only require a light tap to position them. Make sure when gluing that they fit all the way into the cut at both its sides. Once the keys are dry, clean them up on the bandsaw. Sight along the edge of your frame as you make the cut so you don't cut into the piece. Then, trim with a handplane. Make sure you plane away from the corner in each direction to trim the key flush. If you plane toward the corner, you will tear out the tip of the key.

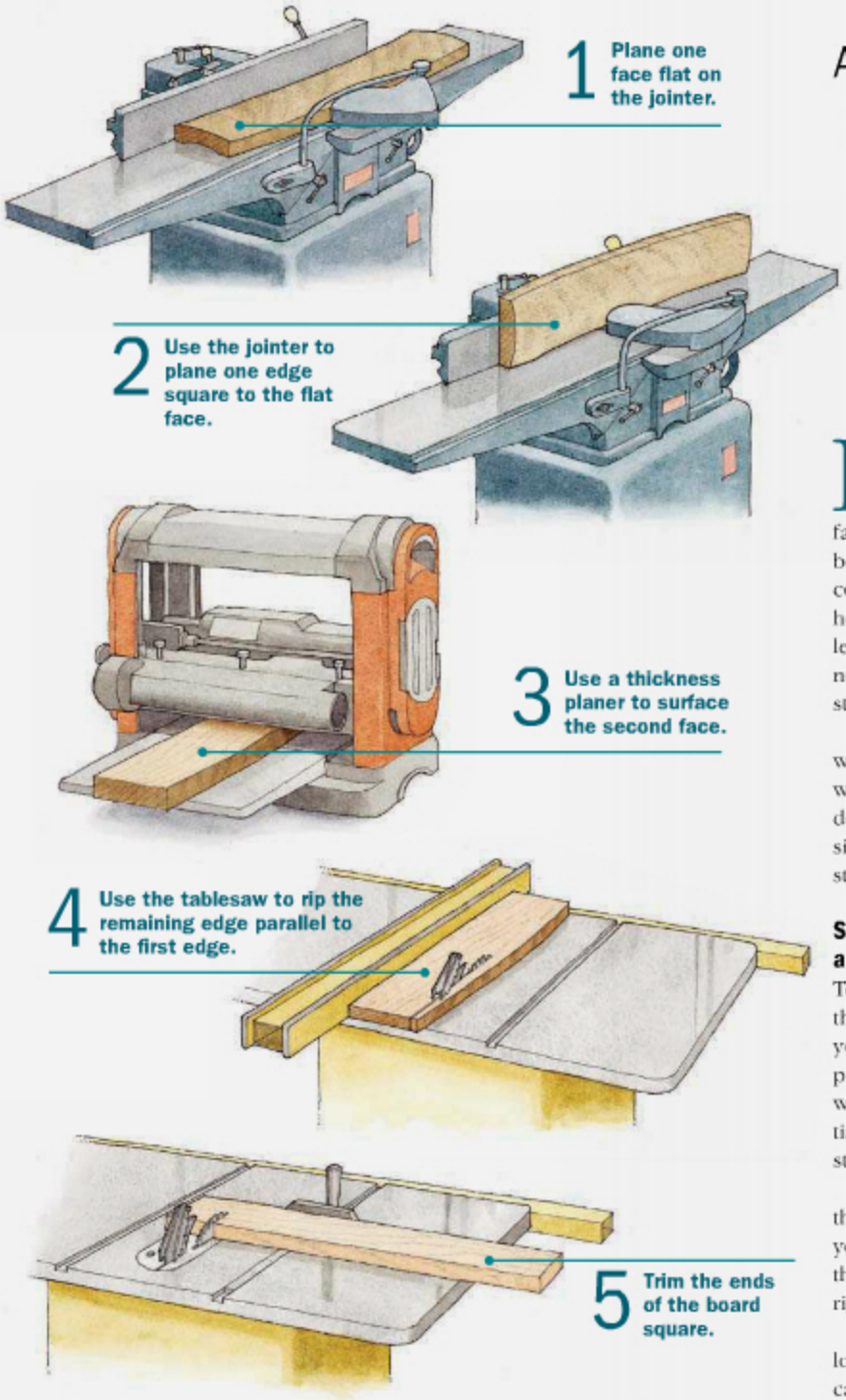
Cutting face-keyed miters—Make these cuts using the keyed miter jig on the tablesaw. Place the cut just on the outside edge of each corner on both faces of the frame. Make up key stock as before, but this time just make it conveniently thick. When gluing, make sure the keys fit down to the bottom of the cut on both sides of the joint. Put clamps across the keys to hold them in place. The final step is to plane the keys flush with the face of the frame.

But be careful when planing, as the three mating parts create unavoidable changes in grain direction. Use light planing cuts to avoid tearout. □

Gary Rogowski runs The Northwest Woodworking Studio in Portland, Ore. (northwestwoodworking.com).

TECHNIQUES

Milling Lumber



A successful woodworking project begins with stock prepared at the jointer, planer, and tablesaw

BY TOM BEGNAL

Imagine trying to build a skyscraper from bent or twisted beams. It would be an overwhelming challenge, if not downright impossible. Woodworkers face the same dilemma when they try to work with boards that have more curves than straight lines. It's a common problem, because almost all boards we bring home from the lumberyard or home center have at least some measure of warp. And if those boards are not adequately dry, they can warp even more while stored in your workshop.

So before you begin any project, some preliminary work is in order. That work, called milling, is done with the jointer, planer, and tablesaw. When you're done, the six surfaces of each board—two faces, two side edges, and two end edges—should be flat and straight, with all the corners perfectly square.

Select flat, square stock and cut it longer and wider than you need

To make the milling process as easy as possible, begin thinking about flat, straight, and square stock when you're selecting the wood, no matter if it has been planed already or is still rough-sawn. Avoid badly warped stock. A board with a big bend or a substantial twist is almost impossible to mill so it ends up flat, straight, and square.

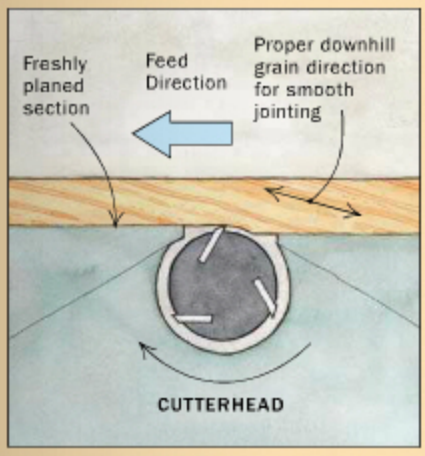
Buy boards somewhat thicker, wider, and longer than the final dimensions you need. That way, when you mill away the extra material to remove the warp, there will be enough stock remaining to provide the right-sized board.

As a general rule, I start by cutting each board a little longer than its approximate final length. Long boards can be a bear to crosscut on a tablesaw, so I cut them

Photos: Tom Begnal; drawings: Jim Richey

1 FLATTEN A FACE ON THE JOINTER

The milling process starts on the jointer. To minimize tearout or splintering, take a reading of the grain direction by looking at the side edge of the board. If it tends to run more in one direction than another, feed it into the planer with that grain direction in mind.



with a handsaw or a power circular saw. An extra inch of length is usually enough.

Once cut to length, I use a bandsaw to rip the boards to their approximate final width. The bandsaw is safer than the tablesaw when cutting warped stock. Depending on the width, I'll allow an extra ¼ in. to ½ in. of stock during this initial cut. Keep in mind, though, that the maximum width is limited by the size of your jointer. If you need to end up with a 10-in.-wide board and you have a 6-in. jointer, you'll want to rip two pieces of stock to about 5½ in. wide and edge-glue them after they've been milled.

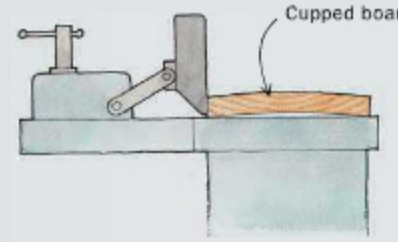
First flatten one face on the jointer

With the boards cut to manageable lengths and widths, the next step is to flatten one face of each board. The jointer gets that job. For safety, always use pusher blocks when planing a face surface.

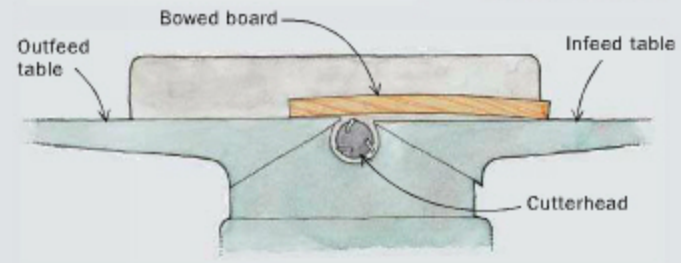
I generally take light cuts, no more than 1/64 in. If I have a lot of material to remove, I might increase the next couple of cuts by an additional 1/64 in, but rarely do I remove more than 1/32 in. with a single pass of the jointer. A cut that's too heavy requires you to exert more pushing force on the board. I prefer to make a few extra passes and not have to push as hard. An

HOW THE JOINTER FLATTENS LUMBER

The infeed and outfeed table surfaces are flat and parallel to each other. All the cutterhead knives are flush with the top of the outfeed table. The infeed table is set slightly below the outfeed table. As the board travels from the infeed table to the higher outfeed table, the knives shave an amount equal to the difference in table height.

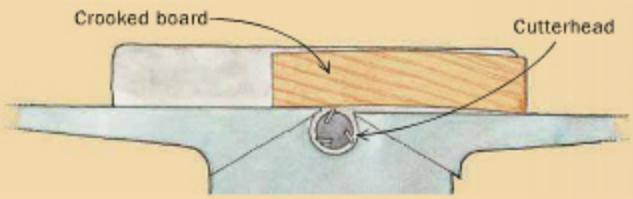


With the bowed, cupped, or crooked surface (see p. 64, step 2) face down, the board rests steady on two points. The flattened area gets wider with each pass over the cutterhead until the entire surface is flat.



2 SQUARE ONE EDGE TO THE JOINTER

After making sure the fence is square to the jointer table, place the planed face of the board against the fence and joint one edge.



added benefit is that light cuts are less likely to produce tearout or splintering.

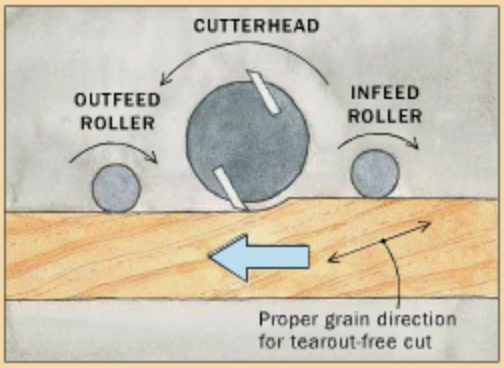
To plane the face, place the board on the infeed table with one edge against the fence. Using the two push blocks, one in each hand, feed the board into the knives. Once the knives start cutting, I use the push-block in my left hand to apply downward pressure to the lead end of the board, pressing it against the outfeed table while pushing the board forward.

As soon as I get 12 in. or so of the board on the outfeed table, the push-block in my right hand joins the one in my left at the outfeed table. Then, with both hands in line on the board, and positioned toward the front of the outfeed table (but not over the knives), I push the boards forward. At this point, all the downward and forward pressure from the push block is over the outfeed table, just past the knives. To keep the board moving, I pick up my lead hand and place it behind the other one and keep repeating the process until the board has cleared the knives. Use extra care as the board exits the infeed table because, for an instant, the guard doesn't cover the spinning knives.

After the first pass, check the planed side of the board to see if the knives have planed along its entire

3 PLANE THE SECOND FACE PARALLEL TO THE FIRST

With the previously flattened face against the bed of the thickness planer, feed the board through the machine to plane the other face.



width and length. If any areas have been missed, make additional passes until the entire surface is planed. At that point, your stock is perfectly flat on one face.

The jointer also mills the first edge

Now, use the jointer to straighten and smooth one edge of the board, making it square to the face you just planed. The planed face goes against the fence. If the edge has a front-to-back bend (called crook), be sure to place the concave edge against the jointer table. This ensures that the board won't rock because two points are always in contact with the table.

Push blocks aren't as effective when edge jointing most boards because the board's top edge is relatively narrow, giving it a tippiness that's not always easy to control with push blocks. So if a board is wider than 4 in., I use my fingers to push it forward while keeping it firmly against the fence. But, for safety's sake, I never push with my fingers over the blade area. After the first pass, check the planed side of the board to see if the knives have planed along the entire length.

Planer cuts the second face parallel to the first

Now it's time to work on the remaining face. It should be flat and straight, parallel to the opposite face. The thickness planer gets the call for that task.

Your first instinct might be to use the jointer again. After all, it excels at making boards flat and straight. But unless you are very lucky, the jointer won't make the second face parallel to the first. Only a thickness planer can do that.

Once again, check the grain direction (see illustration, facing page). I prefer to make light cuts, typically no more than 1/64 in. Place the board on the infeed table of the thickness planer with the unplaned surface face up, then feed the board into the machine. Continue making passes until the entire surface is planed and reduced to the desired thickness.

Cut the second edge and the final length

The board now has both faces flat, straight, and parallel, and one edge that's flat, smooth, and square to the faces. The final edge remains. The tablesaw handles that assignment, cutting the second edge parallel to the first and square to the face surfaces.

Set the rip fence to establish the width you want, then make the cut. If you want a smoother edge, cut the board a little wide and then edge-joint it to the final width.

With two faces and two edges of the board now flat, straight, and square to each other, you can cut the board to length. First, trim one end to make sure it's square. Then, measuring from the trimmed and squared end, mark the final length. Now, crosscut the second end at the marked line. The board is ready to be used on your project. □

Tom Begnal is a woodworker in Kent, Conn.

4 RIP TO WIDTH ON THE TABLESAW

Place the planed edge against the tablesaw fence, then rip the board to final width. The tablesaw is the machine of choice here because it cuts an edge parallel to the opposite edge. With a splitter behind the blade, kickback is less likely because the workpiece can't easily contact the back teeth of the blade.

5 CUT TO LENGTH

Use the tablesaw and miter gauge to cut one end square. Measure from the trimmed end of the board with a tape measure or ruler, then cut to final length on the tablesaw.

TECHNIQUES

Gluing

Lots of tape, lots of cauls, and lots of clamps make glue-ups easy

BY LON SCHLEINING

If a glue joint fails, the first suspect is the glue itself. But that is seldom the real problem. Modern glues are so effective as to be nearly foolproof. More often than not, the user is the culprit.

On those rare occasions when the glue itself fails, either the type of glue being used is unsuitable for the job at hand or the glue has exceeded its shelf life. Remember, some glues have a very short shelf life—as little as three months in some cases. One year is more common, although it varies a great deal. One thing is certain, though: If you are still using that old bottle of glue you got from Uncle Harry a few years back, it's at least suspect. Do yourself a favor and buy a new batch.

I recommend buying small quantities of glue, as much as you'll likely use in a few months, from a place where the merchandise turnover is high. That way, you'll run out of glue before it gets a chance to spoil. When you bring home a new bottle, write the date on the bottle with a felt-tipped marker. Relatively speaking, glue is cheap. When it gets old, throw it away.

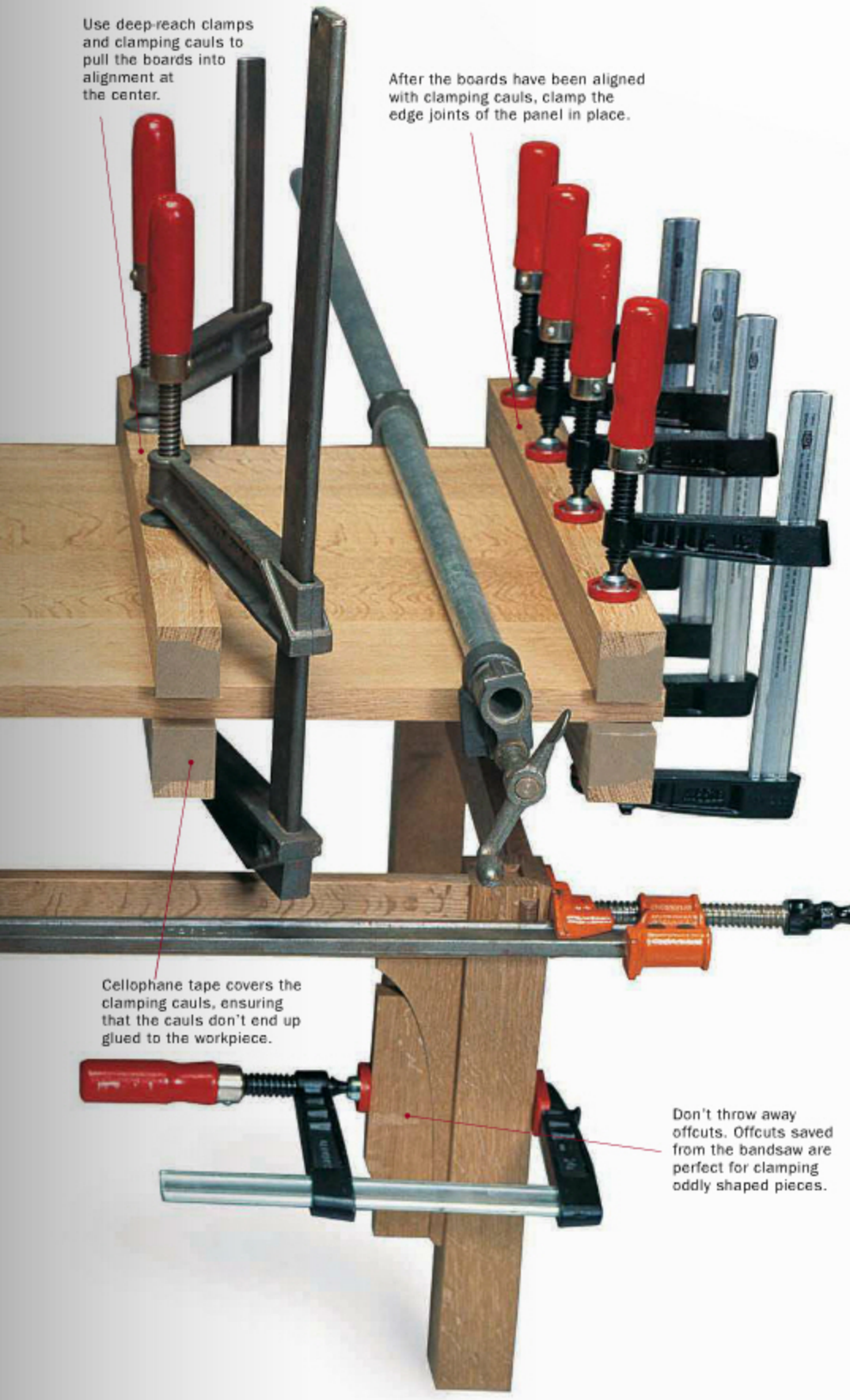
Many glues are susceptible to spoilage from freezing or excessive heat. It's important to keep track of temperature for both storage and

When gluing up square legs or forming multisided tubes, packing tape wrapped around the pieces helps pull the joints closed.

Before you squeeze

- Make sure the glue you're using is fresh.
- Cut all of your cauls to the right length.
- Cover the cauls and clamping pads with cellophane tape.
- Be sure that clamps are plentiful and within reach.
- For easy clamp access, elevate the assembly on a few wood blocks.
- Keep a ruler nearby so you can check to see that the assembly goes together squarely.
- Set clamps to approximate length.
- Do a full dry run of the glue-up to eliminate surprises.

Photos, except where noted: Matthew Teague; this page and facing page: Michael Pekovich



actual gluing. By the way, before you even buy a bottle of glue, read the label. Glue manufacturers want your glue-ups to be successful. They make a point to tell you exactly what you need to know right there in the fine print.

Well-fitted joints are a must

Clean, dry, well-fitted, and porous edges glue well. If the mating pieces do not fit well enough without clamping pressure, perhaps the work is not yet ready for gluing. Joints ought to fit naturally without being forced by oversized clamps. If you have to force the joint together, you're asking a lot of your glue to keep it that way once the clamps are released.

Porous edges allow the glue to ooze into the pores and strengthen the joint. If you make a very slow pass over a dull jointer, chances are you'll pound the wood fibers together instead of cleanly slicing them. This forms a glazed, nonporous surface that won't be suitable for gluing.

Cauls and dry-fitting are the keys to success

Moving too slowly may well be the most common cause of glue failure. Very quickly—especially in warm, dry weather—the surface of fresh glue will form a skin, a sort of blister. This blister prevents liquid glue from adhering to the other surface. If the glue skins over before the two mating pieces come together, you might as well call it a day. Sure, you can scrape off all of that excess glue, but the residual glue will seal the surface. The edges will need to be remilled, not just cleaned.

One sure way to reduce the time it takes to get something clamped is to practice. Especially if the gluing operation is complex or large, a rehearsal helps ensure that you have all of the clamps you need and that all of the little blocks and pieces of masking tape are at hand. It's a

good idea to dry-fit and clamp the project entirely, as if you had spread the glue already, to make sure one last time that the pieces actually go together.

Keep in mind that adding glue to the joints will change the operation a great deal. It will lubricate the pieces just enough for them to move around when you don't want them to. Then the glue will begin to set up and grab the pieces, holding them in place just when you want them to move. But these problems are easily solved. The key for almost every gluing situation is to use clamping cauls. Simply put, clamping cauls hold boards in alignment while other clamps close up the joints.

Clamping time—How long a project must remain clamped depends on temperature, humidity, and the complexity of the project. Follow the directions on the label of the glue you're using. If the label says clamping time is an hour, give it an hour. If the label says overnight, wait until the next morning to remove the clamps.

Remember that the temperature requirements are critical. If the label says the minimum is 50°F, that means the air, the glue, and the material itself must be at least that warm. It also means that the materials must stay that temperature for the duration of the curing time. It's worth noting that a simple light bulb inside a small, insulated enclosure will keep the contents quite warm, even if the rest of the shop is cold.

Cleanup—Gluing over butcher paper or newspaper certainly saves you from having to do a lot of cleanup. Wearing vinyl gloves not only keeps hands clean but also helps you avoid contact with toxic chemicals.

With most of the common polyvinyl acetate (PVA) glues under normal conditions, a project has to stay in the clamps about an hour. I have been accused of using too much glue, but because scraping glue before it hardens is so simply done, I see no need to skimp.

Along a glueline, I want to see at least a thin bead of glue. When the glue has

EDGE-GLUING

Tape is the Teflon of glue-ups. *Cellophane tape prevents the cauls from sticking to the glue joint and provides a slick surface so that the pieces can slide together easily once pressure is applied to the cauls.*

Raising the panel allows room for clamps. *With glue and clamps at hand, begin by laying cauls on blocks so that it's easy to keep boards flat and in place.*

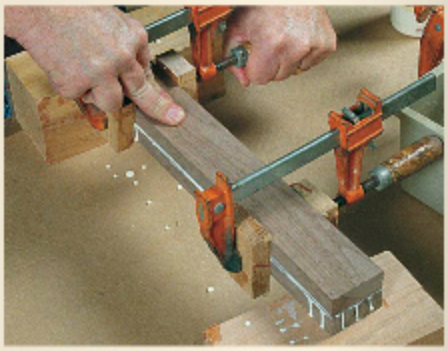
When it comes to glue joint strength, an edge joint can't be beat. That's because an edge joint bonds the long-grain fibers from both pieces of wood. Dowels, biscuits, or splines won't strengthen an edge joint, although they are sometimes used to align the two boards. When edge-gluing, I prefer another board alignment strategy. I make a few cauls to keep everything lined up. The cauls align the boards, and then the clamps squeeze them together.

Clamping cauls are nothing more than straight and smooth clamping blocks covered on one side with cellophane tape. Clamping the cauls from above and below pulls boards precisely flat, even if the boards are warped or cupped. The cauls also will

FACE-GLUING

Nothing is more frustrating than having the boards you're trying to clamp together move around when the clamps are applied. You have to unclamp the whole mess to move them back again, and by that time the two parts are usually stuck in place. Enter our old friend, the clamping caul.

Cauls work just as well for face-gluing as they do for edge-gluing, making the job much quicker and easier. For face-gluing you need only small blocks covered with cellophane tape. First use the cauls to control the alignment, then apply pressure to the glue joint. It's that simple.



Clamping face-glued joint with cauls. *First, use cauls to keep pieces aligned, then squeeze the joint together. Glue flows more easily when you start at one end and work toward the other.*

Tape and scrap make simple and effective deep-reach clamps. *Tape a spacer between two stout scrap boards and slide the assembly over the cauls. Pressure applied near the edge is transferred to the middle of the panel.*

Cauls keep edge joints aligned. *As the cauls are clamped together, the boards are pulled into perfect alignment. After the cauls have been firmly clamped in place, use bar clamps to pull the joints together.*

Bar clamps squeeze the joints together. *Apply just enough pressure to close the joints—too much pressure will force glue out. Keep the bar clamps above the surface because black marks will appear everywhere the clamps touch the wet glue.*

hold the boards flat as they are squeezed together, even if their edges aren't milled perfectly square.

I make cauls from 8/4 square hardwood. Make sure they are straight, then apply cellophane tape to one side. The tape prevents the cauls from adhering to the project and allows the gluing pieces to slide together once they're under control. First, put the lower cauls on blocks so you can get access to them for clamps. Then, after spreading glue on the edges of the boards, place them into position, and begin clamping the cauls down securely.

Start by clamping the caul in the center of the panel. Deep-reach clamps are great to have, but they're expensive. I find that a shop-built version works just as well. Just tape a few scraps of wood into a U shape and slide the assembly over the cauls (see photo, above left).

With this setup you can easily clamp the center of even a 4-ft. panel. After clamping the center cauls, move toward the ends. Feel the alignment of the edges along the joints. Add a new set of cauls any place one board is above another. Once the assembly is perfectly flat, add bar clamps across the panel to squeeze the joints together. The boards slide between the cellophane-covered cauls with no trouble.

Because the joints fit very nicely, it takes only a little pressure—just enough to make contact between the two boards. Too much pressure forces the glue out of the joint.

MITERED FRAMES

Picture frames and mitered boxes—both basically end-grain glue joints—present some of the biggest challenges for gluing and clamping. This is the perfect time for biscuit joinery; and the more biscuits you use, the better. Although clamping is tricky, I prefer to simply use bar or pipe clamps rather than the various gizmos on the market for clamping picture frames.

Glue up all four corners, keeping the pieces in alignment as much as possible. Set a bar clamp across each corner as close to the center of the joint as possible. Keeping the frame down on a flat surface, apply pressure very gradually to one clamp at a time, squeezing the joint into alignment as you go, back and forth until the pressure is even and the joints are aligned. Remember that light pressure is usually sufficient. Tighten just enough to keep the joint together, but stop before forcing all of the glue out of the joints.

Use two biscuits. *A pair of biscuits provides ample gluing surface and keeps the pieces aligned. Once clamps go on, measure the diagonals to make sure everything is square.*

set up in the joints and the clamps are removed, the excess glue should still be soft and pliable. This is the perfect time to remove the excess with a scraper. I never wipe up glue with a wet rag, because the water will raise the grain and the finished surface will be uneven.

My favorite glue-scraping tool is a small hook scraper, available in the paint section of almost any paint or hardware store. With a good edge on it, a small hook scraper will remove excess glue while it's still soft, thus saving hours of sanding. If you wait until the glue has hardened to scrape off the excess, it is very likely, especially with softer woods like mahogany, that you'll tear chunks out of the surface.

I do my best to use a simple and quick system for gluing. Once the glue has been spread, I use every trick I know to speed it along. I always follow the manufacturer's instructions to the letter. When in doubt, I call the manufacturer on the phone. Manufacturers have always seemed more than happy to discuss individual situations.

I have a habit of testing my glue joints over and over again. If I trim a glue-up to length, I take the scrap piece and snap it over the corner of the bench to make sure the joint is reliable. I am always happiest when it breaks ½ in. away from the glueline. If you adopt this habit, you'll soon be confident in the boards you glue together. You'll sleep better, too. □

TIP

PVC pipe cut into narrow sections works like mini spring clamps. The pressure varies by the diameter of the pipe, its thickness, and the width of the section you cut off.

Lon Schleining (woodbender.com) builds furniture and staircases in Long Beach, Calif.

DOVETAIL AND BOX JOINTS

When gluing a box or drawer together, all four corners typically have to go together at the same time. This might be as simple as a small drawer or as complex as a chest carcase, but the processes are the same.

Nowhere is a rehearsal more important than with a box joint or dovetail glue-up. There is no time to fuss with cutting clamping cauls when the glue is beginning to set up. This is one instance when it's nice to have an extra set of hands.

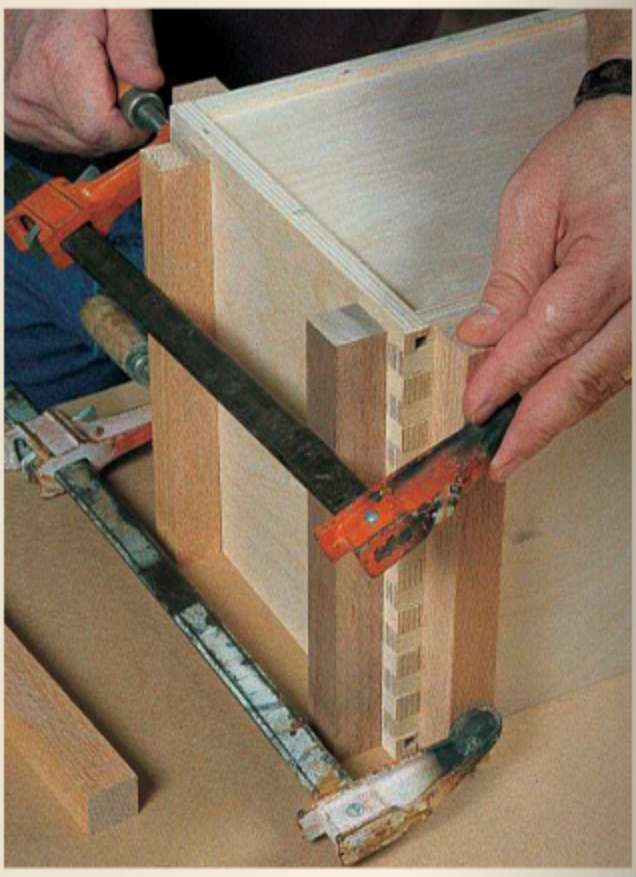
Cauls set just back from the joint on all four corners provide a clamping surface but still allow the joint to move together without interference. The cauls also help spread the clamping pressure evenly.

Apply glue to all of the surfaces and immediately press each corner together. Once all four sides are together and the joints have been hand-fit as much as possible, set the cauls in place and begin to apply light clamping pressure. As soon as the joint comes into contact, that's enough pressure. It's entirely possible to bend and permanently distort the sides of the box by applying too much clamping pressure.

The box needs to be glued up on a flat surface. To be sure there's no twist in the box, see if it rocks. If it does rock, use clamps to apply downward pressure on the high sides until you bring it back into alignment.

To check that the box is square, and while the glue is still soft, measure diagonally across the corners. If the box is square, the measurements will be the same. If it's slightly out of square, a single bar clamp, placed diagonally, will bring it square. Checking the squareness by measuring the diagonals is usually preferable to using a square because it's faster and more accurate, especially if excessive clamping pressure has pulled a curve into the sides of the box.

Masking tape keeps your project clean. *With clamps handy and everything in place, apply masking tape along the inside of the joint. The tape eliminates the need to clean excess glue out of the inside of the box. Apply glue sparingly to the joint.*



Clamping cauls spread the pressure. *Dovetail and box joints are squeezed together from both directions. Typically, these joints are cut so that after gluing, the ends are slightly proud of the wood surface. That way, you can sand them flush. Just make sure the cauls don't cover the joint. Cauls placed right next to the joint serve to evenly distribute the pressure of the clamps.*

MITERED BOXES OF ANY SIZE

Packing tape binds the box. *Stranded tape with embedded fiber has tremendous strength. Strips of tape are laid on the face side of the box, keeping everything in place.*

Mitered parts roll up to form a box. *After the pieces have been turned over, glue is spread in the miters, and the box is rolled up.*

Shopmade blocks allow opposing clamps. *Shop-built clamp blocks provide a perpendicular pad for the clamps. As opposing clamps are tightened, the box is pulled square.*

Mitered boxes are quite easy to glue up using shop-built blocks, stranded packing tape, and a bit of patience. Lay the four pieces faceup along the bench, and run the tape every few inches across the faces of the boards. Turn the assembly over, spread glue in the joints, and roll it up like a tool pouch. It sounds simple, and it is.

To ensure that the box remains square, clamp the box diagonally with the help of clamping blocks. The blocks are made of 2x2 stock and have a mitered groove on one side (see photo, above right). By placing the clamps opposite each other, you can easily check along the box with a square to see that everything is in place. It's easy to make adjustments accordingly.

Packing tape makes clamping even a complex shape like an octagon very straightforward. Start with the pieces faceup on the bench. Using the same technique as the mitered box, apply the tape across the faces every few inches, leaving an overlap to pull the last joint together.

Turn the assembly over, spread glue, and roll it up, pulling the tape ends tight. Check to make sure the distance between faces is even all around so the assembly will be square and consistent.

FRAME-AND-PANEL DOORS

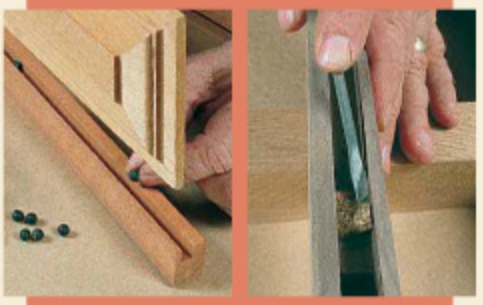
A little glue goes a long way. *To keep squeeze-out to a minimum, apply glue deep into the mortise and on the end of the tenon only.*

More often than not, well-fitted mortise-and-tenon joints align themselves, but you still have to keep everything square and flat. The center panels, if solid wood, need to float so they can expand and contract freely. For ¼-in.-thick panels, little rubber pellets, called Space Balls, can be placed in the grooves that accept the panel. These Space Balls keep the panel centered and securely held. On wider panels, I trim pieces of cork to fit in the groove and never apply glue to the panel.

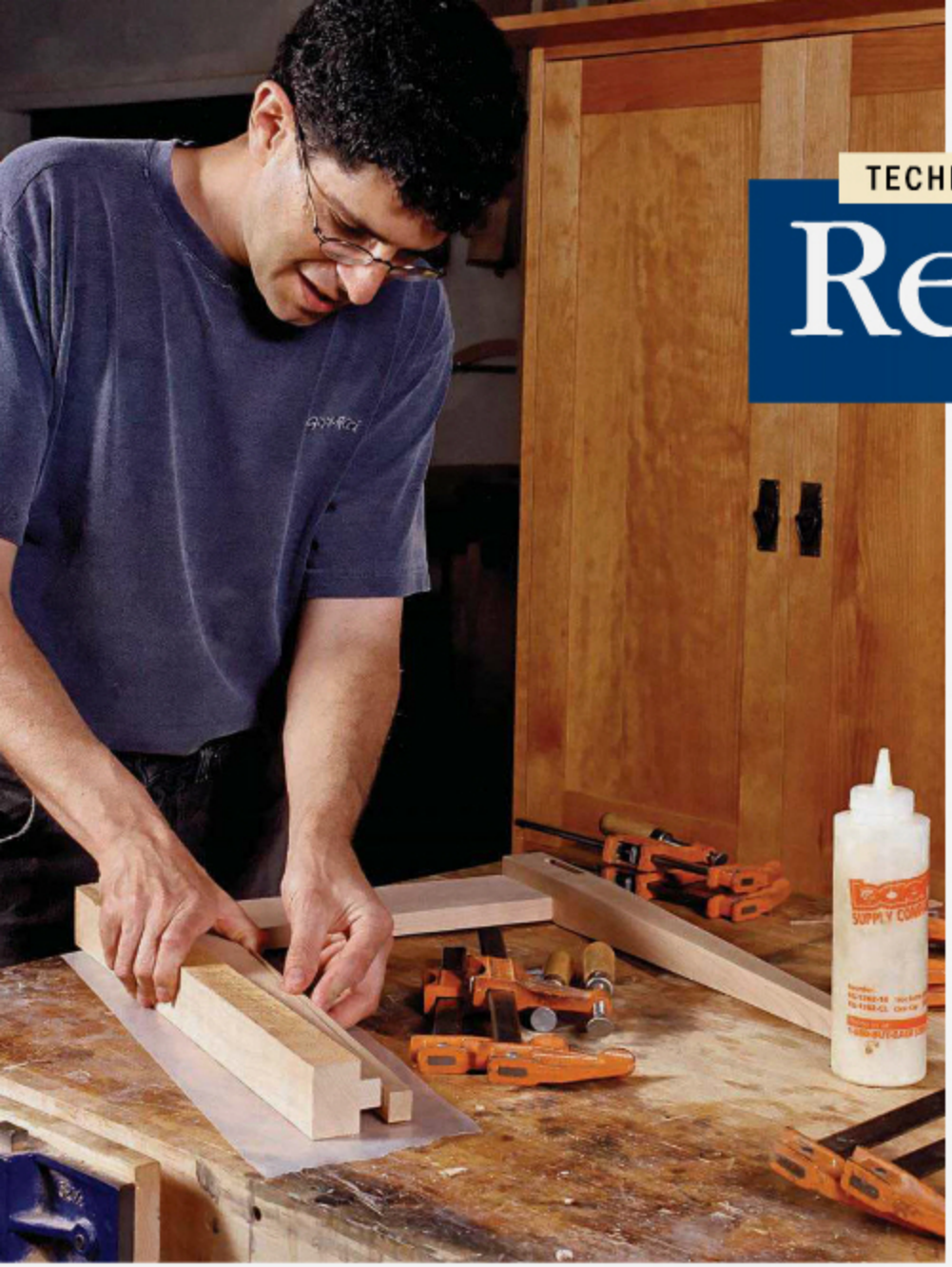
Frame-and-panel doors using cope-and-stick joints usually are glued up without dowels. Considering the amount of use a door might get, it's worth placing a couple of dowels in the corners. The dowels should fit loosely in the holes to allow a bit of room for glue and expansion.

If the cope-and-stick joint is not quite perfect, cauls are an easy way to keep the pieces flat and aligned. It's important to make sure the door is flat and square, adjusting it as you would a box.

Let the panels float



Cork cushions (right) keep the panel centered but allow it to expand and contract. No glue is applied to the floating panel. Use a utility knife to cut cork slightly oversize. Space balls—perfect for ¼-in. grooves—are hard rubber pellets (left) designed to do the same job as cork ($6 for a package of 100; woodcraft.com).



TECHNIQUES

Repairs

How to fix dings, cracks, splits, and more without starting over

BY JEFF MILLER

After reading article after article filled with pictures of flawless work, you might get the impression that experienced woodworkers never make mistakes. I can assure you that isn't true. Pros simply know how to salvage their goofs. What makes me an authority? Well ... lots of mistakes, of course.

Sure, I get angry with myself when things go wrong. But in a perverse sort of way, I've come to enjoy the challenge of salvaging woodworking disasters. I now have an arsenal of repair tricks at my disposal.

It's important to realize that you can't salvage everything. There are times when you have no choice but to throw in the towel and start over. But that happens much less often than you might think, whether the defects are manmade or natural.

Attitude goes a long way toward saving a project that suddenly heads off in the wrong direction. Anxiety is always highest the instant you discover the problem. But self-flagellation doesn't accomplish very much; step back and take a few deep breaths. Do whatever it takes to stop obsessing. Grab a cup of coffee or walk around the shop, and then figure out what went wrong.

It's a good idea to come up with several options to solve a problem. Anything involving a large hammer doesn't count. Then prioritize the options—from the quick and easy to the dreaded scrap and start over. Don't rush into anything—with one exception. If you're in the middle of a glue-up and notice a major problem, now is the time to pull apart the piece, before the glue sets. Otherwise, give yourself time to think before rushing into a fix.

Jeff Miller makes furniture and teaches woodworking (furnituremaking.com) in Chicago.

Photos: Anatole Burkin

REGLUING STRUCTURAL CRACKS

Joints that are too tight may crack when forced together. *After disassembly, pare the tenon for a looser fit.*

Cracks may develop during dry-fitting and disassembly of parts. They are most often the result of joints that are too tight, or they may be caused by hidden, internal stresses in lumber. In either case, the fix is the same. Get glue deep into the crack, then clamp it.

Getting glue into a fine crack may be the most difficult part of the job. My favorite glue applicator is a piece of the wrapper taken from a candy bar or bag of snack food. The thin wrapper won't tear easily or get soggy and is readily available. Spread glue on a strip of the wrapper and work it deep into the crack.

Get glue deep into the crack for a good repair. *A piece from a snack-food package or candy wrapper can be used to force glue into a crack.*

COVERING DEEP SCRATCHES

Don't give up on a piece, even if the damage seems severe. *Shopmade veneer can be used to conceal cosmetic damage.*

Scratches or gouges may be too deep to remove by sanding. If the part isn't too large, such as a table leg, you may be able to veneer an entire face to cover up a defect. (Veneering just one side of something larger, such as a panel, may cause it to warp.) For a veneer patch, choose stock that matches the original in grain and color. Use your bandsaw to cut an oversized piece of veneer. After gluing the patch, plane or sand it smooth, then chamfer or ease the edges to protect the veneer and to help disguise the seam.

Align the grain of the veneer. *Trace the shape using the part to be fixed, and cut it slightly oversized.*

Glue the patch in place. *Use cauls to protect the stock from the jaws of the clamps.*

Plane the patch flush with the stock. *Finally, ease the corners to protect the veneer and help blend it in.*

STEAMING OUT DENTS

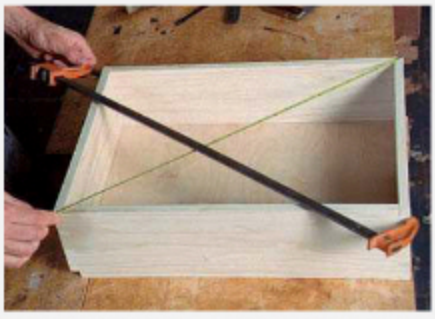
Dents seem to appear out of nowhere. Most are easy to repair, especially if the wood fibers only have been compressed and not severed. You can sometimes swell compressed wood fibers simply by placing a drop of water right on the dent.

More often, you'll also need some heat to help swell the fibers. A clothes iron turned to a high setting works well. Place a drop of water on the dent, then touch the tip of the hot iron to the water. As the water turns to steam and rises, the wood fibers swell. The process may have to be repeated a few times. Severed fibers may call for additional work—either filling or patching in addition to steaming.

Place a drop of water on the dent. *Don't flood the area. Repeat as necessary.*

Touch only the tip of the iron to the spot. *The steam swells the wood fibers and returns them to the surface.*

ALIGNING PARTS



Despite careful preparation, when the clamps come off after a glue-up, nasty surprises occasionally surface. Among the most common problems are out-of-square drawers and carcases.

If a drawer or case looks more like a parallelogram than a rectangle, the bottom (for a drawer) or back (for a case) can be used to bring it square. First, measure the diagonals, then place a clamp on the longer diagonal corner to corner. Pull the box until the diagonals are equal, then add the drawer bottom or back panel and glue or screw it in place.

FILLING DEFECTS WITH SAWDUST

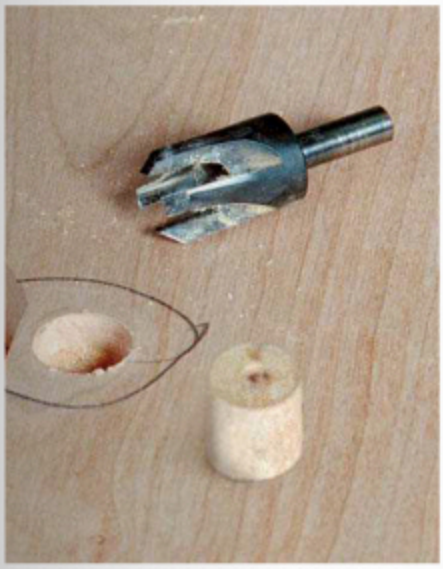
Many types of commercial fillers are available for repairing small defects. Most of them, however, look just like fillers once they've been applied. For a more natural look, apply a drop of cyanoacrylate glue directly to a defect, and then sand immediately with 220-grit or 320-grit sandpaper. The sawdust created mixes with the glue to produce a filler that blends better with the wood. This is a little sneaky. The repair is not at all invisible; it usually looks more like a natural blemish, such as a pin knot or a mineral deposit.

Cracks may be the result of natural defects. *A screw driven too deeply may also cause them.*

Place a few drops of cyanoacrylate glue on the crack. *Then sand over the area with fine (220-grit) paper. Repeat as needed.*

PLUGGING LOOSE KNOTS

Although it's best to avoid stock with loose or crumbling knots, there are times when you're down to your last board. All that's keeping you from completing a project is a dime-sized knot. A defect that large can't be filled, but it can be removed and plugged with another piece of wood. Look through your pile of offcuts and find a piece containing a small, sound knot. The grain around knots usually swirls and curves, features that help disguise the repair. Use a tapered plug cutter to remove the pin knot (the patch) and then set the patch into place.



Drill out the defect. *The patch (right), which includes a small, sound knot, was bored from scrap using a tapered plug cutter.*

Glue the patch. *The old knot extended through the board at an angle. Drill a cleanout hole about ⅜in. deep at the same angle, then patch.*

Work away at the patch. *Plane cautiously over the knot to avoid tearout. Switch to a scraper when the patch is nearly flush.*

Finish off with sandpaper. *Sometimes a dab of dye, slightly darker than the surrounding wood, is needed to blend in the patch.*

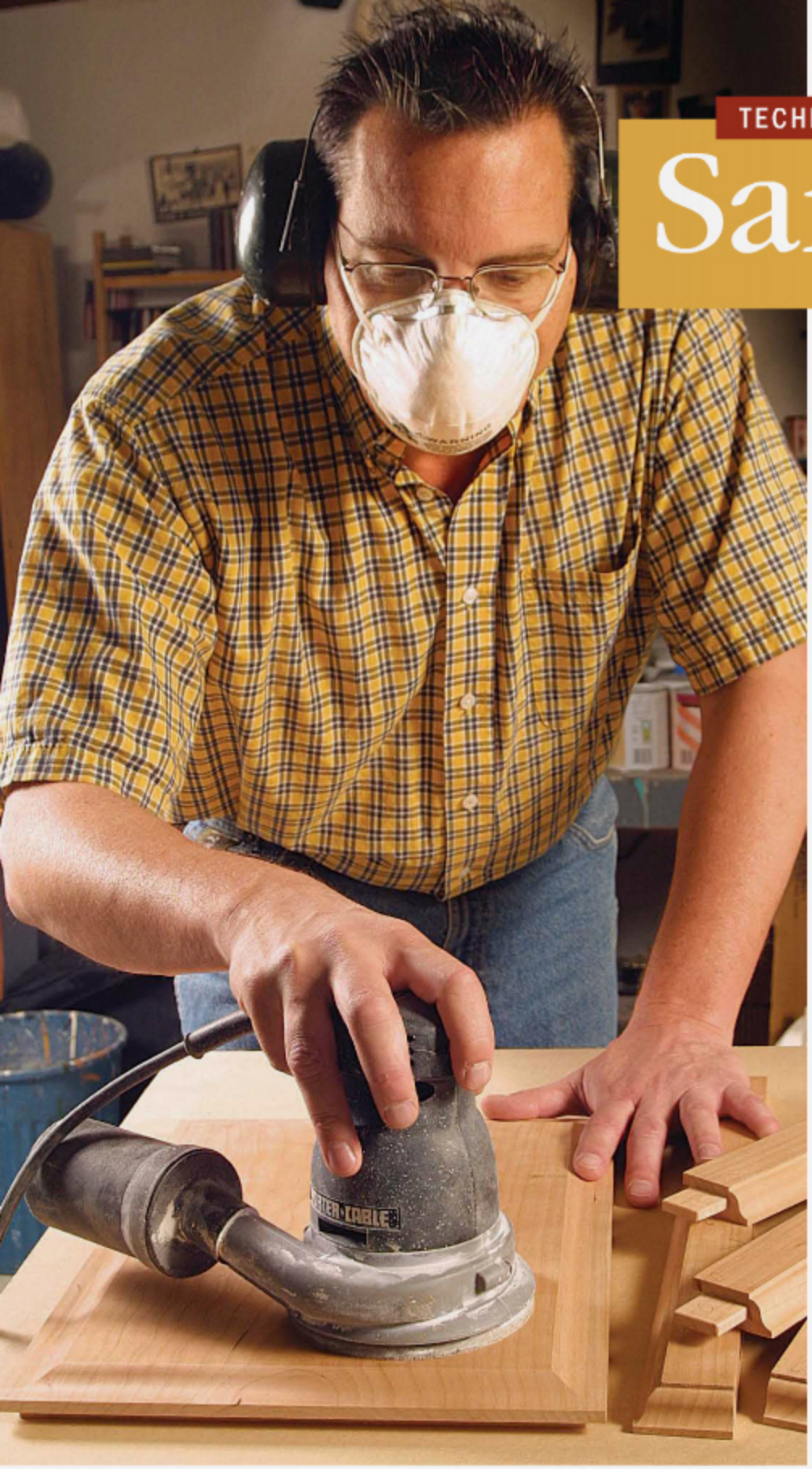
REPLACING EDGES

When a piece of wood breaks off an edge and the piece gets lost, you can still salvage the part as long as you have some matching wood. It's not enough to use the same species. You must find a piece that has similar grain and color. If you can cut and replace wood along the grain lines, the patch will be practically invisible.

Slice off the ragged edge, leaving a smooth, flat surface. *Cut a patch with a tablesaw tilted at an angle.*

Glue the patch in place and hold it with masking tape. *It is easiest to work with an oversized patch.*

Remove the excess material. *Use the tool of your choosing: a chisel, plane, or sander.*



TECHNIQUES

Sanding

Combine power- and hand-sanding for good results with no wasted time

BY DAVID SORG

The course of true love never did run smooth, according to Shakespeare, and smoothing wood true rarely causes love to course, it would seem. Boredom and fear are more common feelings among woodworkers when sanding their projects. But proper sanding is a crucial part of woodworking, so please read on for some tips and techniques that will turn your boredom into serenity, and your fear into fun.

I'll stick my neck out and state that no project should be finished without first being sanded. Even if you are a hero with the handplane or skilled with the scraper, you won't be able to get a surface that is uniformly smooth and with an even sheen. There will be tiny depth changes from adjoining passes of the blade, while the sole of the plane can burnish strips of wood that may show up after a stain or a clear finish has been applied.

Those who rely on power tools alone inevitably will be left with planer- and jointer-knife marks and fibers crushed by the feed rollers. Router tables can leave gouges and scratches, and assembly often produces some errant glue splotches. All of these blemishes should be removed before a finish is applied, and sanding is

Tools for sanding

the best way to achieve this. The most efficient way to sand a surface is with a combination of power-sanding and hand-sanding.

Power-sanding comes first

Of course, you could do all of your sanding by hand, but why? Even if you use power sanders wherever practical, there will be enough hand-sanding on almost any project to give you plenty of hand-done satisfaction. Power sanders deliver results with much greater speed, and with minimal practice, they'll also deliver a flatter surface than hand-sanding alone.

The good news is that unlike much of your other shop equipment, quality sanding tools will not cost you much. I strongly suggest you get a random-orbit sander. A pad sander also is useful, and I'll explain why a detail sander is optional. Don't forget a dust mask and hearing protection. Also, I find it's a good idea to test each sanding step on a sample board.

Fast stock removal with a random-orbit—Random-orbit sanders are wonderful machines. The pad has dual motion: It spins in a circle as well as in an eccentric orbit. These sanders are great for rapidly smoothing and leveling raw wood. Five-in.-dia., palm-held models are most common, but you also can buy 6-in.-dia., two-handed versions.

Most random-orbit sanders have holes in the pad (and, of course, in the sandpaper) for dust extraction. The sanding disks are backed with either pressure-sensitive adhesive (PSA), which is cheaper, or reusable hook-and-loop systems.

Older sanders should be switched on when already resting on the surface of the wood, or they will spin too fast and gouge the wood when you try to bring them in for a landing. Most new models have electronic speed control, which allows you to

CHOOSING WISELY

The author's sanding arsenal includes a random-orbit sander, a pad sander, and a variety of hand-sanding tools. Each sanding method has its advantages.

RANDOM-ORBIT SANDERS

These machines are great for removing large amounts of wood from large surfaces. They are less suitable for small areas, and their shape prevents them from reaching into inside corners.

PAD SANDERS

Less aggressive than random-orbit sanders, pad sanders are easier to control, which makes them suitable for narrower and more confined areas, such as table legs and the insides of cabinets.

HAND-SANDING TOOLS

Sand by hand to finish the job. For flat areas, use a backing block made from cork or rubber to prevent your fingers from applying uneven pressure. To keep moldings crisp, use commercial rubber profiles or shop-made foam ones to back the sandpaper.

Photos, except where noted: Mark Schofield

Sanding with power

POWER-SANDING FLAT SURFACES

LARGE PANELS
With their wide contact surfaces, random-orbit sanders are naturally at home on large panels.

WIDE PARTS
Again, a random-orbit sander does well here. Note: It is easier to sand parts such as table aprons before assembly.

NARROW PARTS
On smaller pieces such as the parts for a frame, a pad sander gives more control than a random-orbit sander.

lift the sander to apply it to an adjacent surface without having to turn it off and restart it each time.

Random-orbit sanders will do a speedy job on large surfaces and bring two pieces of wood into the same plane. However, at the edges of a workpiece, keep the majority of the pad on the wood, or you'll risk dishing or rounding over the edge too much. By the same token, keep these sanders moving; don't concentrate on one spot or you could create a little bowl.

Orient your project, if you can, so that you're working horizontally. By letting the weight of the sander work for you, you'll gain more control with less fatigue. Also, sand subassemblies before glue-up. It's much easier to sand a frame-and-panel, the aprons of a table, or a drawer's parts before they're assembled.

Pad sanders give more control in small areas—Pad sanders, also called palm sanders or finish sanders, use a simple orbital pattern, and the pad does not rotate. This configuration gives a much slower sanding action but greater control. The square pad allows the tool to get fairly close to inside corners (but beware getting it too close, where it quickly can chew up the adjacent surface). This type of sander works well on smaller surfaces, like the edges of shelves or table legs, as well as on the insides of cabinets and in other confined spaces.

The right grit from start to finish—With either type of sander, I'd rather start with 150-grit than 120-grit paper on most pieces, even though it may take longer to remove some milling marks. For wood that is already in good shape, especially with thin-veneered sheet goods, I start with 180-grit paper.

Note: The grits I refer to here are based on the FEPA scale, which uses the prefix P, rather than the alternate CAMI, or C, scale. In the 150 to 220 range, the grits are nearly equivalent, but it's best to stay with the paper from one scale.

Don't continue using a piece of sandpaper until all the grits are gone and there isn't anything left but the paper. That's a false economy if you're charging for your time; and if you're woodworking for fun, well, you're taking away a bunch of it. Move to a fresh section of sandpaper as soon as you feel it stop cutting or start to clog, or when it requires you to exert more pressure.

Having experienced this the hard way, let me assure you that it's very important to vacuum or blow off the piece between

Photo, this page (top left): Matthew Gardner

CHECK YOUR PROGRESS

With the workpiece under a strong light, wipe the wood with some mineral spirits and check the surface for obvious scratches and rough areas.

grits. I do both, then wipe it with a tack cloth. One piece of 150 grit being swirled around on your 220-grit pad will make you curse when you see the results.

Tips for efficient sanding—With a cabinet, begin sanding on the inside: If you start with the inside while you're fresh, you'll be more likely to take a few extra minutes to do it right instead of skimping on it at the end.

For veneered plywood, you can start and stop with 180-grit paper if the inside rarely will be seen or used. Use a hand-sanding block on the corners and on any more visible areas such solid-wood edging.

Devote more time to visible areas and those likely to be touched. Ending with 180-grit paper is fine for softwoods, but go to 220 grit for hardwoods. On end grain, go one grade finer so that it doesn't absorb the stain or clear finish as deeply.

How do you know when you're finished power-sanding? Wipe some mineral spirits on the surface and sight across the wood toward a strong light. Pay no attention to the beautiful color that appears; instead, look at the surface for telltale scratches, especially the ugly orbital kind. You would like to see a uniform appearance

SANDING DETAILS

A quicker way to sand moldings. *Detail sanders come with an assortment of pads designed to fit most molding profiles. The radius on this pad matches the bead of the apron (left). One disadvantage of detail sanders is that the adhesive-backed sandpaper frequently comes away from the pad (above).*

Sanding by hand

HAND-SANDING FLAT SURFACES

FLAT AREAS

To maintain a flat surface, you should always use a backing block when sanding large areas.

EDGES

Break the edges on a project not only to reduce future damage but also to prevent finish from forming a mound at the edges.

END GRAIN

To lessen end grain's darker appearance when the workpiece is finished, burnish the wood and fill the pores by sanding with up to 320-grit paper.

SANDING AFTER GLUE-UP

No matter how thoroughly you sand parts prior to assembly, there still will be small areas to touch up by hand-sanding with 220- or 320-grit paper. Areas where glue was removed with a damp cloth may need smoothing (top), or there may be two pieces that don't join in a perfect plane (bottom). To avoid cross-sanding where grain intersects, mask off one of the pieces.

with no rough areas or single outstanding scratches. Sometimes it's easiest to see this right at the moment of evaporation, when the ruts of the scratches will still be shiny with fluid while the top surface is dull and dry. If you take this step, you'll avoid the agony that many experience when they apply a stain, only to see the scratches jump out.

Sanding details and molding

After sanding the wide-open areas, how should you sand profiled areas? Manufacturers advertise detail sanders as the answer to sanding any shape or confined space. These sanders come with a variety of pads designed to fit different profiles. Although I own a couple of detail sanders, I could live without them, mostly because it's too much trouble to constantly change the paper. By their nature, they put their sanding action into a small area of sandpaper that wears very quickly.

Most of the time, I think it's quicker to sand moldings, interior corners, and other small areas by hand. To keep the moldings crisp, use commercial rubber profile blocks that cover most convex and concave shapes, or make your own profile from pieces of foam-insulation panel.

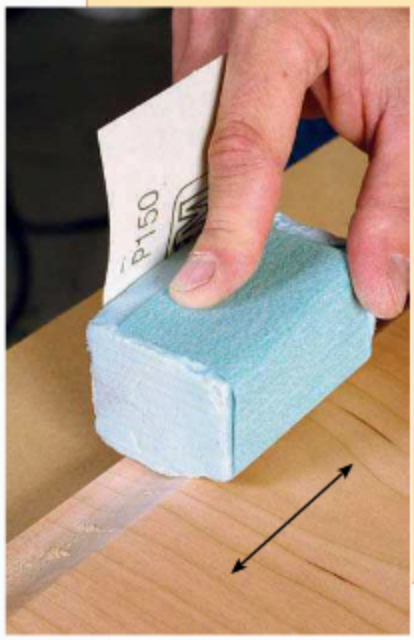
The end grain on raised panels requires a special sanding sequence to tone it into the

Photo, this page (top left): Matthew Gardner

HAND-SANDING DETAILS

Rubber profiles. *Using a rubber pad that fits the molding helps keep the edges of the profile sharp.*

Sanding curves by hand. *Contour the paper to fit curves in the wood.*



CURVE CONSCIOUS

Insulation foam shaped to match the panel's profile makes a good backing for sandpaper (above). The end grain may need to be sanded with paper that is one grade coarser than that used on the rest of the panel, in this case, 150 grit (left). Then sand the entire panel with 220 grit before removing any cross-grain scratches on the end-grain sides using 320-grit paper with the grain.

rest of the panel. Start by sanding across the grain with 150- or 180-grit paper to deal with the rough texture. Then sand the entire profile on all four sides of the panel with 180- or 220-grit paper. Last, sand just the end grain with 320-grit paper, going with the grain in short strokes to eliminate any cross-grain scratches and to lessen the end grain's ability to absorb finish.

Final hand-sanding: the finishing touch

No matter how much you use machines for the initial stages of sanding, you'll want to give each surface some final sanding by hand. Primarily, this is to get rid of the small orbital scratches left by the machines, replacing them with smaller, finer scratches that are all parallel to the grain of the wood and hence less noticeable.

You should back up the sandpaper with a sanding block wherever possible to maintain a flat surface. I find the palm-sized rubber blocks most convenient because they also can be used for wet-sanding between coats of finish. Other choices include cork blocks or wood blocks faced with a sheet of cork.

If you plan to use a water-based stain or clear finish, there are a couple of extra steps. After the final hand-sanding, wipe down the piece with a damp sponge. After the wood dries, very lightly sand with the same-grade paper you finished with, but be careful to remove only the raised grain. Watch out for sandpaper coated with stearates: Although they do a better job at preventing clogging, allowing the sandpaper to last longer and sand more smoothly, stearates are waxy and interfere with many water-based finishes, causing fisheyes on the surface. If you're planning to use a water-based finish, check with the manufacturer to see whether the finish is compatible with stearated sandpaper. □

David Sorg is a finisher and artist who lives in Denver, Colo.

TECHNIQUES

Finishing

Simple method uses spar varnish to produce a lustrous and durable finish

BY LON SCHLEINING

I wasn't asking for much: I wanted a finish with a rich, hand-rubbed luster, neither too glossy nor too dull, that illuminates rather than hides the grain—one that would offer real protection from moisture and sunlight and yet still feel like wood, not plastic. I also wanted a finish I could apply quickly and easily, and something I could use right out of the can. And it would be awfully nice if it smelled good. That isn't too much to ask of a finish, is it?

The answer turned out to be rather simple: high-gloss spar varnish, turpentine, wet-or-dry sandpaper in various grits, a few rags, and a bit of elbow grease. Simply rubbing plain gloss varnish into the raw wood provided the protection, sheen, feel, and ease of application I wanted.

Start with a well-prepared surface

The key is to scrape, plane, or sand each of the pieces of your project before you assemble it. Even if you have to touch up the sanding after final assembly, this step will save lots of time.

During the building process, I sand by machine (belt sander, 120 grit), then sand by hand with a wood sanding block padded with felt. The sanding sequence will depend, in part, on the type of wood. On hard maple, for example, use 100 grit, then 120, 150, and finally 220 grit. With mahogany and its much more open grain, stop dry-sanding at 150 grit. Be sure to change sandpaper frequently.

Make sure the surface is clean by using a vacuum to pull out the sanding grit from the pores of the wood. Don't worry if the surface is less smooth than what you normally shoot for. The sanding doesn't stop when the finishing begins. I wet-sand with

Photos: Mark Schofield

finer and finer grits during the application of the finish itself.

Materials are easy to obtain

The heart of my finish is a high-gloss spar varnish, which has several advantages: Unlike plain oils, it hardens overnight; it's readily available; and it has much greater clarity than semigloss or satin finishes, whose additives not only dull the finish but also cloud the grain. Spar varnish also contains ultraviolet protection that will help keep the wood from fading or yellowing. I've used this varnish for years on boats, protecting the wood from salt water and abuse, so I know it provides the tough tabletop film I'm looking for. As an added bonus, this finish is quite easy to renew by scuff-sanding with 220-grit paper and simply wiping on an additional coat of varnish if the surface ever needs it. This finishing method will also work with other types of varnish, urethanes, and even some finishing oils.

Though it's counterintuitive, gloss varnish does not produce a glossy surface when it's rubbed on. Because you're wiping off any excess varnish, not letting it stand on the surface, it doesn't get a chance to build up to its normal gloss.

To thin the varnish for the initial coat, I like to use natural turpentine instead of paint thinner, simply because it smells better. As a general rule, thin a finish with whatever the label suggests for cleanup.

You will need a few sheets of 220-, 320-, 400-, and 600-grit wet-or-dry sandpaper for sanding the varnish. For dry-sanding between coats, use open-coat, self-lubricating 320-grit paper. A box of soft cotton rags from the paint store ensures that you won't run out of clean rags just when you need one. Finally, disposable gloves are essential. Not only will they protect your skin from solvents, but they make the job a lot less messy.

Application is straightforward

Before starting, spread out a plastic sheet to contain drips and spills. This is also a good time to change into an old shirt and pants. (I might even follow my own advice about this one of these days.) Pour a small amount of varnish into a container using a piece of nylon panty hose as a strainer. Thin with one part turpentine to

FIRST COAT: THINNED VARNISH

THREE PARTS VARNISH + ONE PART THINNER + 220-GRIT WET-OR-DRY PAPER

Apply the finish liberally. *It is important to coat the whole surface as quickly as possible to avoid creating lines where the finish overlaps. Schleining uses his gloved hands to spread the thinned varnish over the surface before sanding it in with 220-grit wet-or-dry paper.*

Grain filler with a perfect color match. *Sanding the varnish with the grain creates a slurry that fills the pores of open-grained wood.*

FIRST COAT (continued)

Sand on and wipe off. *Before the varnish becomes tacky, wipe off the surplus using clean cotton rags. Keep changing the rags until no more finish can be removed and the surface can be buffed smooth.*

about three parts varnish. The first coat saturates the wood more effectively if it is thinned down a bit.

Wearing gloves, quickly flood the entire surface on all sides until it's completely coated, adding more varnish as needed. It's important to cover the piece completely, not in sections. Working on a small area at a time may leave a line where different areas of finish overlap.

Sand the wet varnish into the wood using 220-grit wet-or-dry paper. Sand with the grain until you produce a slurry. This helps fill the pores of open-grained woods, such as mahogany or oak. While the varnish is still wet, wipe with a soft cotton rag to remove any varnish that has not soaked into the wood. There's a point at which the varnish gets quite sticky and difficult to wipe. Working on something like a large tabletop might require a helper. Rub across the grain so you don't pull the slurry out of the wood pores.

Be sure to spread out the oil-soaked rags to dry before disposing of them, to avoid the danger of the rags spontaneously igniting.

Buff with a fresh cloth until the surface is slick and smooth. Polish the piece every half hour or so to make sure no wet spots emerge on the surface. Joints, such as on the breadboard ends of a tabletop, will absorb excess varnish, which will gradually

No place for surplus varnish to hide. *No matter how much you wipe, varnish has a habit of oozing out of joints after you have done your final buffing, creating sticky and glossy areas. Remove surplus varnish using compressed air, and wipe the area clean.*

ADDITIONAL COATS: UNTHINNED VARNISH

Scuff-sand the surface the following day. *Between coats, lightly sand the surface using 320-grit nonloading, or stearated, paper under a padded block. Always sand with the grain.*

UNTHINNED VARNISH

FINER-GRIT PAPER

seep out after the rest of the surface has dried. To avoid this, I blast the joint with compressed air, forcing the surplus varnish out of the gap.

Let the piece sit at room temperature overnight. You can carry on working in the shop because it doesn't matter if dust lands on the piece, but it is a good idea to ensure adequate ventilation to avoid a concentration of fumes. The next morning, the surface should feel smooth and dry. Lightly dry-sand it with 320-grit nonloading, or stearated, paper. Use a felt-padded block, and sand with the grain. Clean the surface with a vacuum or compressed air. Apply a flood coat of unthinned varnish and use 320-grit wet-or-dry paper to sand the varnish into the surface. Wipe and buff the excess varnish as before.

Repeat this process each day, wet-sanding with finer and finer grits until you have at least three coats. Additional coats will produce slightly more luster. Some folks like to wax the surface when it's dry, but I prefer to leave it unwaxed, because it's easier to recoat should the surface become damaged over time.

I haven't yet been tempted to throw away either my spray guns or my badger-hair brushes, but after using this finishing process on several projects, I can't remember the last time I used those tools. This simple technique meets all of my criteria for an ideal finish and produces very consistent results, all without a large investment in equipment. □

Lon Schleining (woodbender.com) builds furniture and staircases in Long Beach, Calif.

Build the finish. *Apply subsequent coats the same way as the first coat. Rub in each coat with a higher grit of wet-or-dry paper. The last coat is rubbed in with 600-grit paper to create a very smooth surface.*

A final buffing. *After the final coat has dried, the surface will be silky smooth with the pores filled. Rub the surface briskly with a clean cotton rag.*

TECHNIQUES

Design

For long-lasting furniture, build with wood movement in mind

BY CHRISTIAN BECKSVOORT

For centuries, granite has been quarried along the Maine coast. Way back in the woods behind my shop, on a granite outcropping, sit a few leftover slabs 10 in. thick by 2 ft. wide by 12 ft. long. The granite faces show a series of ½-in. holes drilled 12 in. to 18 in. apart. The old-timers would have driven dried wood into these holes, then walked down the row pouring water onto the wood. Eventually, the granite slabs would split apart.

When wood cells absorb water, they swell and expand, and not even granite can stop them. Forget about pins, glue, screws, or fancy joinery; wood will move and break apart your work if you don't follow the rules.

Wood movement depends on a combination of several factors, including the environment (the degree to which humidity fluctuates) and how the lumber was sawn (see drawing, below). Movement also varies among wood species, particularly among the hardwoods. Beech, hickory, oak, and hard maple move substantially more than cherry, walnut, and butternut. The type of finish you apply is also a factor. Because light skin finishes such as wax and oil allow greater moisture absorption, wood that has been coated with either of them moves more than wood that has been finished with deeper-penetrating sealants such as urethane and lacquer.

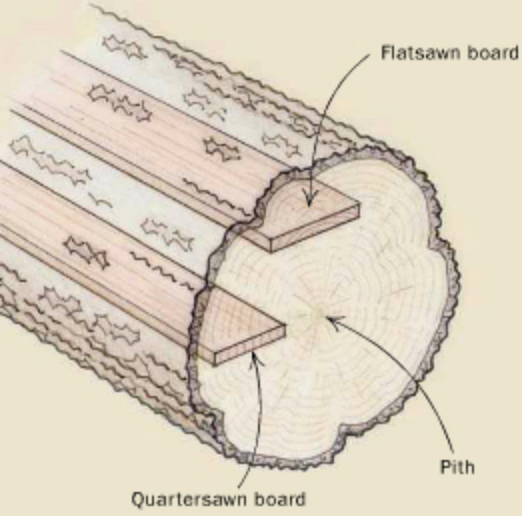
As a professional woodworker, I can't afford to cut corners when it comes to wood movement. Whether you are making a chest, case, bed, or table, it pays to devote your energy to building it right the first time.

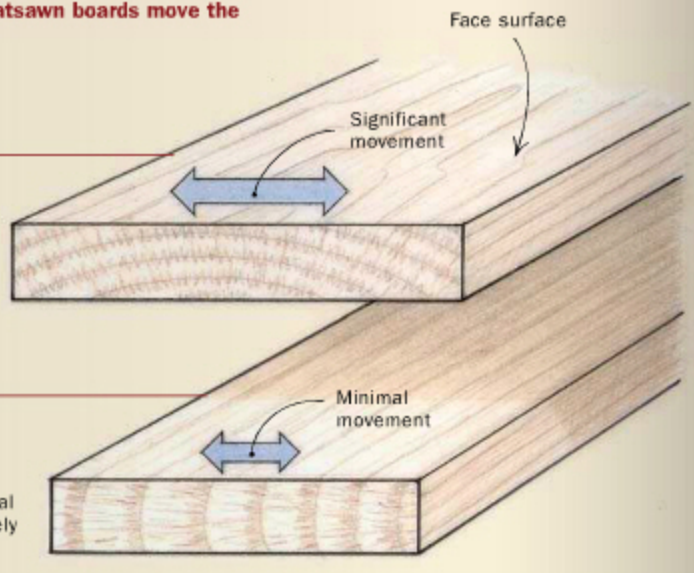
Christian Becksvoort builds custom furniture in New Gloucester, Maine (chbecksvoort.com).

How wood moves

GRAIN ORIENTATION DETERMINES THE AMOUNT OF MOVEMENT

You can predict how lumber will behave by looking at the growth rings. Flatsawn boards move the most; quartersawn boards have the least movement.





FLATSAWN BOARD

Most seasonal movement in a board is along the rings. With annual rings nearly parallel to the face surface, flatsawn boards exhibit more seasonal movement and are prone to cupping.

QUARTERSAWN BOARD

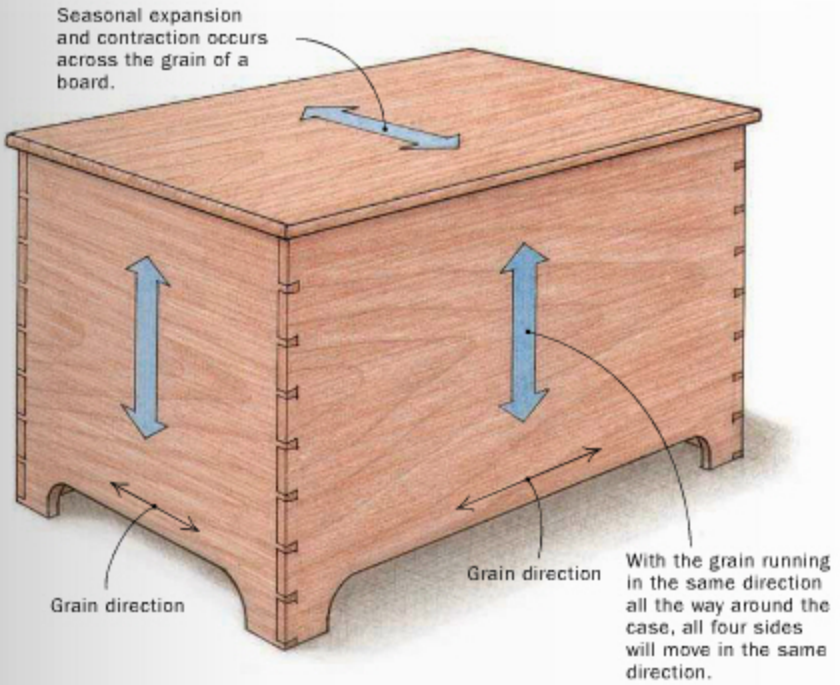
Quartersawn boards have annual rings running perpendicular to the face surface, so the boards experience far less seasonal movement and are less likely to cup.

Photos, except where noted: Dennis Griggs; this page: Karen Wales

BLANKET CHESTS

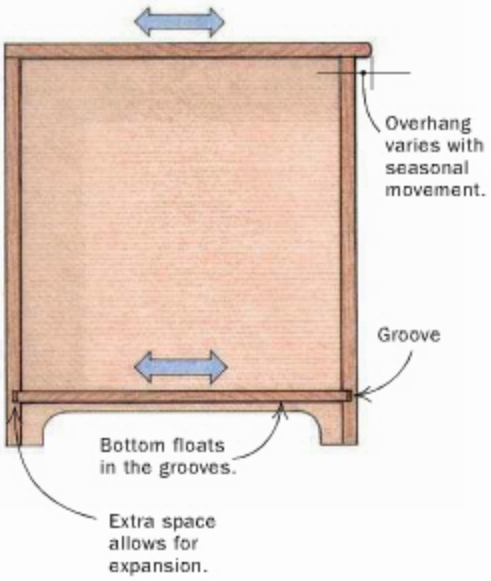
SLAB CONSTRUCTION ALLOWS ENTIRE PIECE TO MOVE

A blanket chest, in which the grain runs in a band around the entire box, is an example of slab construction. The depth and width of the chest remain constant, because the wood does not move lengthwise. But the wood does change in height in response to changes in humidity. The blanket chest gets slightly taller in summer and shorter in winter. Because movement in the top is from front to back, the hasps of the lock (not shown) don't always fit. The solution is to use quartersawn wood for the top, file the hasp parts to increase clearance, and use a good sealing finish.



BOTTOM FLOATS IN GROOVES

Grooves are cut into the four sides of the chest to hold the bottom. The bottom is sized so that there's enough space in the grooves to allow for seasonal movement.

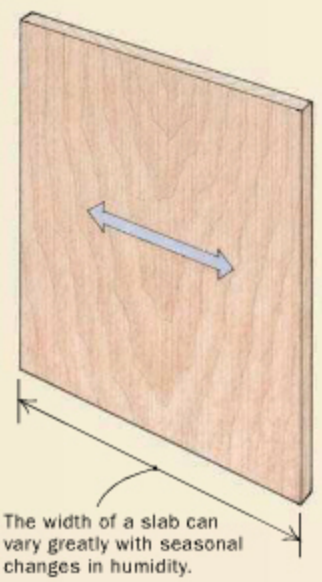


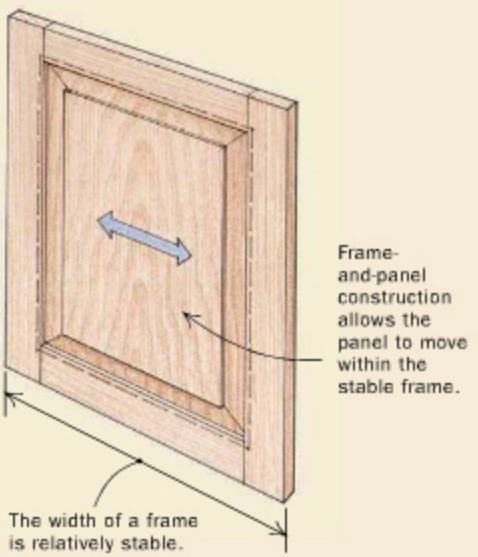
FRAME-AND-PANEL CONSTRUCTION ISOLATES MOVEMENT

Your approach to controlling wood movement will depend a lot on whether the piece is made using slab or frame-and-panel construction.

Slab construction is typical in chests, tabletops, and headboards and consists of single wide boards or narrow boards glued up edge to edge. With solid-wood slabs, you have to worry about cross-grain movement, which can be significant if the slab is very wide.

Frame-and-panel construction, on the other hand, minimizes the effects of wood movement by isolating large areas (the panel) and restricting movement to relatively small areas (the frame). The panel is set into grooves of the appropriate depth, but it is not glued in place. Instead, this "floating" panel is free to expand and contract within the frame.





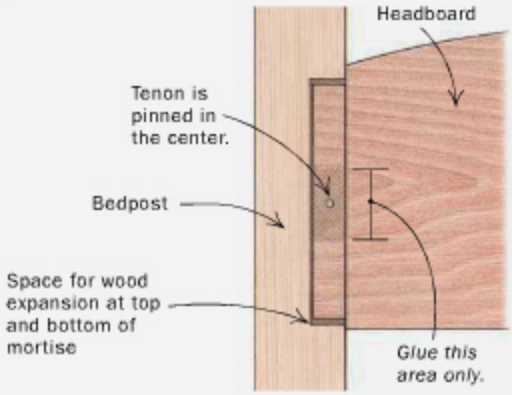
Drawings: Vince Babak

BEDS

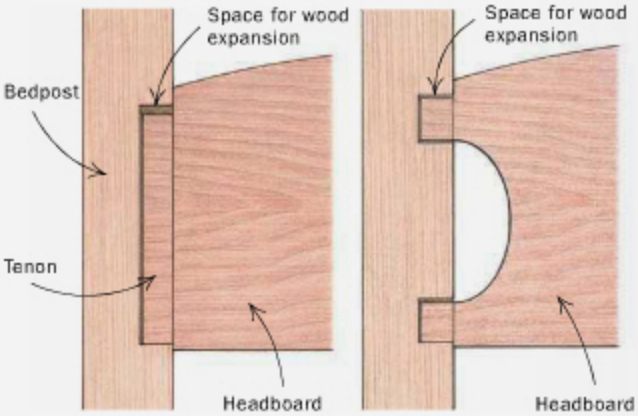
SLAB HEADBOARDS NEED EXTRA-LONG MORTISES

A slab headboard that's 12 in. to 14 in. wide may move up to ¼ in., which means the mortise into which it fits needs to be that much longer. If the headboard is to be pinned and glued in the middle (fixed), leave a ⅛-in. space at the top and bottom of the mortise. On some beds, such as pencil-posts, the headboards sit loosely in the mortises on the posts and the unit is held together by bolts in the rails. Extra-tall headboards (as in old Victorian styles or sleigh beds) require extra-deep grooves or large shoulders and mortises.

ATTACHING FIXED HEADBOARDS



ATTACHING LOOSE HEADBOARDS



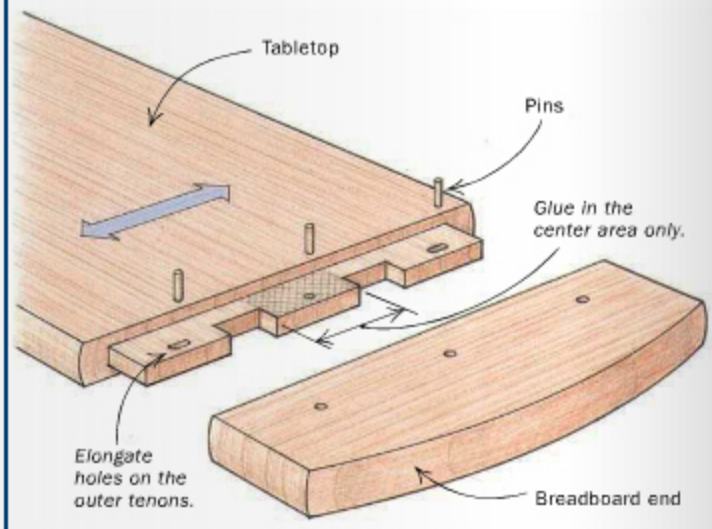
TABLES

BREADBOARD CONSTRUCTION KEEPS TABLETOPS FLAT

Breadboard ends are added to tabletops to help prevent the top from cupping. But they must be attached so as to allow the top to expand and contract.

The preferred method for making breadboards is a single tongue with cutouts. For a stronger joint, parts of the tongue are cut out to within ¼ in. to ½ in. of the shoulder, and the corresponding areas of the mortise are left in place to hold the weak faces of the breadboard together.

The trickiest part of construction is pinning and gluing the breadboard ends. I like to plane a slight (1/16-in.) concave bow into the breadboard to keep the ends tight against the table. I make the mortise longer than the tongue, center the breadboard, and clamp both ends onto the table. I drill a ⅜-in.-dia. hole in the center and then one (for narrow tabletops) or two holes (for wider ones) on either side of center.



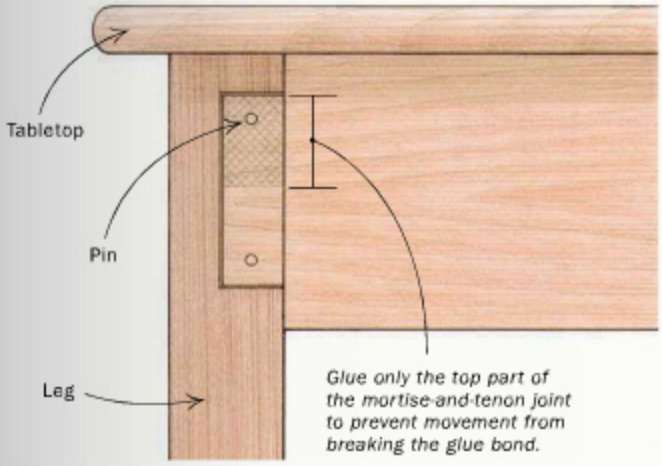
I remove the breadboard end and scribe a line along the edge of the holes closest to the end. Next, I elongate all but the center holes with a ⅜-in. rat-tail file. The farther from center, the longer the oval. For very dry wood (6% moisture content or less), elongate away from the center to allow the top to expand. For wet wood (12% moisture content or more), elongate toward the center to allow for shrinkage. Do not file beyond the scribe lines; doing so will relieve the pressure holding the breadboard to the table shoulder.

MORTISES AND TENONS THAT BREATHE

You may have surmised that cross-grain gluing is a no-no. That is correct up to a point. Wood has a small amount of give to it, and aliphatic resin (yellow) glue is slightly elastic. So you can feel relatively safe making cross-grain joints, such as mortise-and-tenon joints, as long as the tenons aren't too wide. With cherry, for example, I limit cross-grain joints to a width of 5 in. As a precaution, I glue only the top half of the joint. Theoretically, the top of the rail will stay flush, and the bottom will move ever so slightly. That also should work for hardwoods that are less well-behaved than cherry.

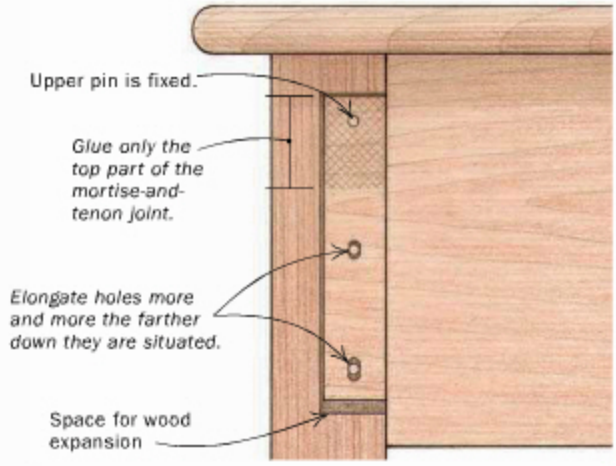
NARROW APRONS CAN BE GLUED AND PINNED

In general, apron tenons 2½ in. to 5 in. wide are glued and pinned, but glue only the top portion. Narrower tenons are fully glued.



WIDE APRONS USE FLOATING PINS

The tenon of a wide apron requires space at the bottom for expansion. A fixed pin at the top forces movement downward.

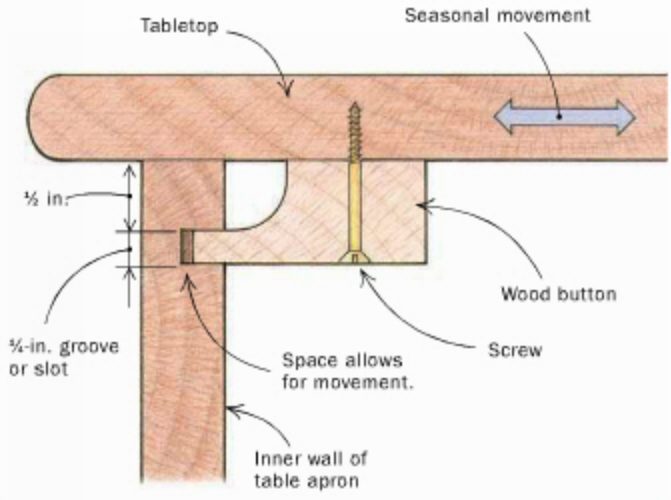


TABLETOPS NEED ROOM TO MOVE

No matter how I go about attaching a top to its base, I anchor it firmly in the middle, ensuring that both halves are equally free to move. As a matter of course, I orient the grain in the long direction to minimize the amount of movement.

A good way to attach tops is to make ¼-in. grooves, or a series of ¼-in. slots, ½ in. below the inside top of the rail. I then install shopmade wood buttons, which grip the grooves and screw to the underside of the top. The buttons at the ends of the tabletop can go to the full depth of the groove, while the buttons along the sides must be placed according to the wood's moisture content and the time of year. (Fit them tighter in summer, looser in winter.)

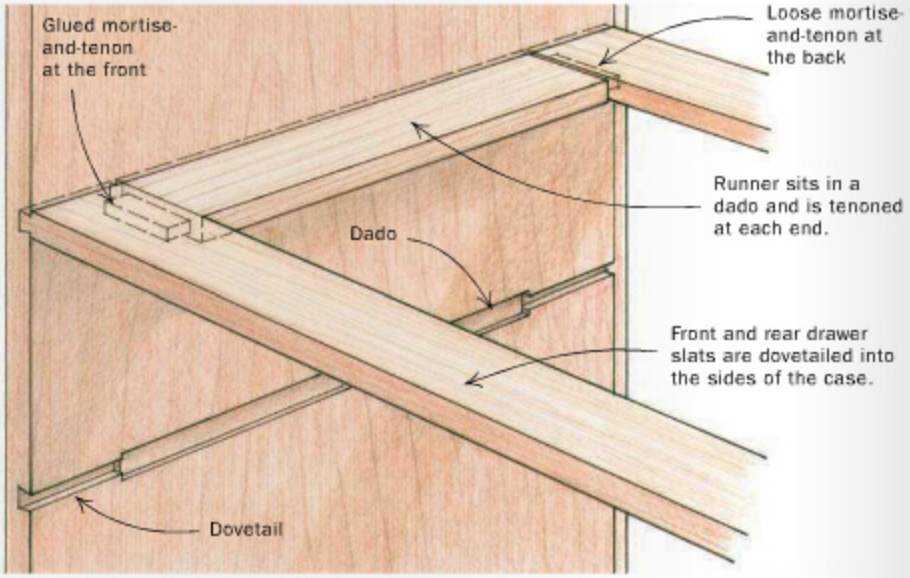
I sometimes use another method when the rails are substantially thicker than ¾ in. I countersink ½-in.-dia. holes from the bottom of the rails. Then I drill ¼-in. holes all the way through. I use a rat-tail file to elongate holes away from the center. Holes in the center of the end rails stay as they are. Because the wood movement is side to side, the ovals in the long rails run across the thickness of the rail. That's why I don't recommend this method for thin rails.



Photo, this page (bottom left): Kelly J. Dunton

WEB FRAMES PROVIDE UNDETECTABLE MOVEMENT

Web frames provide lightweight, low-movement alternatives to solid drawer dividers. For frame-and-panel cases, web frames are merely four slats—mortised and tenoned and then glued. For slab-constructed cases, web frames become a bit more involved. I start with four slats. Two are dovetailed into the sides of the case; one slat in the front, and one in the back (flush with the back rabbet). Before gluing, I rout a dado to connect the front and back dovetails. Then I cut a mortise into each end of both dovetailed slats. I measure the length of the drawer runners and add the depth of the two mortises, minus 1/16 in. for dry wood, or minus 3/8 in. for damp wood. I glue the front slat into the dovetailed slots and then cut the tenons on the front-to-back runners. The front tenon is glued into the mortise, and the runner is forced into the connecting dado. The back slat is then glued into its dovetail slot, but the back mortise-and-tenon is not glued.



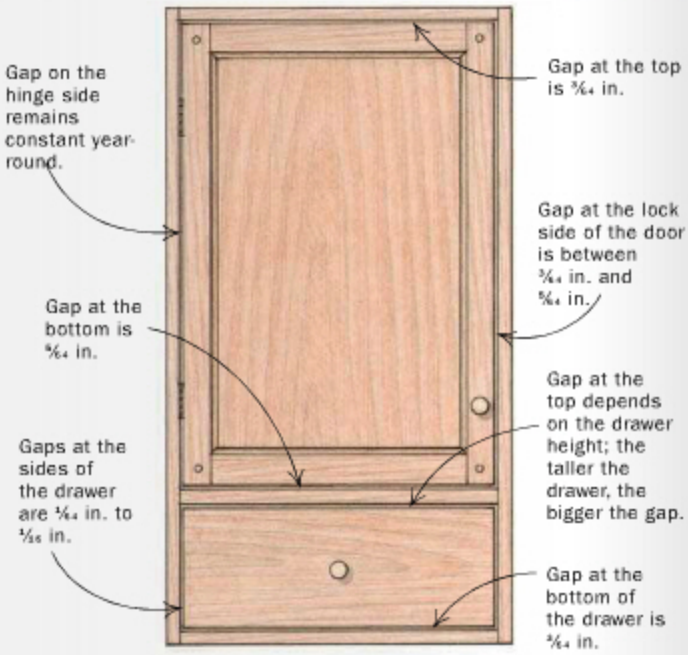
FITTING DOORS AND DRAWERS

The issue of wood movement in doors and drawers must be taken into account. Because they will change in width over the course of a year, I install slab doors only in narrower case openings using quartersawn wood and then stabilize the door with battens.

Frame-and-panel doors are much less of a headache. For quartersawn cherry, I aim for a gap at the lock side of the door that is between the thickness of a nickel (5/64 in.) and a dime (3/64 in.). The hinge-side gap is constant year-round; the top gap is a dime fit; and the bottom gap is a nickel fit.

Fitting drawers is bit more involved. Again, I prefer to use quartersawn stock. I start by making drawers the same size as the opening, side to side. When assembled, I trim them to fit, with a 1/64-in. (minimum) to 1/16-in. (maximum) total side clearance.

The top-to-bottom dimension is another story. The opening is constant, but the drawer front changes in height. I also make my front about 1/32 in. narrower than the sides by planing that amount off the bottom (after cutting the grooves for the drawer bottom).

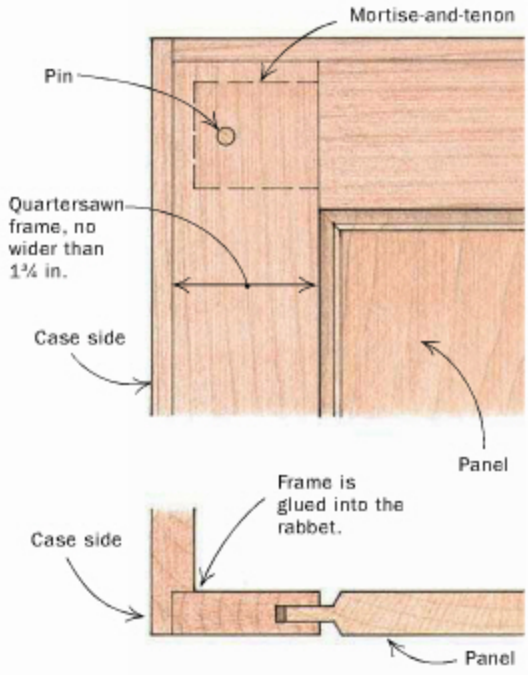


Photo, this page: Michael Pekovich

A FRAME-AND-PANEL BACK ACCOMMODATES MOVEMENT

Building high-end furniture and having a preference for solid wood, I make my backs as frame-and-panel units, set into rabbets and glued into place. This method creates a totally sealed back, which allows for movement yet provides racking resistance.

The success of this method depends on the width and grain orientation of the outside frame members. Because the frame is glued into the rabbets, any excess wood movement will break out the lips of the side and top rabbets. By using quartersawn cherry no wider than 1¾ in. for the sides and top of the frame members, there is enough give in the wood to accommodate any potential movement. Less well-behaved woods require narrower stock. In any event, the stock must be quartersawn.

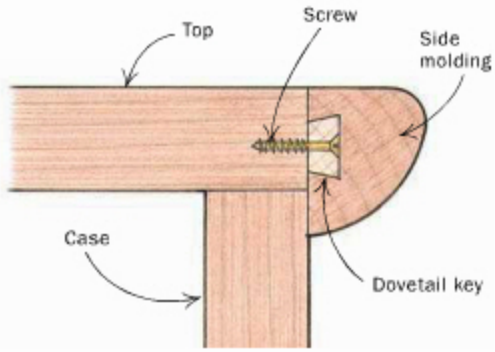


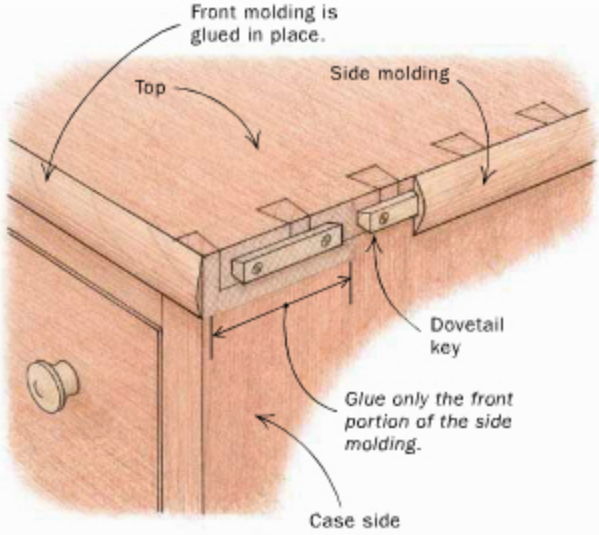
SIDE MOLDINGS THAT HOLD

Most antiques that I've looked at have the side molding glued (and/or screwed) at the miter and nailed the rest of the way back. As the case side moves over the years, the nail holes widen and the nails lose their grip. The long-lasting solution is to use dovetailed keys and slots.

I cut my molding and miter the corners to fit. The side molding receives a dovetail slot that runs its full length, in the meatiest portion of the molding, not necessarily its center.

To locate the dovetail keys, I hold the molding in position, then make knife marks on the case side at the top and bottom of the slot, at both the forward miter and at the back. I connect these tick marks, then cut a dovetail key the length of the cabinet side. Ideally, you want it to be 0.003 in. to 0.005 in. thinner than the depth of the slot to draw the molding tight. Then I mark the strip into five or six equal parts. Into each segment I drill and countersink two holes to accept #4 flathead screws, 1 in. apart. Between these holes, I drill for a 20-ga. brad, apply a drop of glue around the underside of the brad hole, and position the strip between scribe lines. I nail the brads, then sink the screws. Once the long length of the dovetail key has been installed, I chisel out a ⅜-in. section at each pencil mark, leaving five or six perfectly aligned dovetail keys.





Photo, this page (top): Michael Pekovich

TECHNIQUES

Frame & Panel

A TABLESAW DOES THE JOB

A frame-and-panel door is a perfect place to use a version of the mortise and tenon called a bridle joint. The tablesaw does most of the work here. It cuts the grooves, trims the panels, and creates the mortises and tenons.

Build this classic cabinet door with a tablesaw and a few clamps

BY MATTHEW TEAGUE

Traditional frame-and-panel doors are one of the hallmarks of quality woodworking. You'll find the doors in an almost endless range of styles, from traditional to contemporary, and there are a wide variety of ways to build one. The streamlined method described here allows you to cut all the joinery at the tablesaw, which comes in handy if you're working in a small shop or with limited tools.

As the name suggests, a frame-and-panel door consists of a four-sided frame—much like a picture frame—surrounding a panel. The inside edges of the frame are grooved to accept the edges of the panel.

A typical frame has two vertical pieces, called stiles, and two horizontal pieces, called rails. Most often, mortises are cut into the ends of the stiles and mating tenons are cut on the rail ends.

A door made from a panel inside a frame has a couple of advantages over a single flat panel. One advantage is visual; the other is structural.

Visually, most designs benefit from the interplay of shadowlines created by frame-and-panel construction. From a structural standpoint, a frame-and-panel door is preferred because the design accommodates wood movement caused by seasonal changes in humidity (see "How Wood Moves" pp. 86-87).

Build the frame first

Although frame-and-panel doors are typically made using traditional mortises and tenons to connect the frame parts, I usually opt for a simpler and easier-to-make version called a bridle joint. On a bridle joint—also called a slip-joint or an open mortise and tenon—the mortise isn't fully housed. Instead, after all the cutting

Photos, except where noted: Tom Begnal; this page: Matthew Teague; drawings: Kelly J. Dunton

Cut grooves for the panel

Cut the pieces to length first. *To accurately measure the length of each frame part, Teague rough cuts them extra long. Then he places each piece against the cabinet to mark the exact length on the part.*

SETUP

Set the blade height. *Adjust the blade to the depth of the groove, in this case ⅜ in.*

Set the width. *The distance from the sawblade to the rip fence determines the width of the frame grooves.*

is done, the mortise looks much like a yoke. When the tenon is added, it's exposed on two edges—a look I like a lot. Also, because the joint creates considerable glue area, it has plenty of strength.

For this project, I used straight ¾-in.-thick stock for the stiles and rails. The panel is made from ½-in.-thick stock. You can use off-the-shelf lumber from the local home center, or mill the stock with a jointer and planer. In either case, make sure you're working with flat, square stock. Doing otherwise is not only tricky, it can be unsafe—a board that rocks during a tablesaw rip cut could get pinched between the blade and fence, resulting in kickback.

Cut the rails and stiles to width and length—Begin by using the tablesaw and rip fence to rip stock for the rails and stiles to final width. Then, using the miter gauge, crosscut each piece an inch or so longer than you'll need. Set them in place on the case, mark the final length of the parts, and then crosscut them exactly to length.

It's a good idea to cut an extra length or two of stock the same thickness and width as the rails and stiles. This "test stock" can be offcuts from your rails and stiles, or it can be cut from a less expensive softwood. It will be put to use later when you start making tablesaw test cuts for the mortises and tenons.

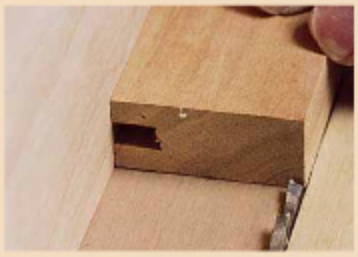
Cut the grooves—When making a bridle joint, it doesn't make any difference if you start by cutting the groove, the mortises, or the tenons. That said, I generally prefer to cut the grooves first; probably for no reason other than habit. Then, I cut the tenons to fit

Two passes over the blade create the full groove. *With a push block and featherboard helping to ensure a safe cut, Teague makes the first pass on a frame part, turns the piece end for end, and makes a second cut to complete the groove.*

The rails get tenons

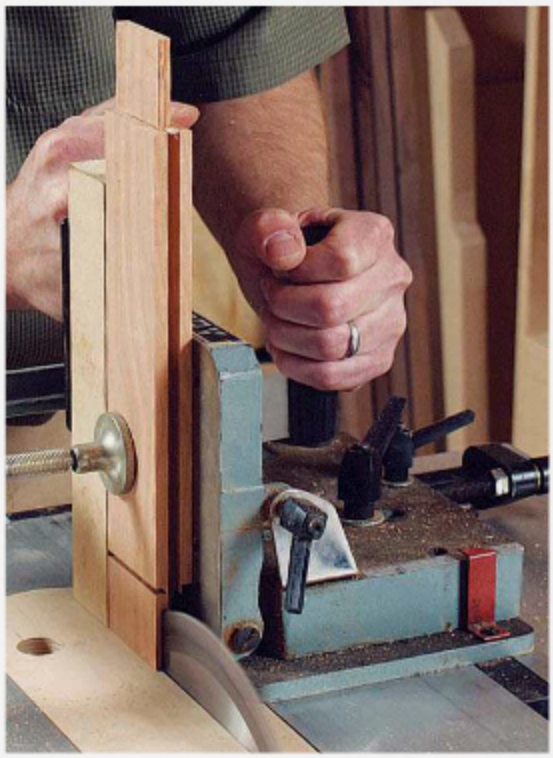
SETUP

Set the blade height. *Using a frame part as a template, adjust the blade height until the highest tooth is flush with the lower edge of the groove.*



Set the tenon length. *Using a stile as a guide, adjust the fence until the outside edge of the stile is flush with the outside edge of the teeth.*

Cut the shoulders. *Butt the end of the rail against the rip fence and use the miter gauge to support the stock as it's passed over the blade.*



Cut the tenon cheeks with a jig. *With a tenoning jig holding a rail on end, make one pass over the tablesaw blade for each cheek cut. A piece of scrap stock between the fence of the jig and the workpiece helps prevent tearout.*

snugly in the grooves. After that, I cut the mortises to fit the tenons. If your stock is ¾ in. thick, the grooves, tenons, and mortises will be ¼ in.wide. For this door, I made the grooves ⅜ in. deep.

You could use a dado blade to cut grooves on the inside edges of the stock, but I prefer to take two passes with a single blade. This ensures that the grooves are perfectly centered on the stock, and saves me the trouble of installing and fine-tuning a dado cutter.

Set the blade height to ⅜ in., then set the fence so that there is ¼ in. between it and the blade. Position the stock on edge, with the inside edges of the door down on the tablesaw. Run all four frame members over the blade with the stock held tightly against the fence. A featherboard helps keep the stock secure. A push block allows you to hold the stock against the saw table while keep your hands a safer distance from the blade. After making one pass, flip the stock so that the opposite face is against the fence and take another pass. The result is a ¼-in. groove perfectly centered on your stock. While you're at it, groove the test stock, too.

Cut tenons on the rails—With the grooves complete, you can cut the tenons. The first step is to establish the shoulders on each one. Lay a frame piece on its side and lower the blade so that the top of the blade is aligned with the inside edge of the groove. Then, adjust the fence to match the width of the stiles.

Once the blade is set, you're ready to make a trial cut on a piece of grooved test stock. Place the face of the stock against the saw table and guide it across the blade using the miter gauge. Be sure that the end of the stock butts against the rip fence throughout the cut. The cut should come just to the groove line. If it's too deep, lower the blade a little and make another cut. If it's a little shy, don't worry—you'll smooth this face when you cut the cheeks of the tenon.

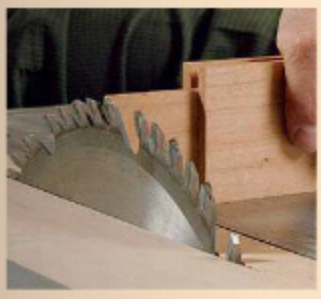
Hold the test stock against one of your stiles, and check to see that the width of the cut matches the width of the stile. Once the correct settings are dialed in, you're ready to make the same cut on your rail stock. Butt the end of the stock against the fence and use your miter gauge to guide it as you make the cut. Then, flip the stock so that the other face is against the table and make another cut.

To cut the tenon cheeks, use a tenoning jig, either shop built or commercial. Position the jig so that the blade cuts to the groove line on the stock. Then, raise the blade until it just reaches the sawkerf that establishes the tenon. Make a trial cut on the test stock, checking to make sure the tenon fits the groove, then make the cut. Be sure to clamp the stock, and push the jig all the way through the cut before removing it. Then flip the stock and cut the other cheek.

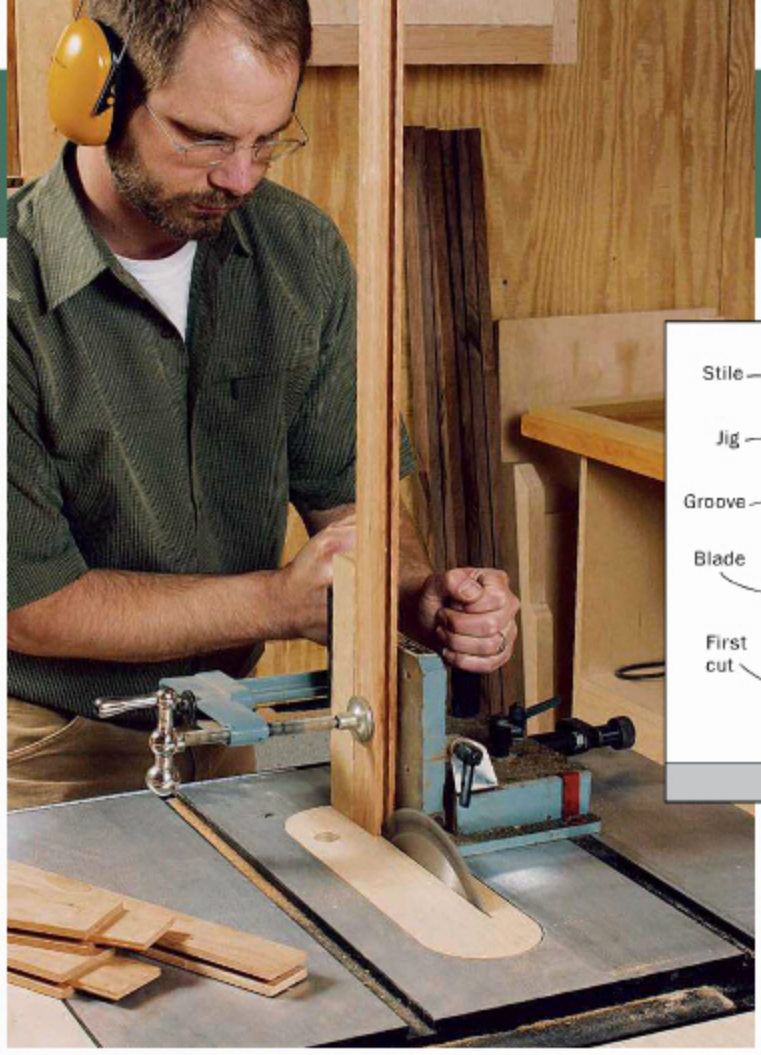
Cut open mortises on the stiles—The stile mortises on this door are cut to house the tenons snugly. Use

Mortise the stiles

SETUP



Let the workpiece guide you. *A rail tenon makes a perfect gauge for setting the height of the tablesaw blade.*



Use the tenoning jig for the mortises, too. *Two passes over the tablesaw blade, with the stile flipped around between each pass, creates the open mortise.*

the same jig you used to cut the tenons. To prevent tearout, attach a piece of sacrificial stock in front of the workpiece. Once the cut is aligned correctly, raise the blade to the width of the tenon stock on the rails.

Instead of going straight to work on the stiles, make a few test cuts. Clamp a piece of the test stock in your jig, then make the cut. Flip the stock so that the other face is toward the jig and make another cut. Most tablesaw blades are ⅛ in. wide, so it should take only two passes to cut each mortise. The result should be a ¼-in. open mortise aligned with the groove.

Test the fit of the tenon in the mortise. It should be snug, but not so tight that you have to use a mallet to get the tenon into the mortise. Also, make sure that the depth and width of the mortises match the tenons. If necessary, adjust the jig or blade height and make another test cut. Once you're happy with the result, clamp your stile stock in place on the tenoning jig and make the cuts. If your blade is flat-bottomed, you won't need to fine-tune the mortise, but if your blade leaves a skew cut, use a narrow chisel to trim up the mortise bottom.

Tweak any tight-fitting tenons. *If a test fit reveals a joint that's too tight, shave the offending tenon with a bench chisel.*

The panel is the last piece

On my door, the ½-in.-thick panel has a ¼-in.-deep by 7/16-in.-wide rabbet on all four edges to fit into the frame grooves. To determine the length of the panel, measure the distance between the mortises on the stiles, then subtract 1/16 in. to allow a little clearance. Seasonal wood movement across the length of the panel is so minimal that you don't need to account for it much when crosscutting the panel to length. Make the cut using your tablesaw and a crosscut sled in place of the miter gauge. A crosscut sled provides better support to the panel during the crosscut. You can find plans for a similar sled on p. 114.

When ripping the panel to width, remember that wood moves across its width with seasonal changes in humidity. While the grooves are ⅜ in. deep, you'll only want the rabbeted tongue to go in about ¼ in. at the sides. This will allow the panel to swell a little in the summer months and shrink a little in the winter,

The panel completes the door

Measure and crosscut. *To determine the panel length, Teague measures the distance between the stile mortises (above). Don't try to cut a wide panel using a miter gauge. A shopmade crosscut sled makes the operation easier and safer (right).*

without causing stresses on the frame. To determine the width of the panel, measure the distance between the tenon shoulders on the rails, and add ½ in.

Rabbet the panel—In order for the panel to float freely in the grooves on the frame, you'll need to cut rabbets—¼ in. deep by 7/16 in. wide—on the back sides of all four panel edges. Before cutting the rabbets, be sure to install a zero-clearance insert in the saw table.

Raise the blade to ¼ in. and take a few trial cuts on test stock milled to the thickness of the panel. The test cut should fit easily, but not sloppily, into the grooves on the frame. Once you're happy with the fit, set the rip fence 7/16 in. from the outside edge of the blade teeth, then take passes on all four edges to establish the shoulder of the rabbets.

Next, attach a high fence to your tablesaw's rip fence. Include a featherboard elevated an inch or two above the table to prevent it from pinching the offcut against the blade. That's important, because if the offcut gets pinched, the blade could shoot it back at you at the speed of sound. Now, raise the blade to 7/16 in. and set the high fence to make a ¼-in.-deep cut. Holding the panel on edge, take a pass over each edge.

At this point in the door construction, I prefer to final-sand the panel and apply the finish. That way I can be sure that the entire rabbet around the edge of the panel gets properly finished. If I finished the panel after assembly, the unfinished rabbet would be visible when the panel shrinks in width. The frame is finished later.

Glue up the door

Once the panel is cut to size and rabbeted, an important step is to dry-fit all the parts before you reach for the glue bottle. A dry-fit allows you to make sure everything goes together without problems. It's also a good way to find out if everything you need—glue, glue brush, clamps and clamp pads—is within easy reach.

When working through the dry-fit, it's not uncommon to find a joint or two that fit too tightly. A little work with a plane or bench chisel proves a good tonic here.

Lay out all the door parts on your bench with the door face down. Set two pipe clamps (or bar clamps) flat on the bench, then assemble the door on top of the clamps. Start by sliding the rabbets on the panel into the grooves on the stiles, then slide

Photo, left: Kelly J. Dunton

Cut the rabbet. *With the blade at the proper height, and the rip fence the correct distance from the blade, Teague makes the shoulder cut adjacent to all four edges of the panel (above). With a tall, wood, auxiliary fence and a raised featherboard helping to support the panel on its edge, each rabbet is completed by making a single pass over the tablesaw blade (right).*

the rails in place from the ends. Double-check to see that the panel seats itself fully into the grooves on the rails.

Center the clamps on the joint across the rails, tighten it part way, then add two clamps on top of the door, centered on the joint across the stiles. Before proceeding to glue-up, tighten down the clamps to be sure that the bridle joints close up completely.

With the dry-fit done, use a glue brush to apply a thin layer of glue to the tenons and the mortises of each joint. Add just a drop of glue at the center of the grooves on the rails—this will secure the center of the panel, but still allow the edges to move with seasonal changes in humidity.

Once the glue is spread, follow the same assembly process you did during dry-fitting. Because the back of the panel is facing up, you can make small adjustments to the location of the panel. Aim for a panel that is centered on the frame. I often insert a few nickels between the stiles and the rabbet shoulder on the panel to make sure the panel is square and centered in the frame.

Once the four clamps are in place, check to see that the door is square by measuring across both diagonals; that measurement should be equal. The last step of glue-up is to add a short clamp to each bridle joint to ensure a good bond between the faces of the mortises and tenons. Be sure to use clamping blocks made of laminate or covered in waxed paper so the glue won't stick to them. □

Add clamps. *A couple of pairs of bar clamps hold the joints tightly while the glue dries. Once clamped, make sure the frame is square by measuring diagonally across the two pairs of corners.*

Matthew Teague is a former managing editor of Fine Woodworking *and one of the authors of* Woodworking 101, *published by The Taunton Press (taunton.com) in 2012.*

PROJECT

Organizer

Practice cutting dadoes and rabbets while building a useful cabinet

BY MARIO RODRIGUEZ

My students always find it more satisfying to perfect their joinery by creating a piece of furniture, rather than by adding to the kindling in the scrap bin. The dado and the rabbet are fundamental woodworking joints found in all kinds of furniture, from bookcases to highboys. Building this organizer, which can be hung on a wall or stood on a table, allows you to practice these joints while creating a useful piece of furniture.

This piece features dadoes that run the width of the sides to support the shelves, and stopped dadoes in the upper shelf and the underside of the top to receive the partitions. Rabbets in the cabinet include those at the top of each side piece and partition, as well as in the drawer construction. Both joints provide accurate alignment of the parts, load-bearing capability, and increased glue surface. They can be cut accurately on the tablesaw, with or without a dado set, and with a router using various fences and jigs. The drawers have a false front that is screwed to the drawer box.

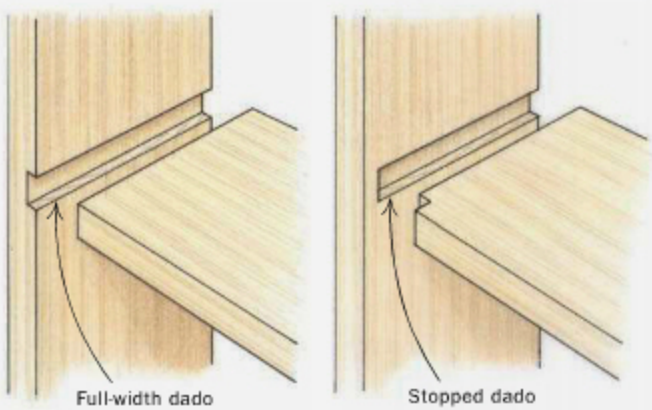
Materials are inexpensive and easy to find

I chose red oak as the primary wood for this project and pine for the drawer boxes and the back slats. If you can find 11-in.-wide oak boards, you will be spared the step of gluing up panels, but glue-up is not a big procedure for a project this size. The oak for the partitions needs to be thicknessed to ½ in., and most of the pine needs to be ⅜ in. thick; this is best done with a planer,

SIMPLE BUT USEFUL JOINTS

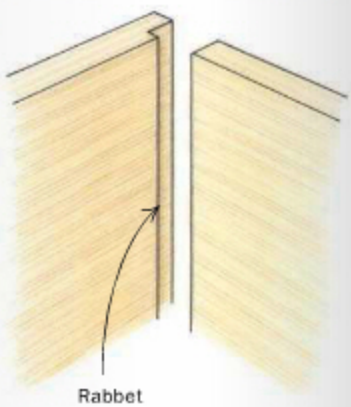
DADOES

The dado, a square, flat-bottomed recess cut across the grain of one board to receive the end of another, can run the full width of the board or stop short of one or both edges.



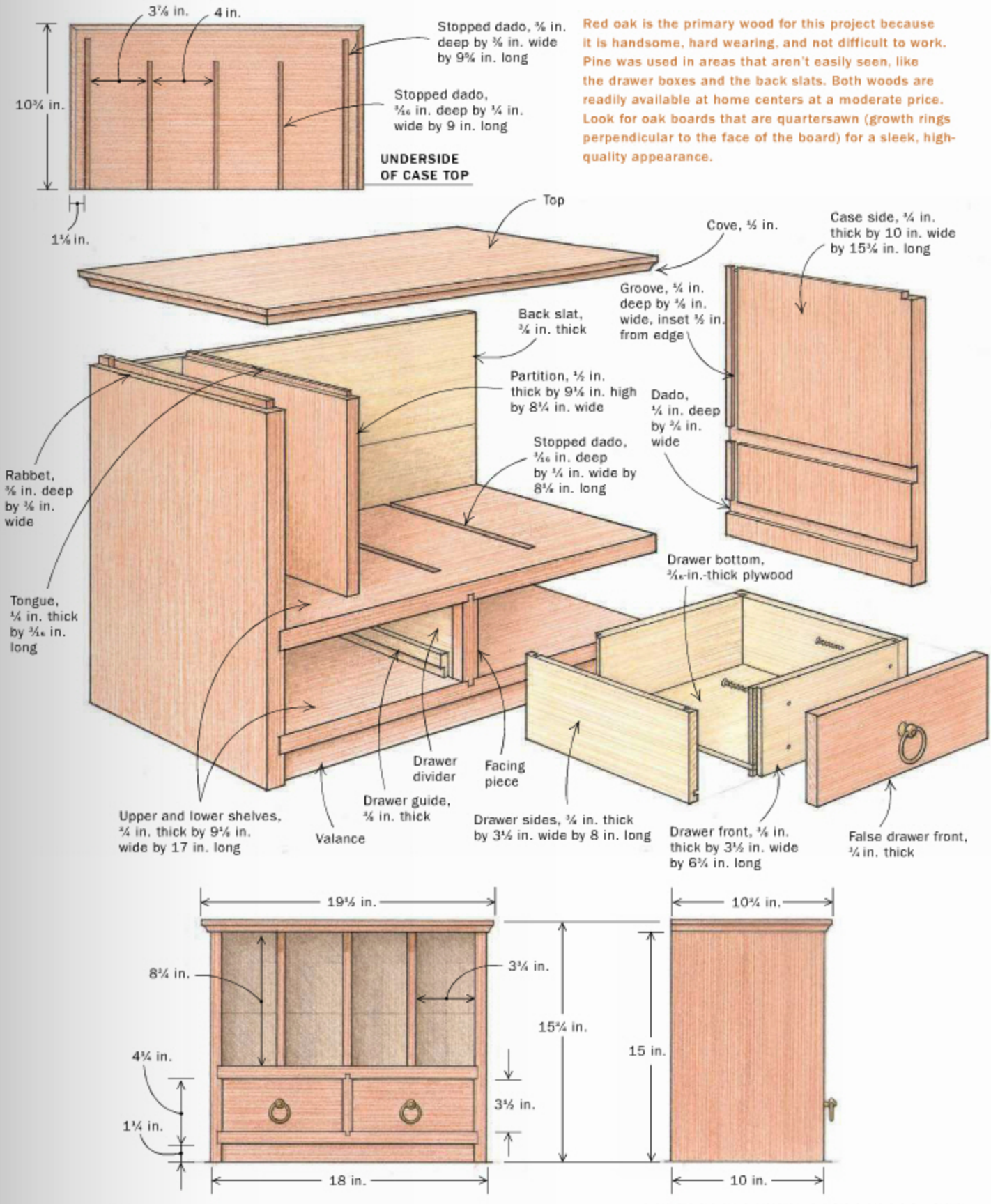
RABBETS

The rabbet is an open-sided recess cut along the edge or end of a board to receive the edge of another.



Photos: Mark Schofield

SMALL STORAGE CASE ASSEMBLES EASILY



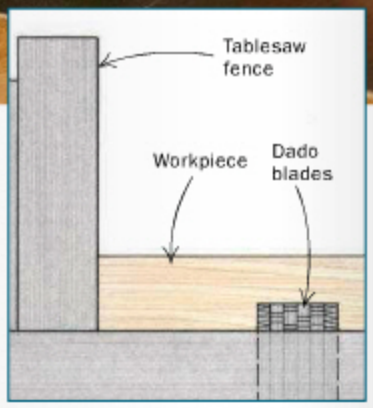
Red oak is the primary wood for this project because it is handsome, hard wearing, and not difficult to work. Pine was used in areas that aren't easily seen, like the drawer boxes and the back slats. Both woods are readily available at home centers at a moderate price. Look for oak boards that are quartersawn (growth rings perpendicular to the face of the board) for a sleek, high-quality appearance.

Drawings: Vince Babak

CUT FULL-LENGTH DADOES AND RABBETS ON THE TABLESAW

TWO TYPES OF DADO BLADES ARE AVAILABLE

The outside cutters of a stackable set of blades (above) are placed on the arbor first and last, with chipper blades between them. The width of the cut is fine-tuned by placing metal or paper shims between the blades. Adjustable blades (right), also called wobble blades, can be adjusted to width by rotating a dial on the side of the blade.



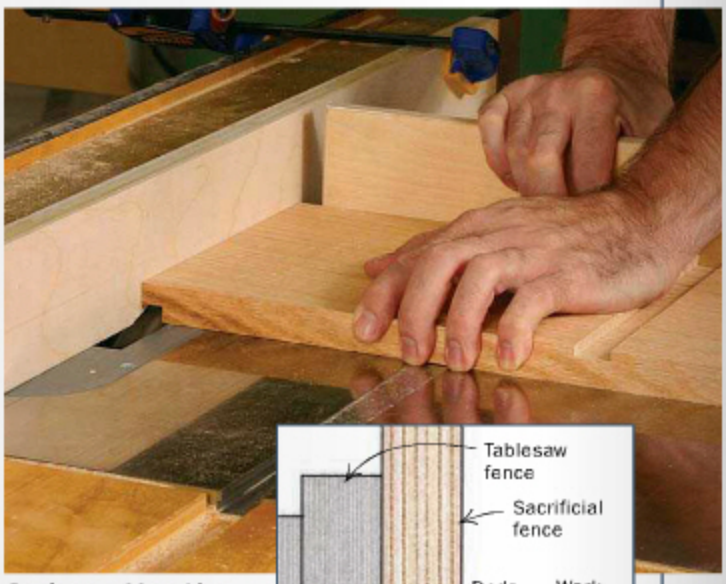
Cutting a dado. *The depth of the dado should equal about a third of the wood's thickness. Apply constant pressure both against the fence and downward to ensure that the cut depth is consistent across the piece. With narrow workpieces, use a miter gauge for guidance and support.*

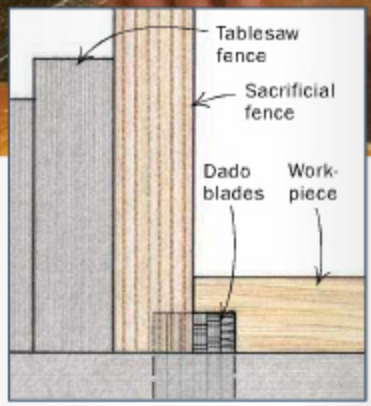
rather than trying to resaw thicker stock. You will need about 18 ft. of 8-in.-wide oak boards, and 12 ft. of 4-in.-wide pine, which includes an extra 20% to be on the safe side.

Dadoes and rabbets can be cut on the tablesaw

Most of the dadoes and rabbets for this project can be cut on the tablesaw using a set of dado blades. There are two types of dado blades (see photos, above): stackable blades, which have two outside blades to cut the sides of the joint and multiple chipper blades to remove the waste in the middle, and adjustable blades, also known as wobble blades. I prefer the stackable set because it makes a cleaner cut. Mount the two outside blades and sufficient chippers to make a cut just under ¾ in. wide. Using a piece of surplus oak as a gauge, fine-tune the width by adding or removing shims between the blades. Also, install a tablesaw throat insert that has an opening wide enough to accept the dado set.

Each side piece gets a pair of dadoes for the shelves, and the top and bottom shelves receive one narrow dado each for the drawer divider. Dadoes shallower than ¼ in. can be cut in one pass, but feed the workpiece slowly to achieve a clean cut and avoid straining the motor. Use the rip fence to guide the location of each dado, making the same cut on both side pieces before adjusting the fence for the next dado. Apply firm downward pressure on the workpiece to ensure that the depth of each dado is consistent throughout its length.

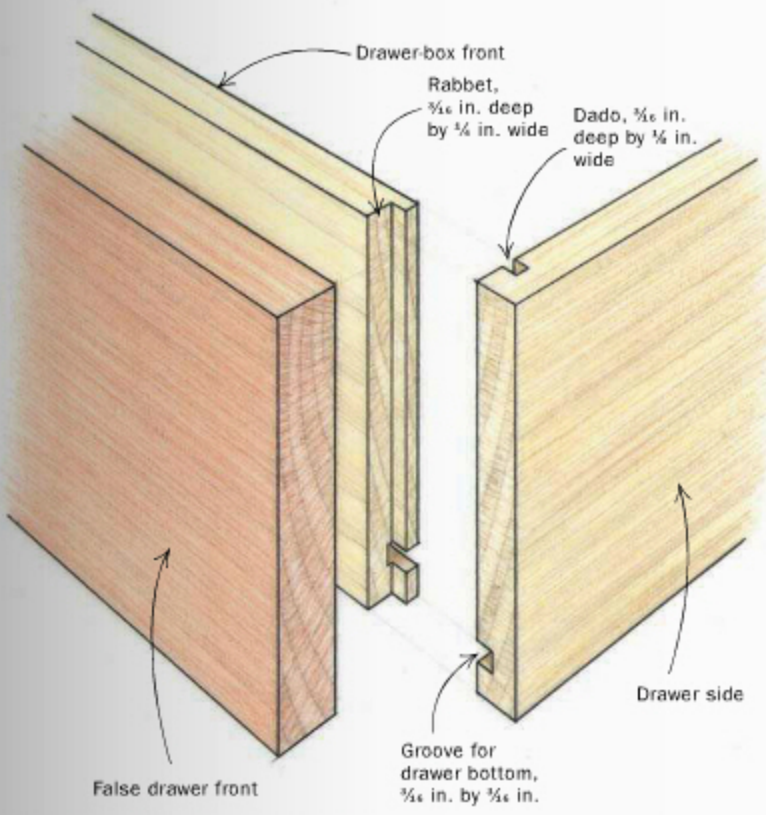




Cutting a rabbet. *After cutting the dadoes for the shelves, flip the board and cut the rabbet on the top of each side, creating a narrow tongue that will enter the top. To avoid damage to the rip fence, clamp on a sacrificial plywood fence.*

A QUICK DRAWER JOINT MADE WITH DADOES AND RABBETS

The front, back, and sides of the drawer boxes are connected by dado and rabbet joints cut on the tablesaw. The false fronts are mounted with screws after the drawers have been assembled.



Cut dadoes in the drawer sides. *The positions of the dadoes on the drawer sides are determined by the thickness of the front and rear drawer pieces.*

Even though the cut for the rabbets on the top of each side piece is ⅜ in. square, there is no need to reset the width of the dado set. Instead, clamp a piece of ¾-in.-thick plywood or medium-density fiberboard (MDF) to the rip fence, locate the fence for the cut, and gradually raise the blade so that it eats into this sacrificial fence.

The final cuts with the dado blade are ⅛-in.-deep by 3/16-in.-wide rabbets on both sides of each end of the three partitions, and 3/16-in.-deep by ¼-in.-wide rabbets on overlapping sides of the pine back slats. Known as a shiplap joint, this overlap allows the boards to move seasonally without creating a gap between them.

Stopped dadoes are best cut with a router

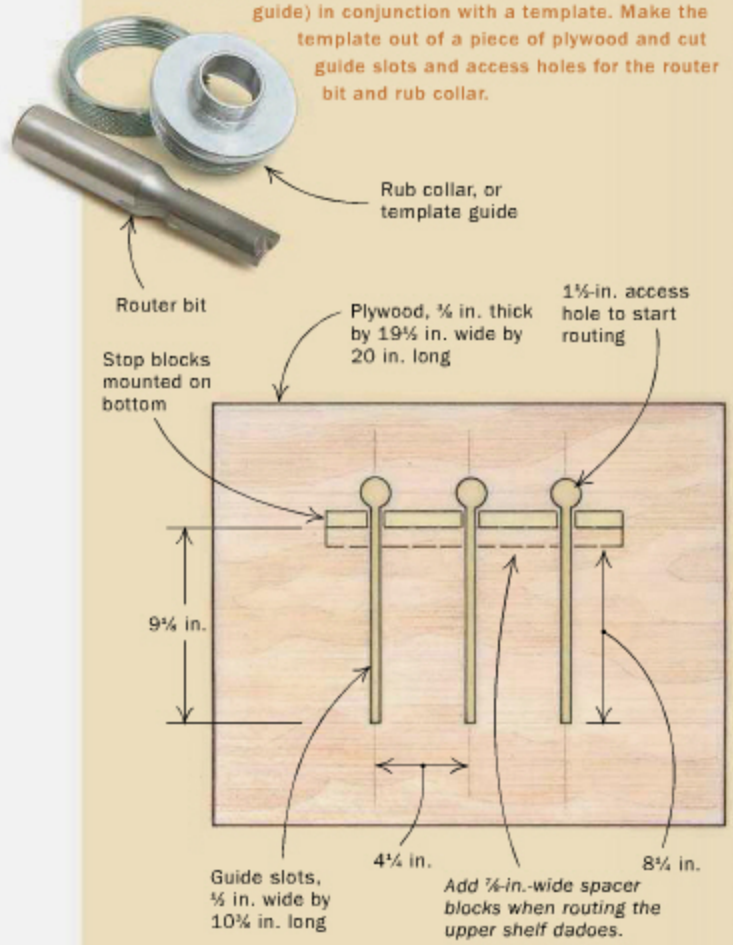
On this project, the partitions are secured in stopped dadoes in the upper shelf and the top.

The stopped dadoes must be cut in identical positions on the top shelf and the underside of the top piece. To achieve this, I use a rub collar (also called a template guide) in conjunction with a template. The collar has a tubelike piece of metal that surrounds the router bit and guides it by means of a template placed on the workpiece. When laying out the job and making the router template, the difference between the outer diameter of the rub collar (in this case 9/16 in.) and the router bit (¼ in.) must be taken into account. Blocks of wood glued to the underside of the

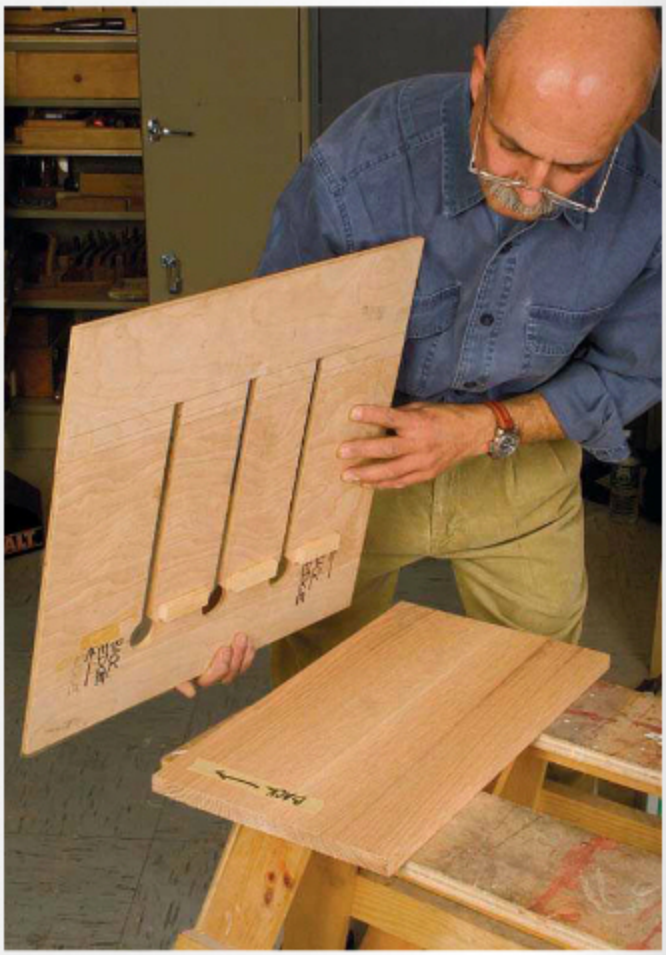
Rabbet the front and rear pieces in two steps. *Using a commercial tenon jig to support the workpiece (above), make a vertical cut on the ends of each drawer box front and back. With the piece flat on the table (left), make the second cut, leaving a tongue that will connect with the side pieces.*

USE A TEMPLATE FOR MATCHING DADOES

The partitions are secured in stopped dadoes in the upper shelf and the underside of the top. Because the cuts must be in matching positions, use a rub collar (also called a template guide) in conjunction with a template. Make the template out of a piece of plywood and cut guide slots and access holes for the router bit and rub collar.



Cut the template guide. *With a T-square guide clamped to the edge of the plywood template, rout the slots for the template guide to ride in.*



Router template spaces partitions evenly. *Because the stopped dadoes for the partitions must be cut precisely and in identical positions on both the upper shelf and the top, it is best to use a plywood template to guide the router.*

template act as stops to ensure accurate placement on both pieces.

I also use the router to cut ⅜-in.-square stopped dadoes on the sides for the back slats and on the underside of the top for the sides. Because these cuts are near the edges of the workpiece, a fence attached to the router and guided by these edges works well. You will need to stop the router just before the end of each cut and square up the end with a chisel.

While the router is out, use it to cut the profile around all four edges of the top. Although the piece shown has a cove on the underside of the front and sides of the top piece, you may prefer the look of a chamfer. Regardless, use a bearing-guided bit running along the edge of the workpiece. For a clean cut with minimal tearout or burning, make the cut in two stages, with the second cut at the final depth removing only a small amount of wood.

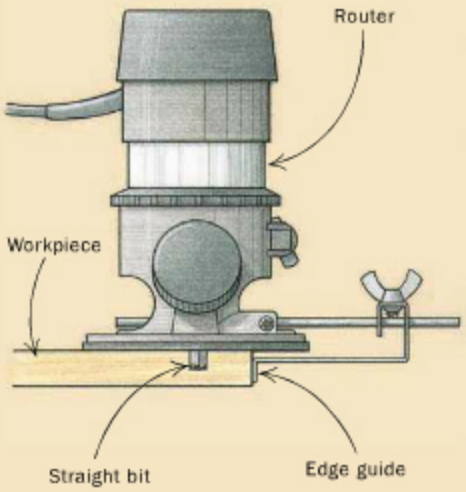
Cut the drawer parts using the tablesaw

Because the drawers have false fronts and are fitted with guides, it is safe to make up the drawer boxes before the carcase is

The template guides the router. *A rub collar (or template guide) screwed to the router base runs against the template, guiding the router bit.*

AN EDGE GUIDE IS ANOTHER OPTION

After cutting the stopped dadoes for the partitions, add an adjustable fence to the router and cut the stopped dadoes at both ends of the top to receive the sides.



assembled. The front, back, and sides of the boxes are connected by dado and rabbet joints cut on the tablesaw: First cut two dadoes on each side piece; the distance from the end is determined by the thickness of the front and back pieces.

Now cut the rabbets on the ends of the drawer back and sides. The rabbets create a tongue that connects with the dadoes on the drawer sides. Because these cuts are made with only a thin section of wood in contact with the tablesaw, install a zero-clearance insert around the sawblade to prevent the workpiece from getting wedged between the table and the blade. Before assembling the boxes, cut grooves on the inside of the front and sides.

The drawer divider simply is a ¾-in.-thick piece of pine that is joined to the two shelves with ¼-in. dadoes. These can be cut on the tablesaw with two passes over a conventional blade. To avoid having end grain exposed on the front of the cabinet, use a tongue-and-groove joint to attach a thin facing piece of oak.

Assemble the carcase and fit the drawers

You will find the assembly of this project much easier on a pair of sawhorses, because the gap between the horses allows more room for clamping. Glue the shelves to the cabinet sides and slide in the drawer divider from the front. When these joints are dry, slide in the back slats, glue in the three partitions, and

CONSTRUCT THE CASE AND FIT THE DRAWERS

Assemble the piece. *Begin by gluing the sides to the two shelves. Apply some glue to the grooves and slide in the drawer divider from the front. Then slide in the back slats and glue in the partitions. The last piece of the case to be attached is the top. Working on a pair of sawhorses gives you more options for clamping positions.*

Drawer guides have a rabbet and stop 1½ in. from the back slats. *This allows the thickness to be trimmed with a block plane after they have been installed.*

Fit the drawer fronts. *After cutting the false fronts to size, mark the location of the drawer box on the back of each, including the holes. To attach the drawer front, drill the holes in the drawer box slightly oversize to allow for fine-tuning to the drawer opening.*

then glue on the top. Screw the center of each back slat to the sides. Mill some rabbeted drawer guides from pine and set them in place with glue. The rabbet along the bottom of each guide and the fact that they are installed 1½ in. short of the back allow them to be trimmed in place with a block plane.

Once you have achieved a snug fit for each drawer box, mark its location on the back of each false drawer front. Transfer the location of the holes on the drawer box and drill pilot holes in the false front to avoid splitting the wood with the screws.

The last pieces to add are a valance that is set just in from the front edges of the sides and glued to the lower shelf, and a two-part French cleat if you are going to hang the organizer on a wall. Before assembly, sand the interior sections with 100-, 150-, and 220-grit paper. With the piece assembled, plane all of the joints flush and repeat the sanding sequence on the outside. Wiping the wood with denatured alcohol will reveal any glue that has squeezed out. Sand these areas again with 220-grit paper.

Finish the wood with three coats of an oil-varnish mixture, such as Waterlox, sanding between the first two coats with 220-grit paper. When the finish has cured, rub the cabinet with 0000 steel wool, and wax and buff the wood for a smooth, satin finish. □

Mario Rodriguez teaches woodworking at Philadelphia Furniture Workshop.

PROJECTS

Saw stand

Support your portable tablesaw with this shop-built movable stand

BY MATTHEW TEAGUE

Whether it's used for building custom furniture, creating kitchen cabinets, or doing work around the house, a tablesaw is the go-to stationary tool in every shop I've visited. And with good reason: A tablesaw allows you to cut boards and sheet goods (like plywood), to length or width. What's more, the cuts are quick and straight, and if you take a few minutes to set up your saw correctly, they're dead square. Outfitted with the proper jigs and accessories—most of them easily made in the workshop—you can also cut a wide variety of joinery.

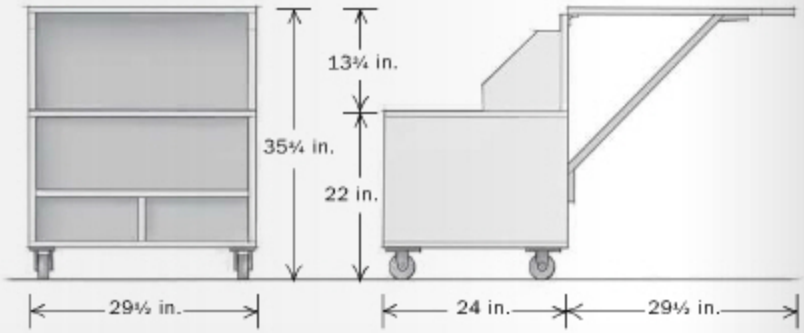
Cabinet saws are wonderful. But they're not only expensive—$1,100 and up—they take up a lot of shop space. Contractor's saws are one step down in price, but I've never found them to be any better than a good, and less pricey, benchtop model. Portable benchtop tablesaws often get a bad rap. In truth, many of them are as powerful as contractor-grade saws, and when set up properly, they can do almost all the same work you'd expect from a large cabinet-style saw.

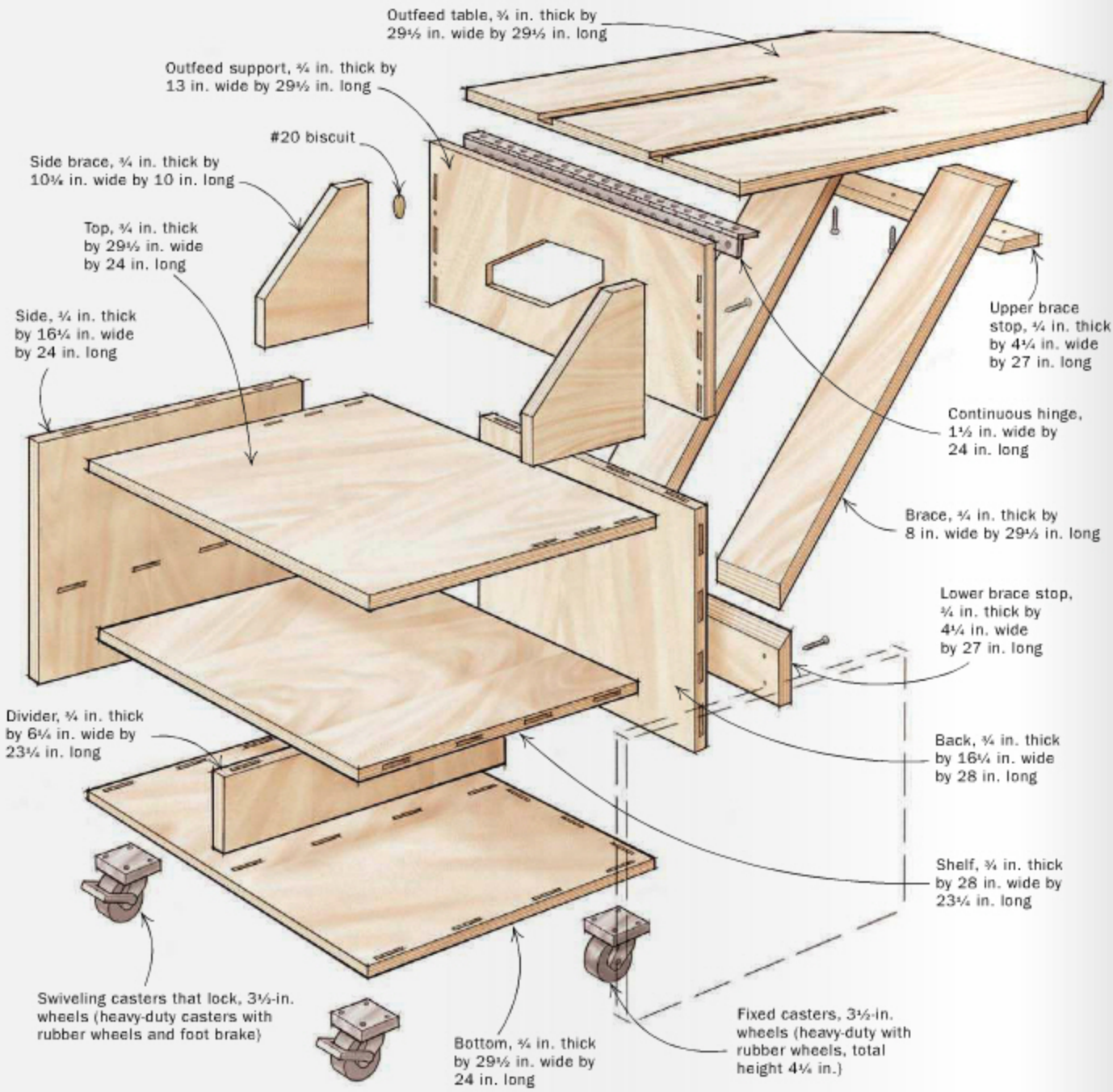
The key to making a benchtop saw perform like its heftier cousins is to secure the saw and increase the surface area of the worktable. Building a good mobile base

Photos: Matthew Teague

BUILD A VERSATILE WORK STATION FOR A PORTABLE TABLESAW

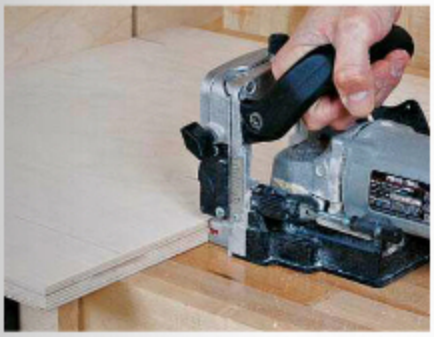
This entire work station can be built from two sheets of ¾-in.-thick plywood, with all the joints held together using #20 biscuits. If you plan to build dust and storage drawers (not shown), they can be made from thinner sheet goods, but the extra weight adds stability to the work station. The outfeed table is attached to the base with a long continuous hinge, allowing it to fold out of the way when not in use.





Drawings: Chuck Lockhart

BISCUITS MAKE CONSTRUCTION SIMPLE



Biscuit the sides and back. *To add biscuits, secure the work, align the centerline on the workpiece with the centerline on the biscuit joiner, and plunge to make the cut (above). Test-fit all the joinery before glue-up (right).*

for your benchtop saw not only provides a more stable work surface, it also increases the capacity of the saw to handle large workpieces—you can't rip long boards or sheet goods unless you have proper outfeed support.

A place for sawdust and accessories

Built solely from ¾-in.-thick plywood, this base offers plenty of stability and a wide enough footprint to keep it from tipping as you work. It also provides outfeed support that allows you to rip long boards or sheet goods. A pair of optional storage drawers (not shown) near the floor allows you to store all the tools you'll want to keep close at hand—wrenches, miter gauges, auxiliary fences, and zero-clearance inserts. Just beneath the saw, I added a dust drawer (not shown) to catch the bulk of the mess made from cutting. When the drawer is full, or it's time to clean the shop, you can easily remove the drawer and dump the waste in the trash. For the cleanest work space, you can attach a shop vacuum to the base.

The best part about this work station is that it takes up little space—it's under 30 in. wide. With the braces removed, the outfeed table folds out of the way when not in use, making it just over 24 in. deep. It's outfitted with heavy-duty locking casters underneath, so you can move it to the middle of the shop when needed. When you're finished, simply fold down the outfeed support and store the whole work station against the wall.

Building this work station is easy, and teaches you a woodworking basic—how to build a box. The same methods can be used for building cabinets, bookcases, even sideboards and chests of drawers. The basic box can be built in just a few hours. At that point, you can set up the saw and begin using it. Outfeed support, as well as the storage and dust drawers, can be added at any time. That said, both the drawers and the outfeed support make this unit more stable and versatile, so I'd suggest building everything in one fell swoop.

The work station and drawers are put together using biscuits, which I prefer because they make it a lot easier to manage all the parts, but screws and butt joints would do the same job. This unit is sized for one of the largest of the benchtop saws on the market, so it should handle whatever model you choose. Still, you'll want to measure your saw and size the base accordingly. Be sure to have the casters in hand before you begin building. If your casters are slightly taller or shorter than those seen here, adjust the height of the base so that your work surface is between 35 in. and 36 in. tall. □

Matthew Teague is a former managing editor of Fine Woodworking. *This article is excerpted from his book,* Getting Started in Your Shop, *published by The Taunton Press (taunton.com) in November 2005.*

Add dust collection

Depending on your saw, you might have to tweak the design of the dust collection. If it has a dust chute—like the one seen here—cut an access hole through the outfeed support and attach your vacuum hose to the saw. If not, make a cutout in the top to allow dust to fall into the dust drawer.

PROJECT

Shaker Stool

Learn fundamental hand-tool skills while building a classic

BY CHRISTIAN BECKSVOORT

The Shakers designed and built a great variety of useful stools and benches. Most had through-mortise-and-tenon joints to prevent racking and help support the top. Some had central stretchers and a few had industrial metal-strap braces.

My favorite, for both looks and strength, adds four dovetailed corner braces to the through-tenons. This sturdy, versatile design can be sized for use as a footstool, a bench, or even as a side table. Maybe the best part is that it can be made using hand tools only.

I make this bench from ¾-in.-thick white pine, with contrasting cherry or walnut wedges to help fasten the through-tenons. I'll show you how to build it using hand tools, but I'd suggest using a jointer and planer to flatten the stock and mill it to thickness (or you can start with stock that is premilled at the lumberyard). To save time and increase accuracy, you might also use a tablesaw to cut parts to length and width. If you do mill the stock by hand, be sure to work both faces to make the parts a consistent thickness.

Through-tenons attach the legs

Start by making the legs. Each one has a pair of tenons at the top and a decorative arch sawn at the bottom. First use a compass to lay out the arch, which is about 2 in. high at its peak, and starts about 1½ in. from each edge. Cut out the waste with a coping saw and smooth the surface with a file and sandpaper. Gluing or stapling a strip of sandpaper to the waste piece and sliding it back and forth works well to fair the shape and smooth the surface. Once the arch is done, turn to the tenons. To lay them out, use

Photo, this page, and drawings: Kelly J. Dunton

Make the legs first

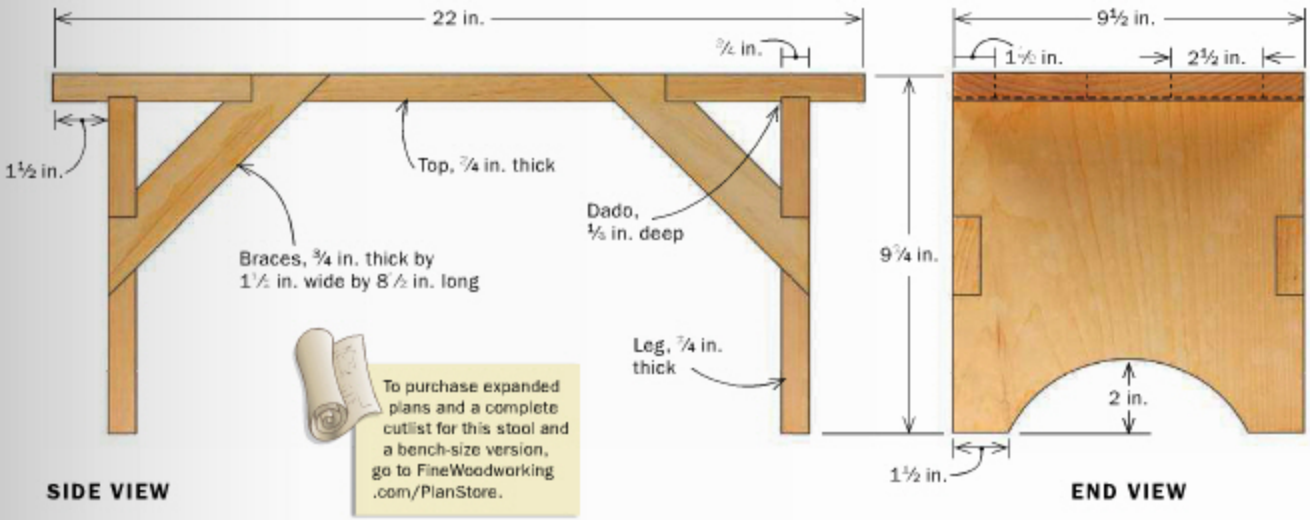
Arched cutout creates two feet. *Stay close to the layout line with the coping saw, then fair the curve with sandpaper attached to the curved offcut.*

Scribe the tenon length. *Set a marking gauge to the thickness of the top and use it to create a baseline for the tenons on both faces and ends of each leg.*

Then mark the width. *Measure in from each edge to mark the width of each tenon. Use a square to carry the layout lines from each mark across the top edge and down to the baseline.*

Saw the tenons. *Use a dovetail saw to cut all four marks down to the scribe line before cutting the end shoulders as shown.*

Chisel in between. *Use a coping saw to remove the waste between the two tenons, then pare to the scribe lines with a wide chisel.*



Photos, except where noted: Steve Scott

Mortise the top

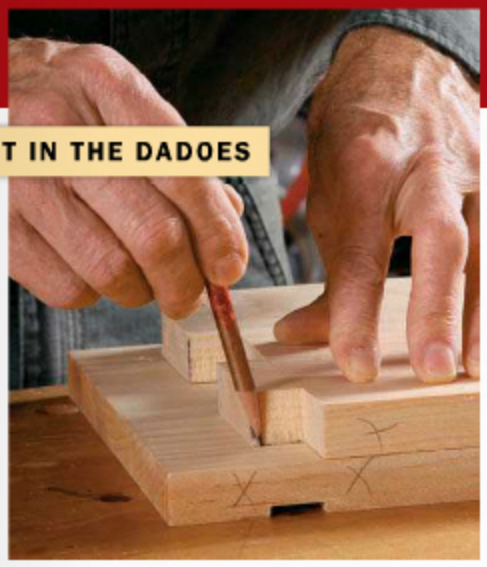
SHALLOW DADOES FIRST

Scribe the edges. *Mark the dado's outer wall using a gauge set to 1⅞ in. (right). Align the leg's face with this line and mark along the opposite face for the inner wall (far right). Mark the top this way, too, to start the mortise layout.*

Excavate the edges. *First, use a marking knife to deepen the scribe lines on the bottom side of the top to about ⅛ in. (right). Then make a series of angled cuts with a chisel (far right) to reveal the vertical wall created by the knife.*

Clean between. *Angle the chisel, bevel down, to plow out the remaining waste and flatten the dado's bottom. A router plane also works well for this task.*

MORTISES FIT IN THE DADOES



Lay out the ends. *Lay the leg flat on the top face, with the edges of the two pieces flush and the tenons resting between the lines you scribed earlier. Use a pencil to mark the ends of each mortise (top). To mark the mortises on the bottom face, place the tenon ends in the dado and use a square to align the two pieces (bottom).*

Chop from both sides. *Start from the underside, removing about half the waste. Then, to prevent blowout, flip the board and finish the mortise from the top. Check the walls with a straightedge, and test-fit the tenons.*

a marking gauge to scribe the thickness of the top on both faces (because the tenons will sit in a dado, they will protrude from the top so you can plane them flush later). Then mark the tenon width on the top and both sides of each leg—at 1 in. and 3¼ in. from both sides. Cut the tenons and remove the waste as shown on p. 109. To keep track of the parts, mark the legs for their orientation in the finished piece: right leg, right side, left leg, left side.

Because the wide pine legs might cup, I seat them in a shallow dado in the top's underside. You can use the legs themselves to help lay out the dadoes and the mortises. Use a marking gauge to scribe a line 1½ in. from each end above and below the top. Now place the leg on this line and knife along its edge to finish marking out the dado. Deepen the scribe lines on the underside to about ⅛ in. using a sharp knife. Next, chisel out the bulk of the waste. You can flatten the bottom and get the dado to a consistent depth with careful chisel work, but a router plane is quicker.

Next, use a pencil to mark the tenon locations on the top and bottom face of the top. I lay the leg flat on the top so the tenons are directly over the scribe marks. Make sure that each piece is oriented correctly, and that the edges of the top and legs are flush. Mark the tenon locations between the scribe marks, then flip the top and stand the tenons in the dado to mark their outlines.

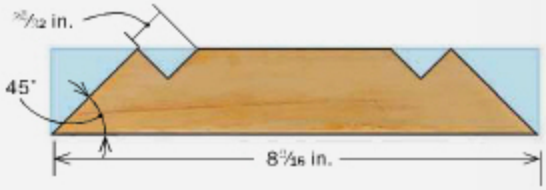
When cutting the mortises, start by chopping vertically, setting the chisel's back flat against the dado wall as you chop along the length. Next, set your chisel in the middle of the waste area and, with the bevel down, make a series of angled cuts toward each scribe line to define the long mortise walls. To prevent blowout on the opposite side, chisel halfway through, then flip the piece and finish the work from the other side. Again, define the mortise walls first, being careful to stay within the scribe lines. When I'm done, I use a small square or the edge of a chisel to check for high points on the mortise walls. These should be pared down. Orient the legs and dry-fit them. Look for a snug fit that holds against gravity but doesn't require brute force to seat.

Corner braces add strength

Each corner brace is mortised into the leg and top, and notched to prevent racking even under heavy loads. With a dovetail saw, cut the brace stock to length with opposing 45° ends. Leave each about ⅛ in. longer than finished length, so the ends can be

Make and fit the braces

Each brace gets two notches. *Miter the ends, then clamp the piece at an angle to cut a right-angle notch at each end. Cut each notch 1/32 in. deeper than the thickness of the mating piece.*



Mark the brace locations. *Dry-fit the stool and rest each brace in place, flush with the inside edges of the assembly, to mark out for the mating notches. Carry the marks onto the faces of the pieces and then use a marking gauge to scribe a baseline for each notch.*

planed flush after assembly. On the short edge of each piece, lay out a pair of 90° notches whose depth is 1/32 in. greater than the thickness of the leg and top stock so the ends will stand proud for trimming. Cut out the notches as close to the lines as possible. I start the cut at the corner with a knife to give the saw some purchase. Afterward, pare with a sharp chisel. Each brace will fit perfectly in only one corner and in only one direction, so label each brace and its corresponding corner.

The next step is to mark and cut the notches that will house each brace. Reassemble the stool. Position a brace on one of the corners so that the horizontal cut at its top is flush with the underside of the stool's top, and the vertical cut at the bottom of the brace is flush with the inside edge of the leg. Mark the location of the brace at the edge of the top and edge of the leg. Then use a square and pencil to carry the layout lines onto both faces of the top and leg. Set a marking gauge to the thickness of the braces and scribe the depth of the notch between the pencil lines.

Use a dovetail saw to cut slightly inside the pencil lines down to the scribed depth mark. Disassemble the stool and use a coping saw to clear the waste between the sawkerfs, then pare to the layout lines. Dry-fit, adjust, and repeat with the other three corners.

Glue-up is simple

Hand-sand the underside of the top and the inner faces of the legs to remove any blemishes, dirt, or pencil marks. Saw a pair of full-depth kerfs about 3/8 in. from the end of each tenon to accept the wedges. Now glue the legs into the top and the corner braces into their notches. Clamp as needed. While the clamps are on but the glue is still wet, glue and pound the hardwood wedges into place.

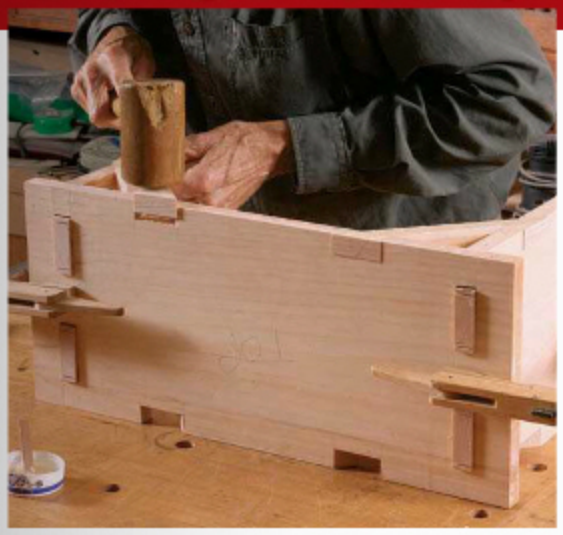
Once the glue is dry, the protruding tenons, wedges, and braces can be smoothed with a block plane. Sand all the edges, rounding the corners of the top slightly. Hand-sand the entire surface if desired, and wipe on the finish of your choice. □

Christian Becksvoort builds custom furniture in New Gloucester, Maine.

Cut the notches. *Saw down each pencil line to the baseline (left), and then remove the waste with a coping saw. Pare away any high spots with the chisel (above), test-fitting the brace as you go for a fully seated and snug fit.*

Photos, facing page (bottom left): Michael Pekovich

Assembly and cleanup



Glue-up is easy. *After sawing wedge kerfs in the tops of the tenons, apply glue to the tenons and bring the seat and legs together. Apply glue to the notches and seat the braces, tapping them home if needed.*

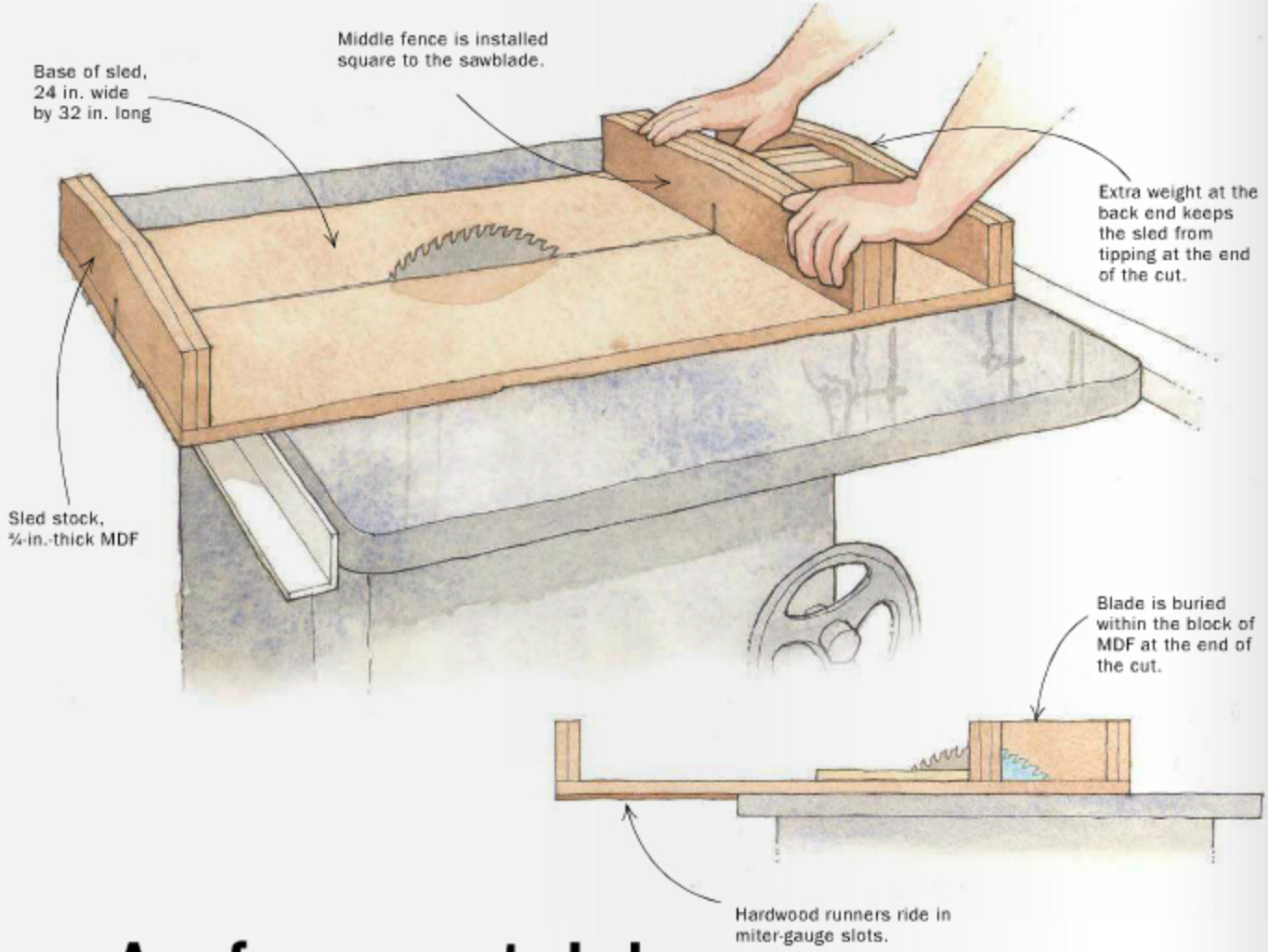
Wedges ensure snug tenons. *Cut the wedges from ½-in.-thick hardwood about 6 in. long. Use a chisel to taper them from 0 at the bottom to full thickness ⅜ in. up. Cut off 1 in. and repeat three more times. Apply glue to both sides of the wedge and tap it into the kerf with a hammer. Trim with a saw when the glue dries.*

Scaling up

The stool design is solid and functional in a variety of sizes. Becksvoort makes a bench version that is 11 in. deep by 40 in. wide by 18 in. tall. When building to larger scale, sketch the design until the overhang and foot arches please the eye. *Fine Woodworking* art director Michael Pekovich built the piece shown above (which has an overhang of 2¾ in., 4½-in.-high arches, and a bracket length of 11½ in.) in white oak as an entryway seat.

Plane everything flush. *The tenons will protude ⅛ in. or so and the braces a bit less. Use a block plane to level them (left) and to bring the edges flush, too (above).*

EDITED AND DRAWN BY JIM RICHEY



A safer crosscut sled

I once saw a beginner in our shop using a cutoff sled to crosscut a heavy workpiece. As he neared the end of the cut, with the far edge of the sled hanging over the back of the saw table, the sled reared up on him. Luckily, someone else was nearby and kept him from flopping the sled back onto the table and into a spinning blade. After that, the first thing we did was to build an outfeed table for that saw. I also decided to make a new, safer crosscut sled, as shown in the drawings above.

I made the new sled of ¾-in.-thick medium-density fiberboard (MDF) because it's an inexpensive, reasonably hard, and very stable material. I milled some scraps of hardwood lumber for the runners and cut a 24-in. by 32-in. piece of MDF for the base of the sliding jig. I laminated two pieces of MDF for the front and back fences and three pieces for the middle fence.

I secured the runners with glue and screws because I didn't want to risk any possibility of them coming loose while sawing. After installing the runners, I sealed and lubricated them with several coats of paste wax.

Before attaching the fences, I cut a shallow kerf into the base of the sled to give me a reference edge to which I could square them. Last, I added a block of MDF (three pieces thick) to fit between the middle and back fences. That block makes it almost impossible to cut your fingers at the end of a crosscut operation because the blade is completely buried within the MDF.

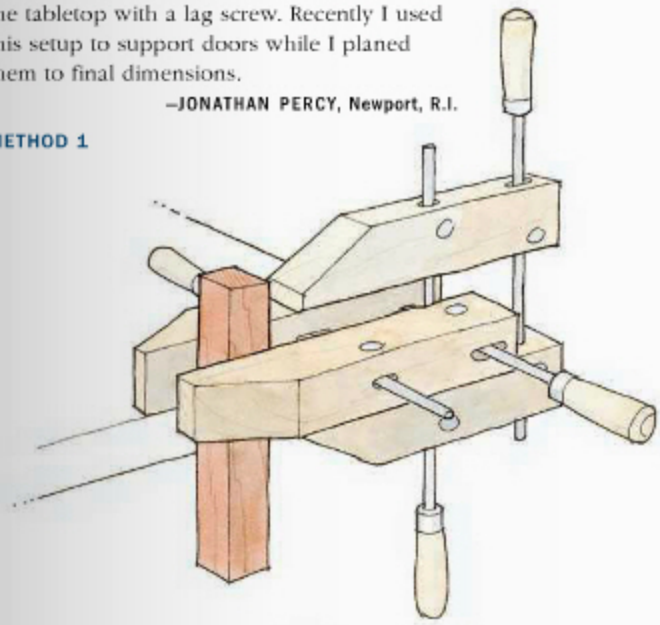
—JOE SANTAPAW, Yardley, Pa.

Bench clamping with hand screws—two methods

Here's a make-do vise I set up until I have the time to build a proper woodworker's bench with a built-in vise (see Method 1, below). Simply clamp one hand screw to the corner of a sturdy table with another hand screw. The bigger the hand screws, the better. This temporary arrangement produces a more than satisfactory substitute bench vise. For a more permanent solution, you could secure the hand screw directly to the tabletop with a lag screw. Recently I used this setup to support doors while I planed them to final dimensions.

—JONATHAN PERCY, Newport, R.I.

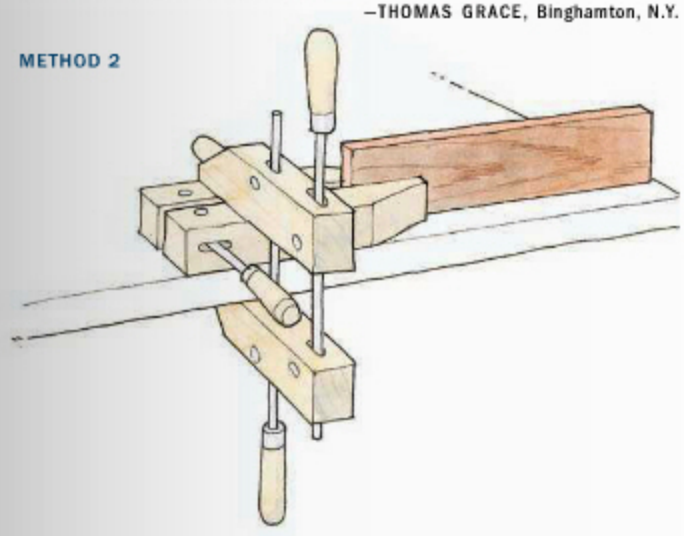
METHOD 1

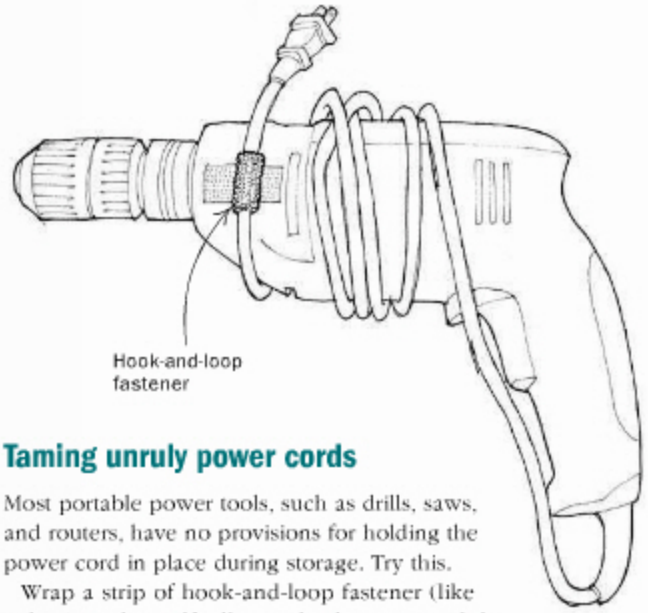


The workbench I am building doesn't have a vise. As an interim solution, I use two large hand screws. I lay the clamp horizontally on the bench to hold the work. Then I clamp the first clamp to the bench lip with the second clamp (see Method 2, below). This arrangement has the advantages of being cheap, movable, strong, and versatile.

—THOMAS GRACE, Binghamton, N.Y.

METHOD 2





Taming unruly power cords

Most portable power tools, such as drills, saws, and routers, have no provisions for holding the power cord in place during storage. Try this.

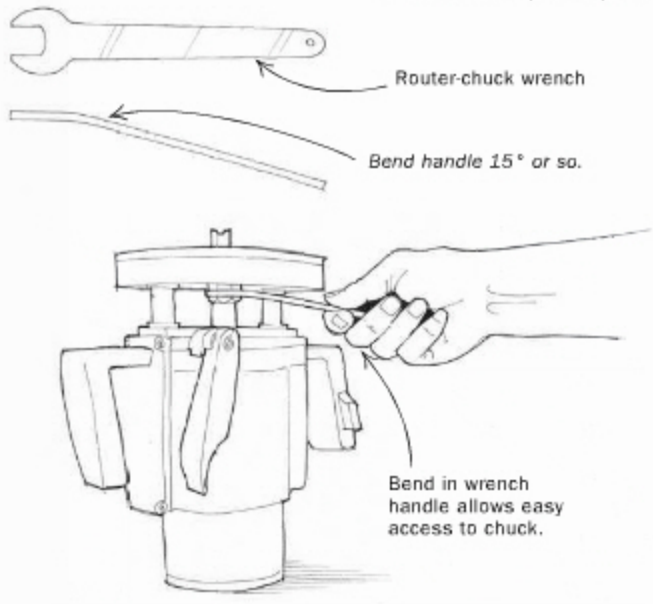
Wrap a strip of hook-and-loop fastener (like Velcro), with a self-adhesive backing, around the cord about 2 in. or 3 in. from the plug end. Then wrap the cord around the tool to determine where the strip will come in contact with the tool body and adhere the mating half of the strip at that location. Now you can wrap the cord around the tool and press the hook-and-loop strips together to fasten the cord. No knots, loops, or unraveling cords get in the way when you need to store or transport the tool.

—LEONARD FELDBERG, Chestnut Ridge, N.Y.

Improved router-chuck wrench

That cheap chuck wrench that comes with your router is an awkward knuckle-banger to use. A low-cost, low-tech remedy to this problem is to clamp the jaw end of the wrench in your vise and bend the handle about 15°. This should angle the wrench just about right to reach in through the opening in the router base.

—FRED TABSHEY, Omaha, Neb.



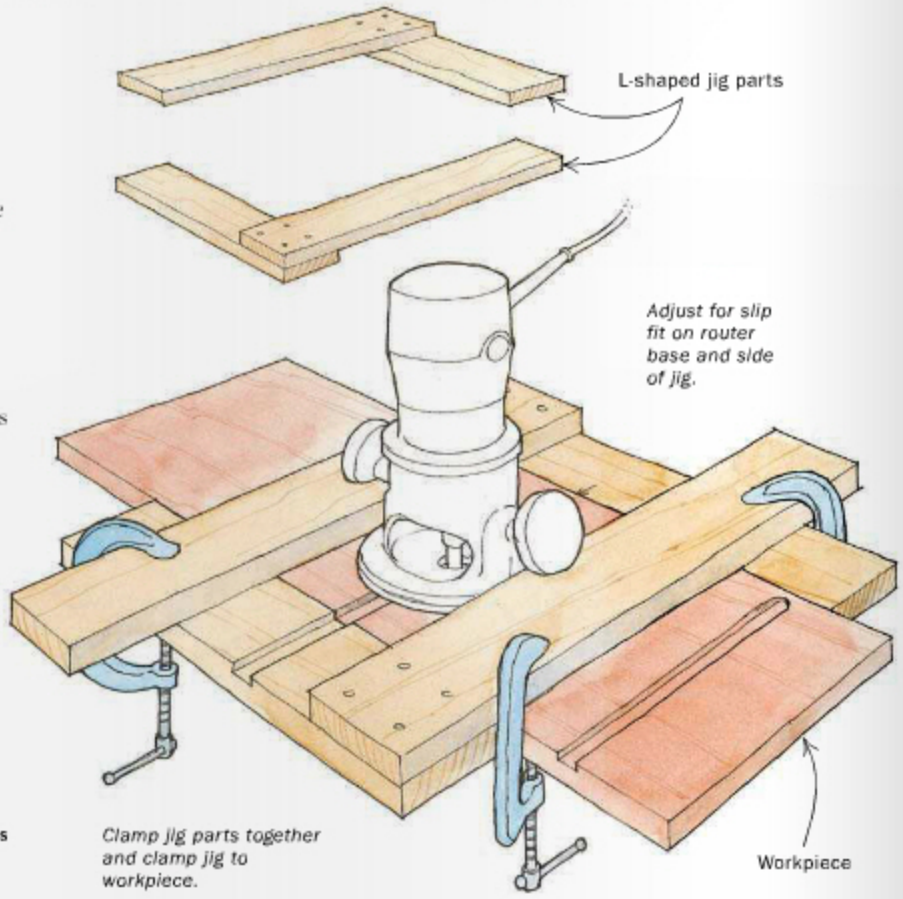
Jig for cross-grain routing

The concept is simple, but this jig is indispensable for routing dadoes in carcase sides, especially when several dadoes are to be made in one board. Once the jig is clamped together, you can slide it quickly into position for the next cut.

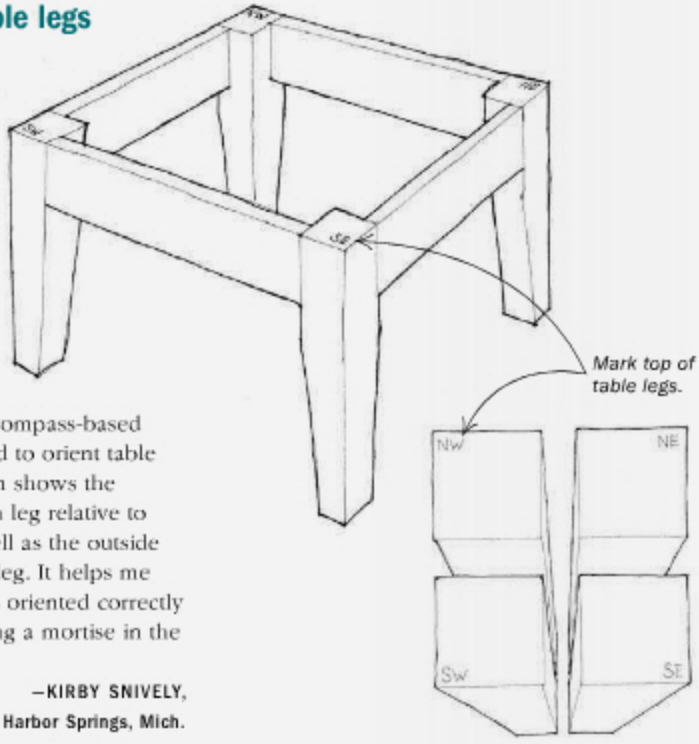
Make up two L-shaped pieces with 4-in.-wide plywood strips. Cut the shorter pieces of the L 16 in. to 18 in. long (router base plus 8 in. to 10 in.) and the longer pieces 20 in. to 30 in. long (widest carcase plus 8 in.). Face-glue and screw the pieces together, taking care to maintain a 90° angle.

To use, place one of the L-shaped parts on the front edge of the board to be routed and one on the back edge so that the two L's form a woven rectangle. Adjust both directions to give a slip fit against the router base and against the sides of the board. Then clamp the intersections of the two L's. Pencil an index mark on both sides of the jig to simplify lining up for a cut. Clamp the jig to the board before routing the dado.

—ROGER DEATHERAGE, Houston, Texas



Marking table legs



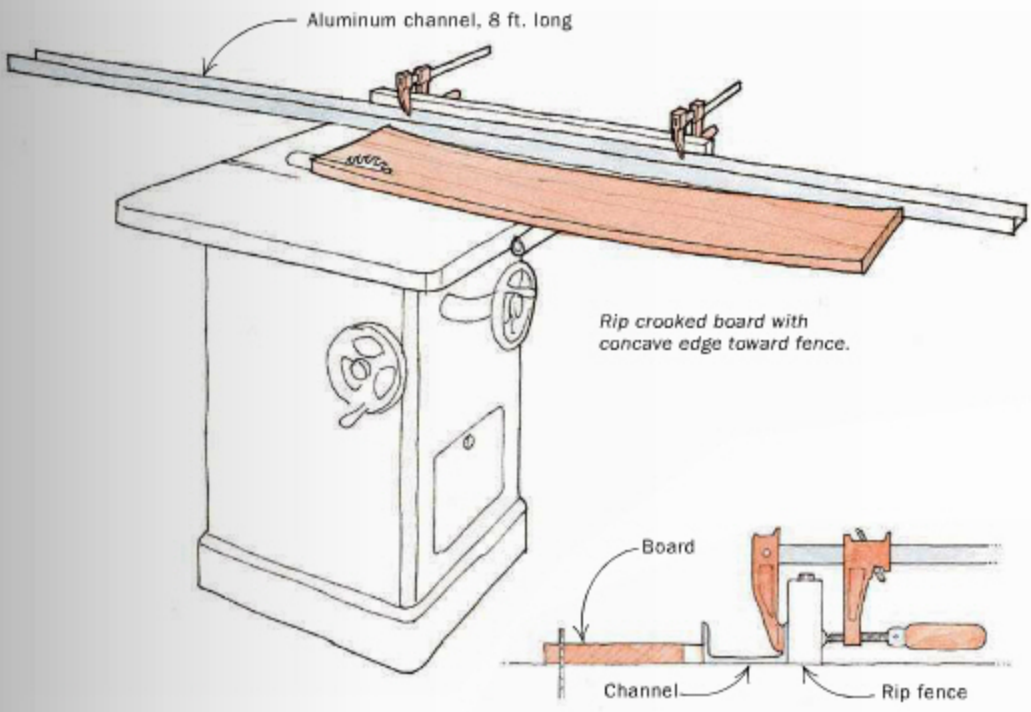
I use a simple compass-based marking method to orient table legs. The system shows the position of each leg relative to the other, as well as the outside corner of each leg. It helps me keep the pieces oriented correctly and avoid cutting a mortise in the wrong side.

—KIRBY SNIVELY, Harbor Springs, Mich.

Quick Tip

To protect my hands around the shop, I use inexpensive latex examination gloves, available by the box from wholesale supply stores (such as Sam's Club). The tight-fitting gloves are sensitive enough to use when operating machinery but strong enough to protect from splinters when handling rough lumber. They are surprisingly durable. As a bonus, the gloves leave my hands in dramatically improved condition at the end of the day, reducing the need for moisturizers and rehabilitation.

—LAWRENCE A. SALIBRA II, Gates Mills, Ohio



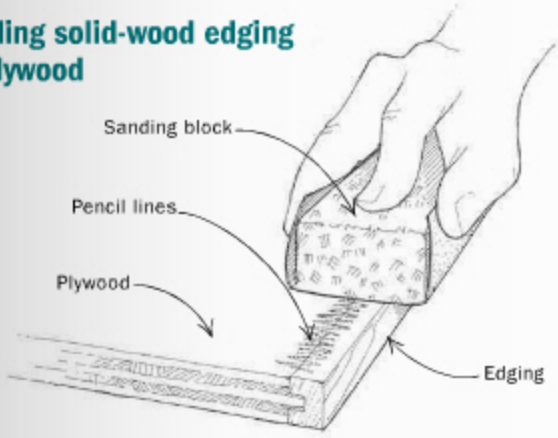
Extension fence helps straighten crooked stock

I put off building one of those carriage fixtures for straightening crooked-edged boards on the tablesaw for several years. The fixtures require expensive hold-down clamps, and they reduce the possible depth of cut by holding the workpiece off the saw table. The real problem was that the length of the regular rip fence is too short.

Then I noticed an 8-ft.-long piece of aluminum channel leaning in the corner of my shop. I clamped the channel to the rip fence to produce an auxiliary fence that would guide fairly long stock in a straight line. To use the auxiliary fence, I just put the concave side of the board against the long fence and push it through. It works.

—WILLIAM MONDT, San Diego, Calif.

Sanding solid-wood edging on plywood



When applying solid-wood edging to plywood, I cut the edging a little wider than the thickness of the plywood. Once the edging has been applied, it sits slightly proud on both sides of the plywood. That allows me to sand the edging perfectly flush.

When sanding, however, it's easy to inadvertently cut through the thin plywood veneer. To avoid the problem, I scribble pencil lines across the edging and veneer. Then, while sanding, I watch the pencil lines. When the lines on the veneer side begin to disappear, I know the edging is flush. Any sanding beyond that point is done very cautiously.

—ERIC L. MYNTER, Remsen, N.Y.

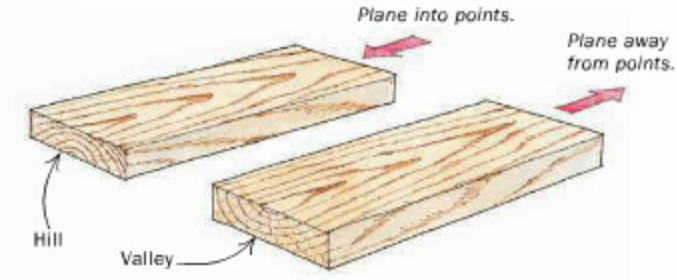
Determining grain direction for handplaning

When handplaning boards, it is sometimes hard to know which direction to choose to avoid tearing out the wood. Checking the grain on the side of the board is a help, but that does not always tell the whole story. Here is another method that works well.

Look at the end grain of the board. With flatsawn lumber you get one of two patterns: hills or valleys. Then look at the surface of the wood to see where the grain forms rounded points (called cathedrals). If the end grain is a hill, plane into the points. If the end grain is a valley, plane away from the points.

To help me remember, I think of an imaginary battle where a band of warriors charges up the hill and into the points of their enemy. The warriors retreat and run back into the valley with the enemy's points at their backs.

—BILLY KING, Oldhams, Va.



A starting kit for finishing

BY MARK SCHOFIELD

Many woodworkers lavish attention on their woodworking tools but don't give much thought to their finishing supplies. With that in mind, I asked four finishing experts—professional finishers Jeff Jewitt, Peter Gedrys and Teri Masaschi, and consulting editor Chris Minick—what they recommend as a basic finishing kit.

POWER SANDING

You'll need a 5-in. or 6-in. random-orbit sander with some form of dust collection. Go with a hook-and-loop attachment system.

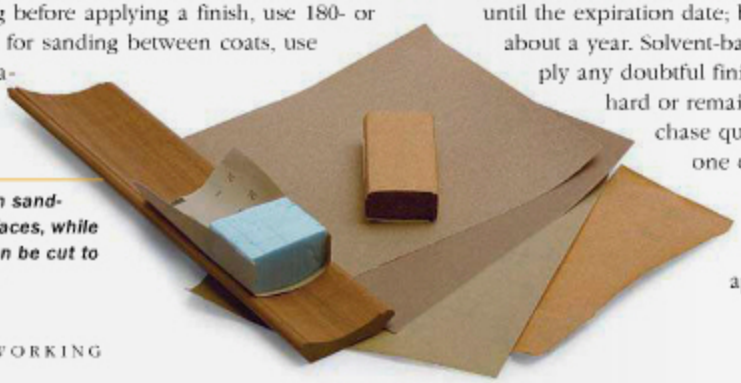
Start with surface preparation

There was unanimous recommendation to buy a random-orbit sander, either a 5-in. or 6-in. model. Whatever model you pick, make sure it has an option for dust collection.

You'll also need a supply of disks with grits of 100, 120, 150, 180, and 220. You may be tempted to purchase a sander that accepts pressure-sensitive adhesive (PSA) disks because they are cheaper than hook-and-loop disks. Don't: It is a false economy for most amateurs, because the disks usually can't be reused once removed from the pad. Unless you are sanding huge projects, you will find yourself moving up to the next grit with half the life still left on the disk you just used.

Hand-sanding is inevitable—Not only will you need to hand-sand small areas and molding, but you'll have to hand-sand between coats of finish. A cork or felt block helps you maintain a flat surface while sanding, and it saves your fingers. An alternative suggested by Minick is to use 1½-in.- or 2-in.-thick rigid foam insulation, usually colored blue or pink. A benefit of the foam is that it can be sawn to match contours. You'll often find scraps in construction-site trash containers.

For the final sanding before applying a finish, use 180- or 220-grit garnet paper; for sanding between coats, use aluminum-oxide paper in grits of 220, 320, and 400. Make sure the paper you use is stearated, or nonloading; otherwise, the finish will clog the paper quickly.



HAND-SANDING

A cork block wrapped in sandpaper helps flatten surfaces, while rigid foam insulation can be cut to match molding profiles.

Don't be afraid of dyeing

Some may question why beginning finishers should dye or stain their work. All four experts say that adding color to some woods is such an integral part of finishing that it should be learned early on.

Gedrys favors water-based dyes for their light-fastness, arguing that it is very little extra work to raise the grain prior to the final sanding. The others say premixed non-grain-raising (NGR) dyes, such as those made by Solar-Lux, are easier to use and compatible with all clear finishes.

ADDING COLOR

Dye concentrates are the most flexible way to add color. Non-grain-raising dyes are easiest to use, and water-based dye powders are cheapest.

These are the first half-dozen colors that you will need in a basic finishing kit:

1. Green—to kill the salmon pink color often found in mahogany and to tone down the overly red color of many cherry stains
2. Medium yellow—the first dye applied to a piece to unify the color tone of different boards
3. Medium brown—to lower the brightness of a stain and make it look more natural
4. Dark brown such as mission brown
5. Reddish cherry brown
6. Black—in most dyes this is actually a very dark blue and will cool down other colors.

You'll need a few clear finishes

Unlike fine wines, finishes don't age well, so don't let dozens of cans gather dust in your shop. Shop-mixed shellac has a shelf life of about six months. Premixed shellac, if unopened, can be used until the expiration date; but once opened, use the finish within about a year. Solvent-based varnishes last about two years. Apply any doubtful finish to a piece of scrap and see if it dries hard or remains sticky. To avoid wasting finish, purchase quarts rather than gallons and start with one of the following three finishes.

Danish oils are easy to apply—For a close-to-the-grain appearance, apply one of the many oil/varnish/sol-

Photos: Mark Schofield

AN ASSORTMENT OF FINISHES

Oil/varnish combinations. *Generally known as Danish oil, these finishes can be applied and wiped off with a rag for a low-luster, open-pore finish.*

Shellac comes in two forms. *Premixed is easier to use but has a limited shelf life. Dry flakes last much longer and come in a variety of colors.*

Tough finishes. *For surfaces subject to frequent contact, alkyd varnish or polyurethane provides a durable finish.*

vent blends known as Danish oil, such as Watco or Waterlox. They require minimal skill to apply and give an acceptable appearance, but on the downside, they provide minimal protection.

Shellac is the most versatile—Shellac is sold in flake form or premixed varieties. It can be used as a barrier coat to seal softwood knots, as a sanding sealer, as a stain controller to minimize blotching, as a layer between incompatible finishes (in its dewaxed form) and as a beautiful finish in its own right.

The best way to start is with Zinsser's SealCoat, which has a slightly orange tone. It is dewaxed and comes as a 2-lb. cut. For best results, dilute it with one part denatured alcohol to two parts SealCoat. For the last coat, cut it to a 1:1 ratio.

Shellac comes in a variety of colors, from almost-clear super blond to dark buttonlac and seedlac that instantly give an aged appearance to a piece. The dry flakes last almost indefinitely.

BRUSHES

From the top: A 3-in. synthetic-bristle brush covers large surfaces. A 1½-in. angled sash brush copes with smaller areas. An artist's wash brush can lay down a final thin coat of finish, leaving almost no brush marks.

Varnish is a durable tabletop finish—Neither Danish oil nor shellac provides sufficient protection for tabletops subject to heavy use. For maximum durability, apply a solvent- or water-based polyurethane varnish. Minick favors Minwax Fast-Drying Polyurethane because it flows nicely off the brush, dries quickly, and does not have the plastic look of many polyurethane varnishes.

If, like Gedrys, you don't like polyurethane, try an alkyd varnish. However, be prepared to thin it with mineral spirits to get the alkyd varnish to flow out evenly from the brush. If you plan to rub out the finish, avoid using spar varnish, which is formulated to remain softer and more flexible to survive outdoor elements.

Buy a quart of denatured alcohol and a quart of mineral spirits to thin the respective finishes and to clean the brushes when you're done.

A good finish needs a good brush

It is best to match the brush to the finish and the project. Synthetic bristles are cheap and easy to clean, and today's synthetic brushes are equal in quality to all but the most expensive natural-bristle brushes. The bristles should be 2½ in. to 3 in. long and taper to a point to facilitate proper flow from the brush and to minimize bubbles in the finish. Buy a 3-in.-wide brush for large, flat areas, and a 1½-in.-wide angled sash brush for detail areas such as legs, moldings, and edges.

If you favor water-based finishes, try a foam brush that costs only a dollar or two. For solvent-based varnishes, you may want to invest in a 2-in. or 3-in. natural-bristle brush, either china (hog) bristle or a more expensive blend of bristles. For applying the final thinned coat of shellac or varnish, Masaschi recommends a brush with Taklon bristles, such as that used for watercolor washes.

Tools for rubbing out the finish

To degloss a finish, it's easiest to rub it out with 0000 steel wool, preferably Liberon's brand, which lasts longer and cuts evenly. To achieve a high-gloss finish, you can use the traditional pumice and rottenstone or the newer Abralon abrasive pads. Start with 500 grit and work your way through 1,000, 2,000, and finally 4,000 grit, using mineral oil as a lubricant.

Applying a good paste wax protects the surface from scratches as well as improves the feel. □

Mark Schofield is a former managing editor at Fine Woodworking.

RUBBING OUT

An easy, low-luster finish. *Rubbing out the finish with good-quality 0000 steel wool lubricated with wax polish yields a smooth, low-luster finish.*

High-tech high gloss. *For a glossy finish, use cushioned abrasive pads starting at 500 grit and moving up to 4,000 grit. Buffing with an automotive compound gives the highest gloss.*

WOODWORKERS MART

glossary

Adjustable clamps—Another name for the modern type of bar clamp where the handscrew end slides up and down the bar.

Aluminum oxide—An aggressive sandpaper or honing-stone abrasive often distinguishable by its light gray color.

Apron—A horizontal member connecting the upper parts of the legs of a table. The aprons also support the tabletop.

Arkansas stone—A fine-grained natural honing stone used to sharpen chisels, plane blades, and other woodworking cutting tools made from steel.

Baltic birch plywood—Formerly a trade name, now used generically for a high-grade birch plywood made of many very thin veneers. Baltic birch is stronger and more stable than other birch plywood.

Bar clamp—Properly any clamp with a bar, including throat clamps and panel clamps.

Bearing surface—The portion of the joint or surface that bears a load.

Bench chisel—A moderately sized chisel on which the back edges are lightly chamfered.

Board foot—A volume of wood equal to 144 cubic inches. The formula for calculating board feet is: [length (inches) x width (inches) x thickness (inches)] ÷ 144. Wood sold in bulk can vary in its dimensions and is therefore sold by volume.

Bow—A type of warp in which a board is not flat along its length but rather bent like a bow.

Brad—A short, thin nail used for light-duty work.

Brad-point drill bit—A drill bit designed for boring holes in wood, featuring a sharp point to prevent skidding over the surface and spurs to start the cut.

Bullnose plane—A plane with a blade close to the front so that it can get into corners.

Burr—The thin wire edge you can feel on the back edge of a blade after honing the bevel.

Cabinet-grade birch—A general-purpose grade of plywood with a knot-free surface, but where the veneers may not match.

Carcase—The structural frame of a cabinet.

C-clamp—A clamp with a fixed head and a handscrew shaped like the letter C.

Chamfer—A beveled edge.

Checks—Longitudinal cracks in the ends of boards caused by drying.

Chopsaw—A powered circular saw mounted on guides with a fence to ensure accurate cuts at any angle.

Chuck—The part of a tool that holds a bit.

Circular saw—A hand power tool with a circular blade used for ripping and crosscutting with guides. Not suitable for cutting curved lines.

Cleat—A piece fastened to or across something to give it strength or hold it in position.

Collet—A device that holds a bit in a chuck by compression.

Combination square—A measuring and layout tool that combines a sliding rule with a base capable of measuring both 45° and 90°.

Common pine—A grade of pine that is structurally sound but that allows for knots. Grade 1 pine has the fewest knots, whereas Grade 5 has the most.

Compound miter saw—A miter saw capable of tilting the blade off the vertical, a critical attribute for cutting crown moldings.

Conditioner-stain (or prestain)—A sealer coat used on hard-to-stain woods. It soaks into the areas of end grain and seals them, making subsequent coats of stain absorb more evenly.

Corner chisel—A chisel with two adjoining faces used for squaring corners.

Counterbore—(n.) The bit used for counterboring a hole. (v.) The act of making a larger-diameter enlargement in the outer end of a hole for accepting a plug or a nut and washer.

Countersink—(n.) The bit used for countersinking a hole. (v.) The act of making a funnel-shaped enlargement in the outer end of a hole for accepting the head of a fastener.

Crook—A type of warp in which a board isn't straight end-to-end along the edge.

Crosscut—A cut across the width of a board.

Cross-grain—Grain that runs perpendicular to the length of a board.

Cup (also cupping)—A condition of a piece of wood in which it is warped across its width.

Dado—A square-bottomed groove running the width of a piece. Properly, a groove runs lengthwise, a dado across the width.

Dimensional lumber—Lumber that has been dried to about 10% moisture content and surfaced on four sides to standard dimensions.

Dye stain—A water- or alcohol-based stain that penetrates the surface of the wood and often enhances the appearance of the grain.

End grain—The open grain showing at the end of a board, and sometimes on the face of the board.

Engineer's square—An all-metal fixed square.

Epoxy—A waterproof glue that can be formulated to meet a variety of needs. Open times are typically short, with the cure time ranging from five minutes to overnight depending on the formulations and conditions. The only glue that forms a strong bridge across gaps.

Face grain—The familiar cathedral grain pattern seen on the face of most flatsawn boards.

Fixed-base router—A router in which the motor and bit are fixed while the bit is turning.

Fixture—A device for supporting work during machining.

Flatsawn—A method of sawing logs by cutting along the length of the boards. This is the most cost-effective way to produce lumber. Also said to be sawn through-and-through.

Forstner bit—A type of drill bit used mostly for larger-diameter holes. Two or three spurs are surrounded by a toothed rim. Forstner bits work well for angled cuts or when part of the bit must be off the workpiece.

Garnet—A soft abrasive best suited for sanding bare wood. It leaves a slightly burnished surface that often results in a lighter, more even color when used before staining.

Gel stains—Stains that are thickened for ease of use on vertical surfaces.

Grain—Generally refers to the direction of cells in a piece of wood. The term also refers to the appearance of this grain, which is distinctive for each species of wood as well as for how the piece was cut from the log.

Groove—A wide kerf running the length of a piece. Properly, a groove runs lengthwise, a dado across the width.

Gullet—The valley between the teeth on a sawblade.

Hand-sanding block—A block of felt, cork, rubber, or wood around which sandpaper is wrapped. A sanding block ensures flatness when sanding.

Hardboard—A very dense homogeneous product made by combining finely milled sawdust with binders and adhesives. This is the material used to make pegboard. Often used for jigs and drawer bottoms.

Hardwood—The wood of deciduous trees, which are those that lose their leaves in autumn.

Hatch marks—Straight or squiggly lines drawn on a workpiece to show where the parts of a joint overlap. It's an informal marking, intended to delineate the area where glue will be applied.

Heartwood—The mature wood in a tree between the pith in the center and the sapwood near the edges.

Hollow-grind—A concave profile on the bevel of a chisel or plane blade, usually created when the bevel is ground on a bench grinder.

Honing—The part of the sharpening process where a blade's bevel is abraded with ever finer abrasives at a set angle (most often 30°) to make it level, flat, and smooth.

India stone—A honing stone made from aluminum oxide grits.

Iron—The blade of a handplane.

Jacking—A condition that occurs in a screw-fastened joint when the threads grip the upper piece and force the two pieces apart as the screw is driven. Can be prevented by boring a properly sized pilot hole in the upper piece.

Jig—A device used to maintain parts in the correct position during cutting or assembly.

Jigsaw—A hand power tool with a reciprocating blade used for cutting curves.

Joinery—The process of joining pieces of wood together; the word embraces many methods.

Jointer—A stationary power tool with a rotating cutterhead set between two tables. Jointers are used to flatten and straighten the face of a board, or make an edge square to the face.

Kerf—The groove left by a saw. Sometimes refers to the material removed in making the groove.

glossary continued

Kickback—When a piece of wood binds on a tablesaw blade, and the speed and power of the blade launches the wood back at the operator with potentially lethal force.

Kiln—A chamber for drying wood using a complex interplay of heat, steam, and sometimes vacuum.

Lag screw—A long, large-diameter coarse screw with a hex head.

Light-fastness—The ability of a product to resist a change in color when exposed to light.

Long grain—Grain that runs parallel to the length of a board.

Marking gauge—A hand tool with a narrow fence and a short pin used to mark layout lines on a board.

MDF—Medium-density fiberboard, made by combining finely milled sawdust with binders and adhesives. Sold in 4x8-ft. sheets like plywood, MDF is strong, heavy, stable, and easy to machine and paint.

MDO—Medium-density overlay, a type of plywood with a tough, smooth coating. Also called signboard.

Micro-bevel—A secondary, narrow bevel applied to the cutting edge of a plane blade or chisel.

Miter—An angled cut. Usually refers to a 45° angle, but the usage is not limited to that.

Miter box—A device for guiding a handsaw for making square crosscuts or angled miter cuts.

Miter saw—An electric saw that swivels on a base used for making square crosscuts and angle cuts at virtually any angle from 0° to about 50° (depending on the brand).

Mortise gauge—A hand tool with a narrow fence and two short adjustable pins used to mark the sides of a mortise.

Nibs—A slight roughness left on the surface of paint, varnish, shellac, and similar coatings that can be removed by a light sanding.

Oil finish—In woodworking this usually refers to boiled linseed or tung oil. Takes a long time to dry but enhances the grain.

Oil/wax finish—A very old recipe that combines oils, beeswax, and some dryers. Imparts a soft patina.

Panel clamp—A clamp used for joining wide panels. The work rests on the bars to keep the bottom side flat, while the narrow-throated jaws grip the edges of the panel. Sometimes called a sash clamp.

Pigment stain—An oil- or water-based stain that colors the wood by applying a light film of pigment on the surface.

Pilot hole—A small-diameter hole used to guide a screw or larger drill. When used in reference to screws, it refers to a hole as long as the screw with a slightly smaller diameter.

Pipe clamp—A type of clamp made up of removable head and screw mechanisms mounted on standard black iron pipe.

Pith—The center of a tree. Generally this wood is not desirable for woodworking.

Planer—A stationary power tool with a flat table and a rotating cutterhead to remove wood from the top of a board until it reaches the desired thickness.

Plug—Also called bung. A round, tapered cylinder of wood set into a counterbored hole and cut flush. When installed properly, a plug is virtually invisible. Proper plugs are made with face grain showing at the top.

Plunge-base router—A router that is designed to be raised and lowered into position while the bit is turning.

Ply—A layer of veneer in a plywood panel.

Pocket hole—A long, angled hole bored in the face of a board near the edge that nearly pierces the side of the board.

Pocket-hole jig—A tool used to drill the angled holes needed for pocket-hole joinery.

Polyurethane adhesive—A waterproof adhesive that cures in the presence of moisture.

Quartersawn—A method of sawing logs that involves rotating the log to yield the maximum amount of clear, straight, dimensionally stable lumber.

Rabbet—A groove cut in the edge of a board, which leaves a shoulder.

Rabbet plane—A plane with a blade that extends to the edge of the sole, a feature particularly useful when cutting or trimming rabbets.

Rack—(v.) To be forced out of square and into a parallelogram shape.

Radiused—A rounded surface. Usually used in reference to corners and edges.

Rail—The horizontal part of a frame.

Ray fleck—The peculiar grain structure shown in quartersawn lumber caused by the sectioning of storage pockets in the grain. The degree of flecking varies from species to species.

Resaw—The process of ripping a board (on a handsaw or tablesaw) to make it thinner.

Riftsawn—A board that shows the growth rings on the end grain as lines running about 45° off the vertical.

Rip—A cut made the length of a board, parallel to the run of the grain.

Root diameter—The diameter of the core of a threaded object, such as a screw or drill bit.

S2S—Boards that are surfaced on two sides but where the edges are not necessarily machined.

S4S—Boards that are surfaced on four sides, usually as dimensioned lumber, but can refer to lumber machined to any specified dimension.

Sapwood—The younger wood near the bark of the tree. In many species this wood is a different color than the heartwood and is less stable.

Select pine—A grade of pine that is nearly clear, allowing for only a few pin knots.

Shank—The unthreaded portion of a wood screw just below the head. Also, the portion of a router bit or drill bit that fits into a chuck.

Shellac—A film finish that uses alcohol as a solvent. Very good as a sealer coat because it sticks to most finishes.

Shop birch—An economy-grade birch plywood with no voids in the core but which may have knots or other defects in the face. Used around the shop for jigs, fixtures, and enclosures.

Side grain—Straight, even grain running along the edge of a flatsawn board.

Silicon carbide—A very aggressive sandpaper abrasive intended for use on finished surfaces.

Softwood—The wood of conifers.

Sole—The bottom of a plane; its plane of reference.

Splitter—A piece of shaped wood or metal that sits behind the tablesaw blade to prevent kickback by keeping the wood from binding on the blade.

Square-drive screw—A screw-head design with a square recess for the screw driver.

Stain conditioner—A thin coat of sealer or a specially formulated product that inhibits stain penetration to reduce blotchiness in hard-to-stain woods.

Stickering—A method of stacking wood that keeps air circulating around all sides. Rather than piling one board atop another, several pieces of wood about 1 in. high rest between each layer to allow air to circulate.

Stickers—Small pieces of wood placed between layers in a stack of wood to provide space for air to circulate.

Stile—The vertical member of a frame.

Stop block—A square piece of wood clamped in place to set the length of a piece to be sawn.

Stop collar—A ring that fastens in place around a drill bit or countersink to control the depth of cut.

Stretcher—A structural member between the legs of a chair or table.

Structural lumber—Lumber used in the building trades, such as softwood 2x4s.

Throat clamp—A type of clamp where the head and screw are at least 4 in. or so from the bar.

Throat plate—The removable insert around a tablesaw with a slot for the sawblade.

Tung oil—Natural oil made from the seeds of the tung tree. Slow drying but flexible.

Twist—A defect in a board in which the ends of the board are not in the same plane.

Varnish—A durable, thick film finish made of oils and resins; mineral spirits or turpentines are the solvents.

Veneer—A thin slice of decorative wood glued to the surface of a stable but less attractive substrate. Also, the thin layers of wood laid up into plywood.

Veneer core—A type of decorative plywood with a core made up of thin veneers.

Warp—Any deviation from flatness or straightness of a board; it includes bow, crook, cup, and twist.

Wet sanding—Sanding with special sandpaper (or synthetic steel wool) soaked in water. Rather than making dust, wet sanding makes slurry. If you wipe down or hose off the slurry before it dries in place, you get a smooth finish with less mess.

Yellow glue—A commonly used wood glue, requiring close-fitting joints and firm clamping pressure. □

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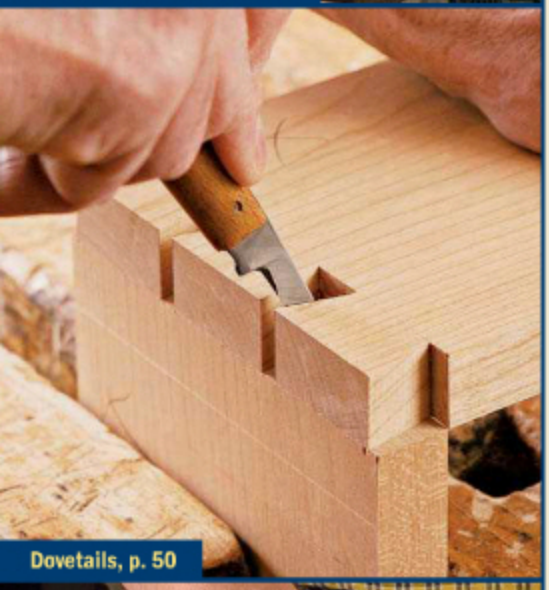

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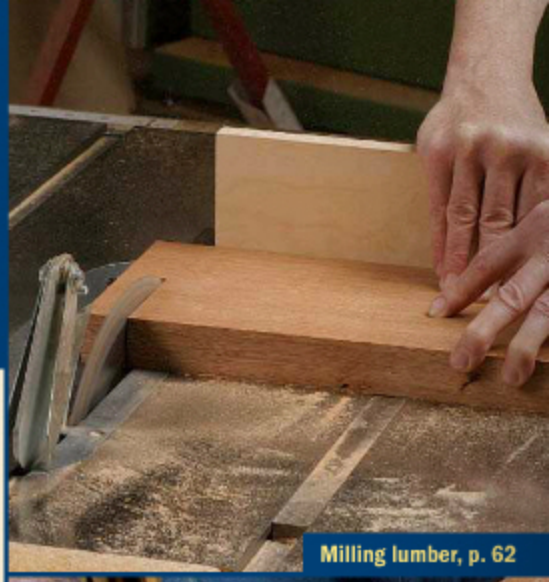

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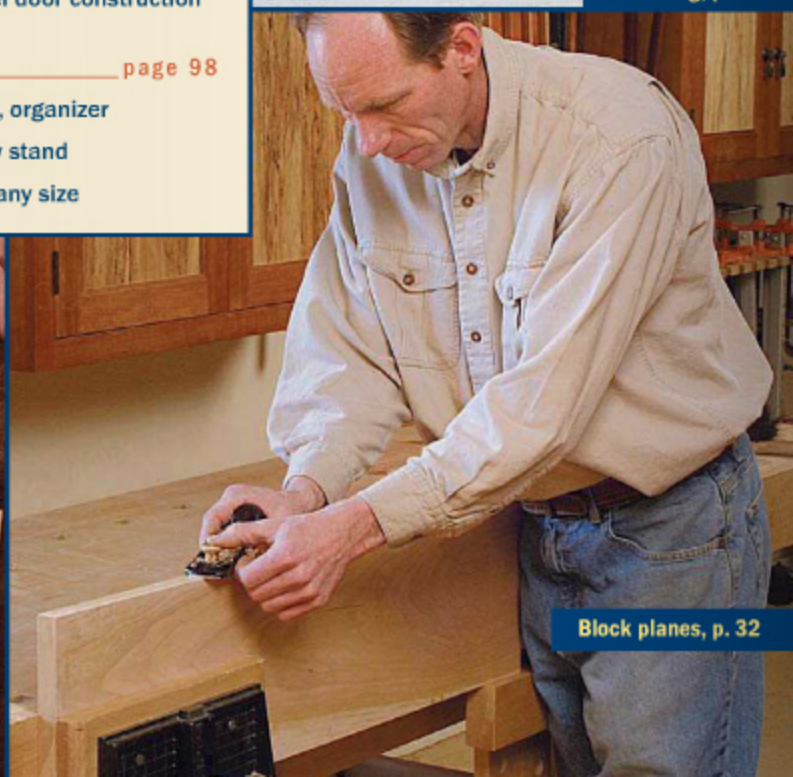

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