5 FIXES FOR COMMON FINISHING PROBLEMS

Build Michael Dunbar's Shop Stool

POPULAR Woodworking

Learn How. Discover Why. Build Better.

OCTOBER 2009 #178

NEW BENCHTOP TABLE SAWS
Are They Ready For Joinery?

Heirloom BIBLE BOX

TOOTHING PLANES
The Easy Way to Tackle Tear-out

Make it Stick THE RIGHT WAY TO USE GLUE

popularwoodworking.com

fw media

US $5.99

10

0 74470 01355 6

Display until October 5, 2009

POPULAR Woodworking
Learn How. Discover Why. Build Better.

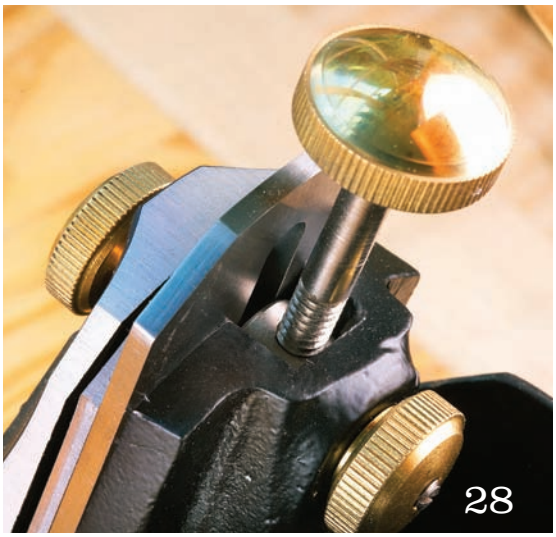
OCTOBER 2009

Features

Number 178, October 2009. *Popular Woodworking* (ISSN 0884-8823, USPS 752-250) is published 7 times a year in February, April, June, August, October, November and December by F+W Media, Inc. Editorial and advertising offices are located at 4700 E. Galbraith Road, Cincinnati, Ohio 45236; tel.: 513-531-2222. Unsolicited manuscripts, photographs and artwork should include ample postage on a self-addressed, stamped envelope (SASE); otherwise they will not be returned. Subscription rates: A year's subscription (7 issues) is $19.96; outside of the U.S. add $7/year ▪ Canada Publications Mail Agreement No. 40025316. Canadian return address: 2835 Kew Drive, Windsor, ON N8T 3B7 ▪ Periodicals postage paid at Cincinnati, Ohio, and additional mailing offices. Postmaster: Send all address changes to *Popular Woodworking*, P.O. Box 420235, Palm Coast, FL 32142-0235 Canada GST Reg. # R122594716 ▪ Produced and printed in the U.S.A.

OCTOBER 2009

Regulars



ON THE OCTOBER COVER

Benchtop table saws have come a long way in the last few years – the big upgrade is a riving knife. Find out why one might be useful in your shop. Page 32.

COVER PHOTO BY AL PARRISH

OCTOBER 2009
ONLINE

New This Month:

All About Glue: Part 2

There's more to gluing than simply slathering on the sticky stuff. In this issue (page 50), Marc Adams writes about how to choose the best glue for the job and more. Plus, you can download a free pdf of Marc's tips for successful glue-ups in every situation.
popularwoodworking.com/oct09

popularwoodworking.com

- Contact Customer Service
  popularwoodworking.com/customer service
- Free Project Plans
  popularwoodworking.com/projects
- Article Index
  popularwoodworking.com/articleindex
- Tool Reviews
  popularwoodworking.com/tools
- Editor Blogs
  popularwoodworking.com/blogs
- Writer's Guidelines
  popularwoodworking.com/writersguidelines
- Contact the Staff
  popularwoodworking.com/contactus

Video Gallery

Breadboard Ends

Breadboard ends are a traditional method of keeping large panels (such as tabletops and chest lids) flat. But, you don't need to use traditional methods to make them. Senior Editor Glen D. Huey shows you how to easily make great-looking breadboard ends using a router, one bit and a few scraps of wood.
popularwoodworking.com/video

Making Sandpaper

Take a behind-the-scenes tour of Ali Industries and get a look at the manufacturing process of sandpaper. The electrostatic process that pulls the grit onto the paper looks like magic – very cool.
popularwoodworking.com/video

Contest

Enter to Win an Apollo HVLP System

You could win an Apollo Precision Series HVLP Turbine (model 1040VR), complete with an Atomizer 7500 spray gun, just by reading a couple paragraphs then answering a few questions. One lucky winner will be chosen at random from all the correct entries. Visit popularwoodworking.com/apollo and enter now – but hurry – the contest ends at midnight on September 30, 2009.
popularwoodworking.com/apollo

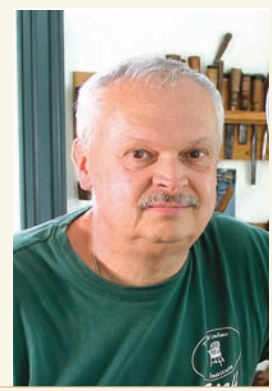
And More!

Visit popularwoodworking.com/oct09 to find a complete list of all the online resources for this issue – including videos, additional drawings and photos.

Contributors

Deneb Puchalski has been working with wood for more than 25 years as a carpenter, boatbuilder and furniture maker. His first exposure to woodworking was in his father's boatbuilding school when he was a child; later Deneb built houses in Alaska and spent summers in salmon fishing boats just off the Alaskan coast in the Bering Sea. Deneb got back into boatbuilding because he enjoyed the challenge of "nothing flat or straight," and after moving to Florida worked on a replica pirate ship that still sails off St. Petersburg and Clearwater. Then, Deneb gravitated to furniture building, which for him held the appeal of a condensed process rather than the years or months it takes to build a house or boat. To hone his skills, he attended the Center for Furniture Craftsmanship in Rockport, Maine, where he later served as artist in residence. Now, Deneb teaches at Lie-Nielsen events throughout the United States, as well as at woodworking schools. You can also find him teaching online on Lie-Nielsen's YouTube channel (youtube.com/user/LieNielsen).

In his first article for *Popular Woodworking*, Deneb writes about toothing planes, which can help make even the gnarliest woods behave (page 46).



Michael Dunbar has been a chairmaker since 1971, and has written seven woodworking books and authored countless magazine articles. In 1980, he and his wife, Sue Dunbar, founded The Windsor Institute, a New Hampshire-based school that teaches all things Windsor (thewindsorinstitute.com). Most recently, Mike has been writing a series of adventure novels for middle school-aged readers and is actively looking for an agent and publisher.

In this issue, Mike writes about making a Windsor shop stool. The story begins on page 39.

Glen D. Huey This issue marks Senior Editor Glen D. Huey's three-year anniversary as a full-time staff member of *Popular Woodworking* (and *Woodworking Magazine*). For this issue, he wrote the cover story on benchtop table saws (page 32) as well as an article on making a simple inlaid Bible box (page 56). And, Glen has a new furniture book coming out at the end of October from Popular Woodworking Books: "Building 18th-century American Furniture." Inside, you'll find plans and step-by-step instructions for making some of Glen's best period work – 20 projects in all. Look for "Building 18th-century American Furniture" (at the end of October) at Woodworkers BookShop.com.

Popular Woodworking®
Learn How. Discover Why. Build Better.

OCTOBER 2009, VOL. 29, NO. 178
popularwoodworking.com
EDITORIAL OFFICES 513-531-2690

PUBLISHER & GROUP EDITORIAL DIRECTOR Steve Shanesy
EDITOR Christopher Schwarz
x11407 ■ chris.schwarz@fwmedia.com
ART DIRECTOR Linda Watts
x11396 ■ linda.watts@fwmedia.com
SENIOR EDITOR Robert W. Lang
x11327 ■ robert.lang@fwmedia.com
SENIOR EDITOR Glen D. Huey
x11293 ■ glen.huey@fwmedia.com
MANAGING EDITOR Megan Fitzpatrick
x11348 ■ megan.fitzpatrick@fwmedia.com
ASSOCIATE EDITOR FOR THE WEB Drew DePenning
x11008 ■ drew.depenning@fwmedia.com
PHOTOGRAPHER Al Parrish
CONTRIBUTING EDITORS
Adam Cherubini, Bob Flexner, Troy Sexton

F+W MEDIA, INC.
CHAIRMAN & CEO David Nussbaum
CFO James Ogle
PRESIDENT Sara E. Domville
SENIOR VP, MANUFACTURING & PRODUCTION Phil Graham
EXECUTIVE VP, eMEDIA John Lerner
VICE PRESIDENT IT, CIO Mike Kuehn
CONFERENCE DIRECTOR Sara Dumford
CIRCULATION DIRECTOR Linda Engel
NEWSSTAND DIRECTOR Susan Rose
PRODUCTION COORDINATOR Vicki Whitford

ADVERTISING
ADVERTISING DIRECTOR
Don Schroder
331 N. Arch St., Allentown, PA 18104
TEL. 610-821-4425; FAX 610-821-7884
d.schroder@verizon.net

DISPLAY & CLASSIFIED ADVERTISING SALES COORDINATOR
Krista Morel
TEL. 513-531-2690 x11311
krista.morel@fwmedia.com

SUBSCRIPTION SERVICES: Subscription inquiries, orders and address changes can be made at popularwoodworking.com (click on "Customer Service"). Or by mail: *Popular Woodworking*, P.O. Box 420235, Palm Coast, FL 32142-0235. Or call 386-246-3369. Include your address with all inquiries. Allow 6 to 8 weeks for delivery.

NEWSSTAND DISTRIBUTION: Curtis Circulation Co., 730 River Road, New Milford, NJ 07646

ATTENTION RETAILERS: To carry *Popular Woodworking* in your store, call 800-894-4656 or write Magazine Retail Sales, P.O. Box 5014, Iola, WI 54945-5014.

BACK ISSUES are available. Call 800-258-0929 for pricing or visit popularwoodworking.com. Send check or money order to: *Popular Woodworking* Back Issues, F+W Media Products, 700 E. State St., Iola, WI 54990. Please specify publication, month and year.

by Christopher Schwarz, editor

Don't Do the Math

Nearly every woodworking book tells you the wrong way to purchase wood.

There's a formula where you multiply the width, length and thickness of each part in your project and divide the result by 144. Then add 15 to 20 percent for waste, order the surfaced wood and start cutting.

I can't think of a more stressful way to buy wood for a home woodworking project. And not because I dislike math. I like math OK. But math here is not your friend.

The few times I've ordered wood this way, the results were frustrating. Even if I got a load of quality stock, I never got the widths I needed. I never got the grain patterns that were suitable. And the defects were always in the wrong place.

So I'd order more wood to fill in the holes in my cutting list. It was an expensive and slow way to work.

At the other end of the perspective is James Krenov. In his books, Krenov details how he maintains a stash of planks that he sorts through when preparing for a project. He waits for the right board to call out to him and declare how it should be used in a finished piece of furniture.

I fall somewhere in between. I don't hear voices, and I don't run the numbers.

When building one project, I go to the lumberyard and pick through the stock myself. I take my cutting list and a tape measure and pick through every pile.

I've learned to read boards while they are in their rough state. Not only are boards in the rough less expensive, but they're less likely to be warped than surfaced stock. That's because no matter how nice the lumberyard's planing equipment is, stock that has been surfaced is almost certainly cupped and perhaps twisted. This warping can happen because the machines were used improperly, the wood wasn't completely dry – or both. If you buy it surfaced, you're going to have to flatten it again.

And all this above is why I can be a difficult person when a reader calls to ask: How many board feet should I order for that chest in your magazine? The answer is: I have no idea. You might need 50 board feet. You might need 100.

This is also why I resist offering optimization charts that show all the cuts necessary for the parts on dimensional stock. How often have you seen a piece of perfectly clear dimensional stock? For me it was the last time I saw the tooth fairy playing Scrabble with the Easter bunny.

You need to get closer to your raw material. You need to be fussy at the outset of the construction process. When you do this, two magical things will happen: Your wood will behave predictably because you could pick all quartersawn stock for the rails and stiles. And your projects will look more harmonious because all the parts will relate to one another.

All because you decided not to do the math. **PW**

PHOTO BY THE AUTHOR

Popular Woodworking®
Learn How. Discover Why. Build Better.

Customer Service

How can I contact customer service with questions regarding my subscription, including a lost or damaged issue?
Visit popularwoodworking.com/customerservice. Or write to *Popular Woodworking*, P.O. Box 420235, Palm Coast, FL 32142-0235. Or, if you prefer the telephone, call 386-246-3369 and a customer service representative will be happy to help you.

When does my subscription expire?
The date of your subscription expiration appears on your magazine mailing label, above your name. The date indicates the last issue in your subscription.

Can I get back issues of* Popular Woodworking*?
Back issues are available while supplies last. Visit popularwoodworking.com/backissues. Or if you know the exact month and year of the issue you want, call our customer service department toll-free at 800-258-0929 to order.

What if I want more information about the projects and tools I read about in* Popular Woodworking*?
For all editorial questions, please write to Popular Woodworking Editorial, 4700 E. Galbraith Road, Cincinnati, OH 45236. Or e-mail popwood@fwmedia.com.

Does* Popular Woodworking *offer group discounts?
Group discounts are available by special arrangement with the publisher. For more details, send an e-mail to Debbie Paolello at debbie.paolello@fwmedia.com or call 513-531-2690 x11296.

Our Privacy Promise to You

We make portions of our customer list available to carefully screened companies that offer products and services we believe you may enjoy. If you do not want to receive offers and/or information, please let us know by contacting us at:

List Manager, F+W Media, Inc.
4700 E. Galbraith Road
Cincinnati, OH 45236

Safety Note

Safety is your responsibility. Manufacturers place safety devices on their equipment for a reason. In many photos you see in *Popular Woodworking*, these have been removed to provide clarity. In some cases we'll use an awkward body position so you can better see what's being demonstrated. Don't copy us. Think about each procedure you're going to perform beforehand.

Why You Should Get Really Hammered

I have a question for you regarding Warrington hammers. Looking through the Lee Valley Tools catalog, I can see that there are different types that come in various weights. What weight is appropriate for most cabinet and furniture making? Also, other than the weight, are there any other differences that might make one more desirable than the other?

John Leko
Huntsville, Alabama

A little Warrington (3.5 oz.) is best for adjusting tools and driving (at most) veneer pins.

Slightly bigger hammers (6 oz. and 7 oz.) are good for thin brads, finishing nails and the like. I prefer a bigger hammer (more like 12 oz. to 16 oz.) for driving the nails that are used for carcase construction. (This is speaking, however, as someone with a hammer problem.)

The cross-pane of the Warrington is good for lots of things, especially starting small brads, knocking the sneck on plow planes to remove the iron and anything that requires a gentle controlled tap.

The illustration at right shows three common styles of woodworking hammers. At top is a Warrington with a cross-pane. The one below it is an earlier form of hammer called a "strap hammer." The straps are used to secure the head to the handle. The bottom hammer is the common and modern adze-eye hammer in which the head is wedged to the handle, and the hole through the head has a special shape that keeps the whole thing together.

— Christopher Schwarz, editor

Grinder Jig Defense

Larry Williams' August 2009 letter, "Grinder Tool Rest Jig Flaw" (#177), which was written in response to my "Grinder Jig Tool Rest" article from the April 2009 issue (#175), is absolutely correct in that the tool thickness is a significant factor in setting the tool rest angle. But he overlooked that the taper angle of the chisel and the grinding wheel diameter also figure into the jig design. That these factors were included in my calculations was mentioned in the next-to-last paragraph.

I measured a number of different brands of bench chisels of 1" or less and found them to have similar taper angles of 1.5°, and thicknesses of about 0.15". For these numbers, an 8"-diameter wheel and a desired bevel angle of 25°, the tool rest angle is increased by 1°. I plead guilty to a math typo which caused an error in the published design; the angle in Step 1 should have read "… at bevel angle plus 91°." For a 6" wheel, 2° should be added to the bevel angle.

For those interested in exact angles for making my jig, I offered the detailed analysis, "Hollow Ground Geometry," at the end of the second paragraph. I'd be happy to send this to you via e-mail (contact me at wedlock@alum.mit.edu). Graphs are presented showing the exact correction angle for a variety of bevel angles, thicknesses and wheel diameters. You can then design jigs to exactly match your tool's parameters.

The stability of my jig's arc resting against the grinding wheel allows precise adjustment of the tool rest for regrinding at a future time. Eye-balling is not required; you can't beat geometry and trigonometry for accuracy.

Bruce D. Wedlock, Ph.D.
North Reading, Massachusetts

Clamp Pressure Questions For Benchtop Build

I have questions regarding benchtop lamination.

1) In Christopher Schwarz's book "Workbenches," I noticed that several boards that comprise the rear-most sub-assembly of his benchtop have grain that runs horizontally. The front assemblies are more in a vertical

CONTINUED ON PAGE 14

ILLUSTRATION BY HAYES SHANESY

CONTINUED FROM PAGE 12

quartersawn orientation. My question is: How important is vertical grain orientation in a benchtop? I accidentally purchased a few boards that are more quartersawn, which would become flat-sawn in the lamination.

2) I have read that effective clamp pressure radiates out at a 45° angle on either side of the clamp face. If this is so, your recommended clamping strategy of one to two clamps every foot (no cauls), would not apply even pressure to the joints of the outer boards. A 2" caul would be required at the edge to even out the pressure with one clamp every 6". Should I be worried about this?

3) Lastly, I have also read that the required clamping force for woodworking joints is a function of the joint's surface area and the wood species and grain orientation:

Joint length x height x species (quartersawn or flat-sawn) factor = total clamping pressure required.

If this is true, the joint of a massive Roubo lamination would require a Herculean amount of pressure:

4" x 96" x 150psi (approximation for Southern yellow pine) = 57,600 pounds.

Calculation of number of needed clamps: 57,600 pounds/600 pounds per parallel-jaw clamp = 96 parallel clamps.

This is impractical. However, are benchtop laminations typically way underclamped?

Scott Vanzo
Los Angeles, California

1. I haven't found the quartersawn stragglers to be a problem. I don't find that they stick up or become depressed. Softwoods move so little in service anyway (once they are at equilibrium).

2. One or two clamps every foot does the trick if your mating surfaces are well-prepared. If your surfaces are flat you can get away with even less (though I rarely do). Yes, you want the radiating clamp pressure to overlap across the joint lines. But just because it doesn't overlap in some areas does not mean the joint will open up or fail. That's because that "unclamped" area is co-planar to areas that are clamped. So the mating surfaces are brought close enough to form a bond. Quick historical note: Early joiners used one clamp (or no clamps – it's called a rub joint) for panel glue-ups. A lot of this modern engineering of laminations is overkill.

3. I've seen this formula and it flies in the face of everything I know from my life of woodworking. You do not need that many clamps. Promise! I wish I had an engineering degree to explain why, but I don't. All I have is my work and the historical record.

I hope this helps. And best of luck with your workbench.

— Christopher Schwarz, editor

Dispelling Bubble Myths?

I've read articles where Bob Flexner likes to bust myths about finishing, including "How to Brush a Finish" (December 2008, #173). I've been waiting and waiting to read Bob bust his own myth about bubbles in finish. But time and again I see he still promotes the same incorrect theory: "There's no way to avoid them because they're mostly caused by the turbulence created by the brush movement (the same as underwater bubbles created by the turbulence from a propeller), not by shaking or stirring."

Who puts on a finish coat while whipping their brush like a propeller? Nobody. I see bubbles even if I apply finish with a rag (the first coat or two, anyway). No propeller action there. I even drizzled unshaken finish on wood from a stick, and in each drop, bubbles arise. So saying that bubbles are "caused by the turbulence created by the brush movement (the same as underwater bubbles created by the turbulence from a propeller)" is a myth.

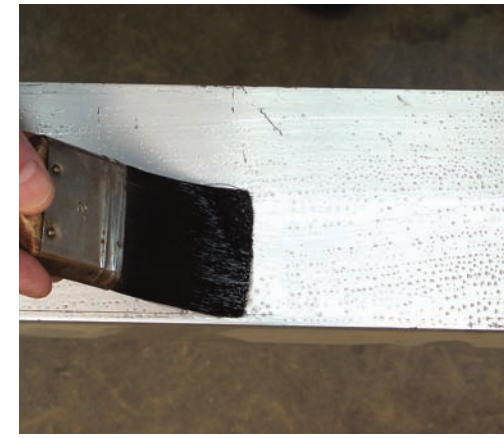
Bubbles must be the air in the wood pores being displaced by a viscous liquid; the displaced air rises through the liquid and as a result, we see bubbles. (It happens with water, too, but the bubbles go immediately to the surface and pop because water isn't viscous.) It is basic physics. It doesn't matter what the finish is or how it is applied; if air is being displaced by a viscous liquid, bubbles will rise.

Bob's theory makes it sound like a side effect of the brush application technique, or an operator error (what else would you call a "propeller effect?"), but it is neither. It is simply what happens when air inside the wood gets displaced by a viscous liquid. And it also is why a thinned finish sealer coat has less chance of trapping bubbles; it is less viscous.

What do you think? Have I burst his myth?

Spence Bloom
via e-mail

My physicist son explained to me the principal cause of bubbles when brushing. It's a physical phenomenon called "cavitation," in this case turbulence caused by the brush movement. Take a look at the photo below of brushing varnish onto an aluminum surface: no pores, no shaking or stirring, and still there are bubbles.



You are right, however, that bubbles can appear above the pores of large-pored woods such as oak due to air displacement.

The one thing I think we agree on is that manufacturers are wrong when they assign the cause to shaking or stirring a finish. That's the myth to which I was referring . **PW**

— Bob Flexner, contributing editor

Question? Comment?
We want to hear from you.

Popular Woodworking welcomes comments from readers about the magazine or woodworking in general, as well as questions on all areas of woodworking. We are more than happy to share our woodworking experience with you by answering your questions or adding some clarity to whatever aspect of the craft you are unsure about, and if you have a complaint, we want to address it whenever possible.

Though we receive a good deal of mail, we try to respond to all correspondence in a prompt manner. Published correspondence may be edited for length or style. All correspondence becomes the property of *Popular Woodworking*.

Send your questions and comments via e-mail to popwood@fwmedia.com, or by mail to:

Letters
Popular Woodworking
4700 E. Galbraith Road
Cincinnati, OH 45236

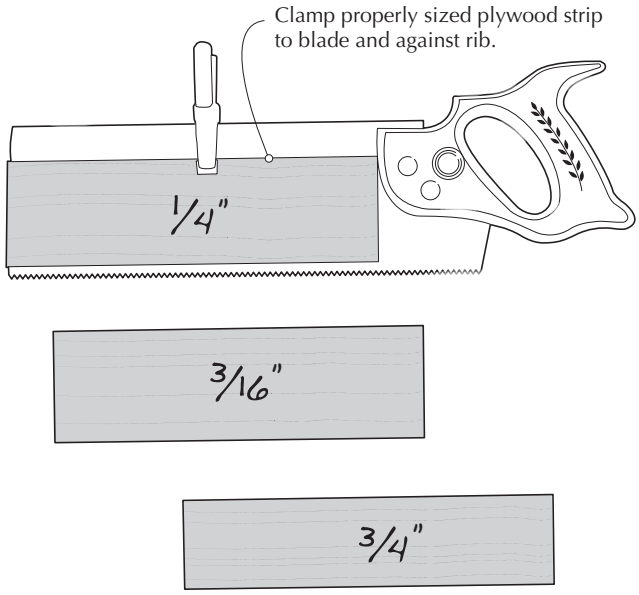
EDITED BY PAUL ANTHONY

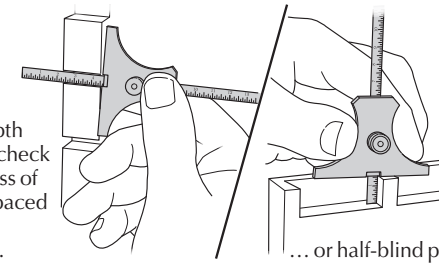
THE WINNER:

Backsaw Depth Limiter

I work almost exclusively with hand tools, and when I need to crosscut the shoulders of a dado or tenon, I have trouble cutting to a consistent depth along the width of the board. To solve the problem, I clamp a strip of 1/4"-thick plywood to the blade, tucked up against the saw's rib. I keep on hand several different widths, sized to establish common cut depths, and it's easy to make new ones when needed.

— Alejandro Balbis,
Longueuil, Quebec





Depth Gauge as Mini-Square

For well-fit hand-cut dovetails, the cheeks of the tails must be perfectly square to the face of the board. Likewise, the cheeks of pins must be square to the ends of the boards. Unfortunately, it can be difficult or impossible to insert a try square into the pin cutout between closely spaced tails. It's also hard to gauge the squareness of a pin cheek inside a half-blind socket with a square. That's where a depth gauge comes in handy.

A depth gauge is a precisely machined tool with a T-head and a narrow sliding blade. Designed for gauging the depth of mortises and other recesses, it also works beautifully as a mini square of sorts. When making dovetails, the blade is narrow enough to insert between tails to gauge the squareness of the cheeks. The blade can also be retracted to check pin cheeks in half-blind sockets by placing the head of the tool on the end of the pin board. When it comes to making perfect dovetails, minute adjustments matter, and this tool will show you where you're off.

— Ric Hanisch, Quakertown, Pennsylvania

CONTINUED ON PAGE 18

Cash and prizes for your tricks and tips!

Each issue we publish useful woodworking tips from our readers. Next issue's winner receives a $250 gift certificate from Lee Valley Tools, good for any item in the catalog or on the web site (leevalley.com). (The tools pictured at right are for illustration only, and are not part of the prize.)

Runners-up each receive a check for $50 to $100. When submitting a trick (either by mail or e-mail) you must include your complete mailing address and a daytime phone number. If your trick is selected for publication, an editor will need to contact you. All entries become the property of *Popular Woodworking*. You can send your trick by e-mail to popwoodtricks@fwmedia.com, or mail it to Tricks of the Trade, *Popular Woodworking*, 4700 E. Galbraith Road, Cincinnati, OH 45236.

ILLUSTRATIONS BY MARY JANE FAVORITE

CONTINUED FROM PAGE 16

Dovetail Starter Notches

At a recent woodworker's meeting, Editor Christopher Schwarz demonstrated a time-honored trick for hand-cutting tenon shoulders. After laying out the joint, he chiseled directly downward onto the shoulder cutline, then made a V-groove by tapping inward from the waste side. This created a channel to guide the saw perfectly for the desired cut.

I decided to try this technique for hand-cut dovetails, and found it worked equally well for starting a cut accurately, which can be the trickiest part of making dovetails. Regardless of whether you're a "tails first" or a "pins first" dovetailer, it's not necessary to do this when cutting the first half of the joint, but it's a smart move when making the mating part. For example, saw your tail board first, use it to trace your pins on the mating piece, then notch the cutlines on the end of the pin board before sawing the pins. It makes starting the cut much easier and ensures that you're on the money.

— Bill Law, Cincinnati, Ohio

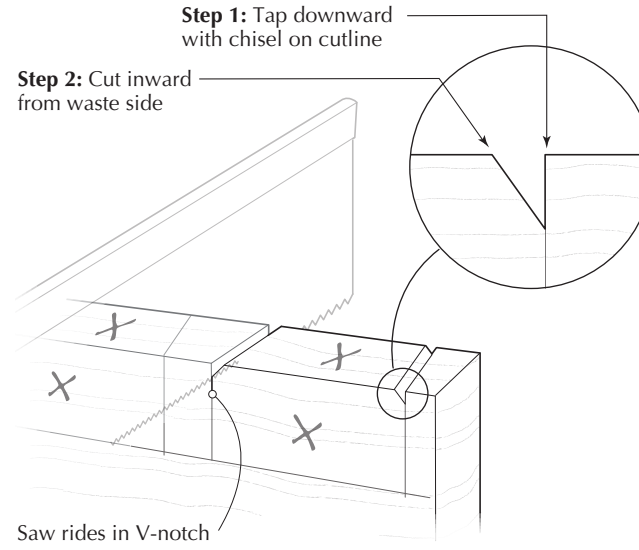


Table Saw Infeed Extension

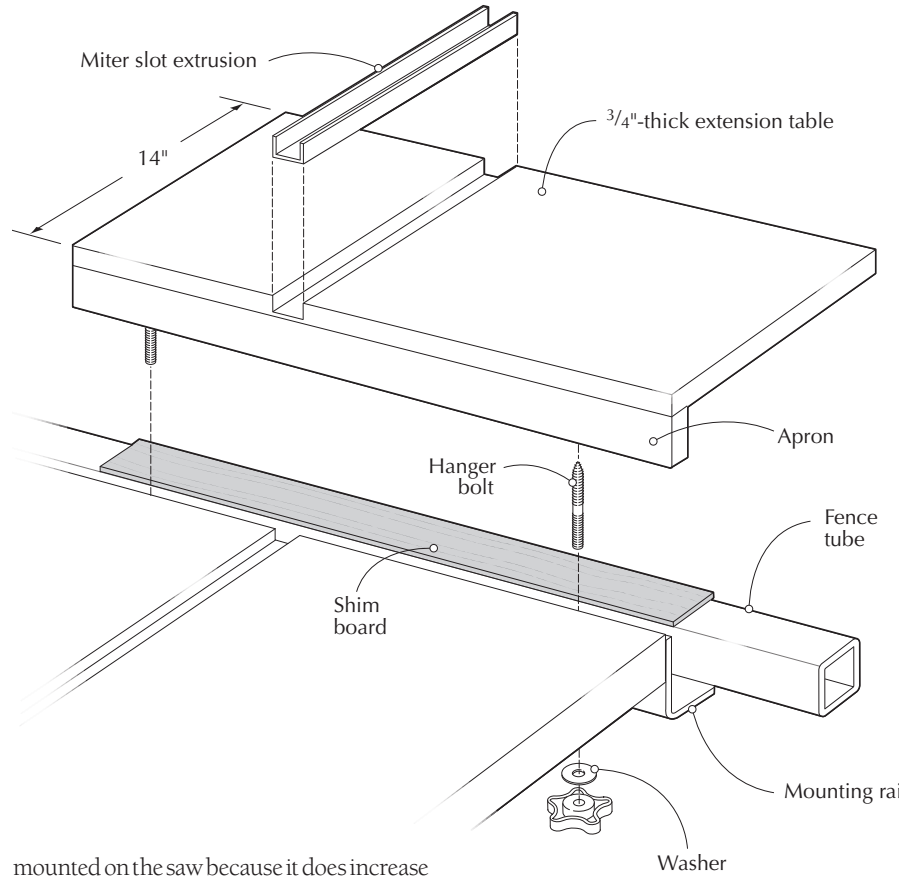
I used to get frustrated cutting angles on wide panels on my table saw. A crosscut sled isn't well suited to that particular job, and a miter gauge is hard to handle when cantilevered off the front of the saw.

I decided to build an infeed extension for my saw that would safely carry and guide my large aftermarket miter gauge, as well as the workpiece. The unit consists of a 3/4" x 14" x 24" MDF panel pocket-screwed to an apron that tucks between my fence tube and its mounting rail. The lower edge of the apron houses two hanger bolts that allow attachment through-holes I drilled in the fence's mounting rail. Knobs on the hanger bolts allow easy attachment and removal, and an miter slot extrusion (available from Lee Valley) let into the panel serves as an extension of the saw table's miter gauge slot.

As the drawing shows, the construction is straightforward, but there are a couple things to keep in mind when building this for your saw. Make sure that the apron height brings the top of the panel level with the saw table. And if the offset between your saw table height and the top of your fence tube is greater than 3/4", apply shims under that section of the extension table.

The unit installs in about a minute, and hangs on the side of the table saw cabinet until needed. I don't leave it regularly mounted on the saw because it does increase the distance between the operator and the blade, inviting dangers caused by overreaching. **PW**

— Steve Sawyer, Livonia, Michigan

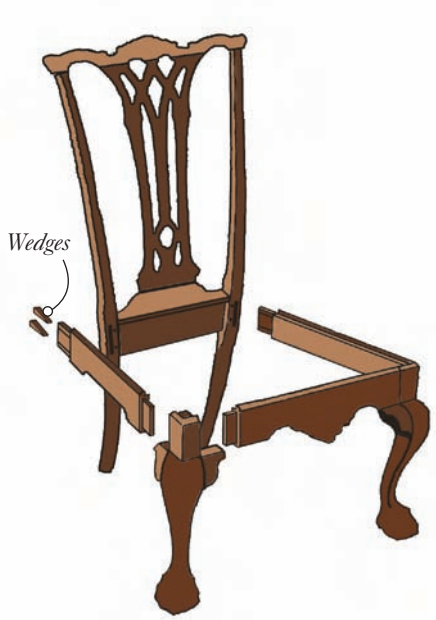


BY ADAM CHERUBINI

Sticking Together

Anatomy of an 18th-century chair glue-up.

Eighteenth-century Philadelphia's iconic Chippendale-style chairs featured unique joinery. Unlike earlier Philadelphia chairs or New England chairs of the same period, Philadelphia Chippendale-style chairs didn't have lower stretchers (joining the legs together beneath the seat support rails) to help support the back. This design choice put a great deal of stress on the seat-rail-to-rear-leg-joint. Typically, furniture forms with structurally inferior joints (such as William & Mary high chests with their spindly turned legs) don't last long. The pieces themselves don't survive and the forms are abandoned by furniture makers and go extinct.



Unique joints. *Philadelphia chairmakers working in the third quarter of the 18th century built chairs without lower stretchers. The highly stressed joints between the seat and the back were unique. Rear tenons extended all the way through the back legs. Tiny wedges, hammered in from the back, ensured a tight fit.*

Traditional fix. *I've had trouble with these joints throughout this series. They have either been the albatross around my neck or my scarlet letter of shame, whichever is worse. Despite my troubles with these loose-fitting tenons, the wedges I'm tapping in are typical of Philadelphia Chippendale-style chairs.*

PHOTOS AND ILLUSTRATIONS BY THE AUTHOR

Despite their inefficiencies of joinery, Philadelphia Chippendale chairs have, in large part, beaten the odds and remained in good condition. The reason for the success of this seemingly marginal furniture form is probably the mixture of careful joint preparation, joints designed to be repaired, and the use of hide glue.

In this article, we'll look in detail at how these chairs were put together. I'm hoping that even if you never intend to build a Chippendale-style chair, this article will get you thinking about what you can do to improve the lifespan of your projects and the quality of your joinery.

Wedged Tenons

Philadelphia Chippendale-style chairs are characterized by their use of through-tenons in the back legs. The increased length of a through-tenon reduces stresses inside the joint, making the joint stronger. But the extra length only helps if the joint is tight. I found cutting these joints a none-too-easy feat of woodworking. A close inspection of period chairs revealed I'm not completely out of my league. Period chairmakers seemed to have wedged their through tenons from the back.

We have reason to believe the wedges were original and intentional (that is, they're not a standard shop repair when tenons weren't prepared as required). The wedges are small; usually 3/16" thick (and as wide as the mortise) but only half the length of the tenon. Typically, the tenons are sawn down to their shoulders 1/4" from the top and bottom to allow for the wedges. Some chairs' tenons were not sawn, rather the wedges were placed above and below the tenons. The difference could be due to whether the side seat rails were pegged or not.

Pegging Judiciously

The rear seat rail tenons were typically pegged. I saw some chairs on which the rear side seat rail tenons (the wedged ones) were also pegged. I saw no chairs with pegs in the front legs. I think the pegs complicate repair. My experience is that they can be difficult to remove. Drilling them out isn't always so easy, especially without modern drills. Where pegs were used, the wedges were placed above and below the tenons to allow for maximum separation of the pegs. I don't know about you, but I get the sense these guys were really thinking about how their choices affected structural integrity, future repairs, etc.

Wedge prep. *Repairs and X-rays done at the Philadelphia Museum of Art indicate 18th-century Philadelphia chairmakers sawed their tenons in preparation for wedges.*

I meant to do that. *The story of this joint stretches back nearly a year to the beginning of this series. The first thing I did was undercut this leg. A hasty repair was a recognition that I was in over my head with this project. As bad as this joint looks, the wedges are actually not repairs.*

Using Hide Glue

Hide glue was used traditionally but it's also the best glue for this job. Mixed and used correctly, hide glue offers as much strength as any modern glue. But it has two unique advantages: Hide glue can be reversed with the application of heat and water. This allows furniture to be repaired more easily.

Second, hot hide glue has a very high stiffness, which allows it to bridge small gaps. Because of this, hide glue (or epoxy) will always be your best bet for sloppy joints. Unlike PVA (yellow and white) glues, hot hide glue doesn't need strong clamp pressure to achieve bond strength. My experience is that it actually prefers the opposite. If a joint is too tight, the hide glue can get pushed out, which starves the joint and consequently reduces its strength.

There are two types of hide glue on the market: hot hide glue, available in dry form that you mix with water then heat, and liquid hide glue. Liquid hide glue is essentially hot hide with some form of salt added. The salt reduces the strength and the stiffness of the glue somewhat, but makes the glue more convenient to use. Make no mistake about it, the liquid stuff such as Patrick Edwards' Old Brown Glue (wpatrickedwards.com) is a gateway glue. Try it and you quickly become addicted to the hot stuff.

Using hide glue is like everything else we period woodworkers do. There's a technique you have to learn. There are no foolproof ways to use it.

What is often missing from discussions

Hot and sticky. *I cover the bottom of my glue pot with dry glue. Then I pour in cold water to cover it. The dry glue quickly absorbs the water and becomes a gelatinous mush. Ten minutes later, I look in the pot, and maybe add a bit more water. In an hour it looks like this. The glue has absorbed all the water it cares to. A little excess water is present. Were there a cup of excess water, I would try to pour it off. The glue is gloppy, not runny at this point. Or you could forget about it and cook the water off.*

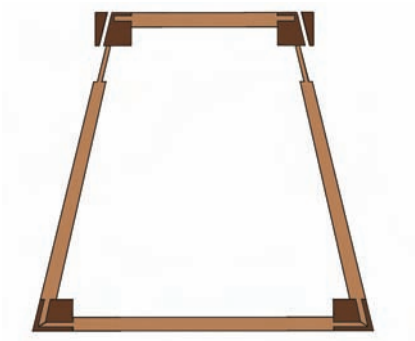
about glue is the fun factor. I find hide glue really fun to work with. When effecting rub joints, you essentially just stick pieces of your projects together like Lego bricks. Woodworking doesn't get more fun than that.

For those of you worried about hot hide glue stinking up your shop, stop worrying. Modern hide glues are very clean. It's essentially a refined form of Jell-O. It's not like having a rotting piece of meat in your shop – though that may have been what it was like 250 years ago. Glue lasts about a week in my shop, then it molds and I throw it in the garden.

Assembling the Chair

Several woodworkers I've spoken with expressed concern about fitting together a chair with angled tenons. The issue is a real one. On paper, there's no way to glue up the front seat rail and legs and get the rear tenons to fit.

The solution is to leave the front seat rail loose (at least). The problem with this approach is dealing with the very short working time of hot hide glue. Mix up a batch of thin glue. Test it between your thumb and forefinger to get an idea of how long it takes to gel. Once it starts gelling, you may have trouble pulling your joints up. You may have a few minutes of working time with fresh hot hide glue. A careful dry fit is always a good idea. Joints that require clamps to come together probably won't work with hide glue. They need to slide together nicely when dry. The warm, wet hide glue is less slippery than yellow glue and it probably swells the wood a little.



Angled challenge. *In this illustration, we're looking down at the seat. Obviously the angled mortises in the back legs present a problem fitting the chair together. There may be enough flexibility in the side seat rails to get the tenons started, but I wouldn't recommend it.*

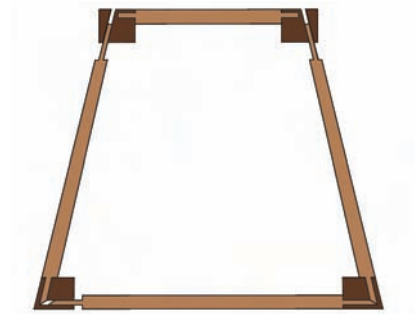
Gentle, even heat. *The traditional cast iron glue pot is essentially a double boiler. It's important to heat the glue gently. Even heating is also helpful. Fill the outer pot such that the water comes above the level of the glue inside the inner pot.*

Continuous stream. *Cook the glue until you get a single, uninterrupted stream flowing off your glue brush. If your glue is gloppy, it could be too cold or too dry. Use a thermometer until you can tell by eye what it needs. Heat the glue to 120° to 140° Fahrenheit. I keep an old wine bottle of water nearby. I check the glue periodically, adding water as it evaporates.*

Glue Blocks

Mortise-and-tenon joints are very capable when the motion is in the plane of the wide face of the tenon. Now that the chair is glued up I'd have no hesitation about sitting in it and leaning back. The tenons will take that. What tenons aren't great for is side-to-side motion. For this, period chairmakers reinforced their joints with carefully installed glue blocks.

Just to place this in perspective, glue blocks on period casework are often installed in a haphazard fashion. Some builders used neatly segmented blocks. Others seemed to use anything they could find from the shop floor. Glue blocks were often beveled, some carefully. Some were brought to shape with a hatchet. Chair makers in Philadelphia seemed to all use the exact same design for their glue blocks. They started with filler pieces. Two 4/4 pieces of pine made up the shape of the corner blocks. The fillers ran parallel to the pieces they had the most contact with. The corner blocks' grain always ran parallel to the legs. Once installed, each corner's block was rounded with a chisel.



No-glue solution. *The solution is probably obvious to you. As long as you don't glue up the front seat rail, you can assemble the chair. The trick is how you do this with hot hide glue.*

Conclusion

The wedges in these chairs' tenons seem to indicate (once again) that period woodworkers really knew what they were doing. As individuals and as a group, they made good decisions. There doesn't seem to be a group of earlier chairs with through-tenons, and no wedges, indicating the wedges were a "lesson learned." The wedges appear to be an integral part of a pervasive design.

What I'm seeing here are smart woodworkers who understood their materials, their methods and their physics, solving problems caused by fairly sophisticated designs. The customers were looking for works of art in their homes. The style makers

Add fillers as needed. *Filler blocks were used to flush the rear seat rail to their adjacent legs. Some fillers stretched across the entire rear rail. Some chairs didn't need fillers.*

Simple blocks. *The corner blocks were made up of two laminations of 4/4 pine. I didn't see any thought as to grain orientation beyond that they ran parallel to legs. The pieces didn't seem to be quartered or riven.*

of the day (Thomas Chippendale was only one of many) were showcasing furniture with flowing curvilinear elements, naturalistic carvings, pierce work and more. In this case, the choice to skip the lower stretcher was probably an aesthetic one. Though it had the potential to reduce the strength and lifespan of the chair, the lack of the stretcher allowed for an uninterrupted cabriole leg. It also eliminated turned components (the stretchers were usually turned), which may have been a problem for chairmakers in larger cities with more powerful Turners' Guilds.

While you may not enjoy the style, I hope you join me in my awe of these early woodworkers. We often think about them as having no choices, working essentially as "survival" woodworkers. And while that may have indeed been the reality of their day-to-day existence, in this simple joint we see some fairly sophisticated decision making. They chose a through-joint to account for the lack of a stretcher, wedged it to ensure its structural integrity, and added glue blocks to reinforce it. Their glue allowed them to repair their products. They used pegs where they were most needed.

The uniformity of their products indicates to me that this community was closer knit than we might have previously thought. They certainly shared stylistic elements, but here we see them sharing structural elements as well. Their carefully made choices kept their furniture, and their community, together. Even if you never make a Philadelphia Chippendale-style chair, I hope you apply the same thoughtfulness in the connections you make with wood, be they structural or social. **PW**

Visit Adam's blog at artsandmysteries.com for more discussion of traditional woodworking techniques.

BY MEGAN FITZPATRICK

Fish Sticks

This trivet is simple and fun to make – in any number of shapes.

A fishy project. *This trivet is a quick, easy and fun project for kids of all ages.*

This simple trivet is incredibly easy to make, and very inexpensive. I spent $16.44 (including tax) for four 1/2" x 2" x 4' pieces of red oak stock at the home center (and if you happen to have scraps and a table saw, well, this fun project is basically free).

Begin by clamping a stop-block 8" to the left of your miter saw blade (if you're right-handed), then proceed to cut 15 8"-long pieces. The stop block keeps you from having to measure and mark each piece – butt the end of the stock against the block for each cut and hold the workpiece with your left hand.

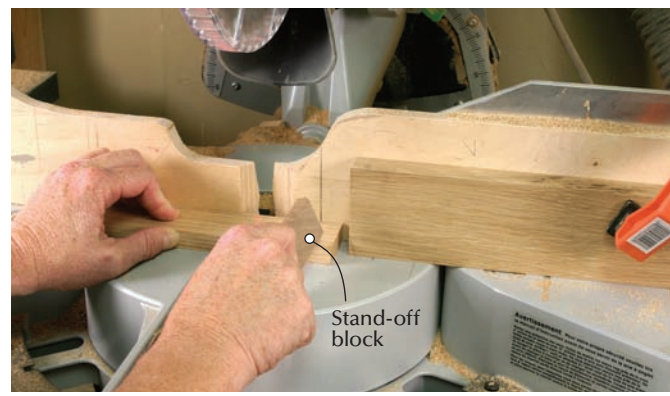
Now grab a small piece of scrap (or use the end of one of your 8"-long pieces) to serve as a stand-off block for the next cuts. A stand-off block is basically just a spacer that's used to set up a cut, then removed before the cut is made, to keep little pieces from getting trapped against a fence and perhaps rubbing up against the saw blade, which could cause the piece to go flying (possibly into your face – ouch). Now clamp your stop-block to the fence to the right of the blade at 2 1/4" plus the width of your stand-off block, hold the stand-off block against your stop-block, and butt your stock against it. Hold the workpiece in place as you remove the stand-off block, then make the cut. Repeat this nine more times.

Make a Sandwich

Now sandwich two sets of three 8" pieces, using glue on both sides of the center pieces, then clamp them together until the glue sets. These will be your head and tail pieces.

With those dry, start stacking your pieces, alternating between long and short. Drill two pilot holes near the center of all pieces other than the two sandwiches using a 1/32" bit, and drive a 3/4" brad into each of those holes until the pointy ends are just emerging from the other side. (If you've a pinner or 18-gauge nailer, eschew the pilot holes and make quick work of the build.)

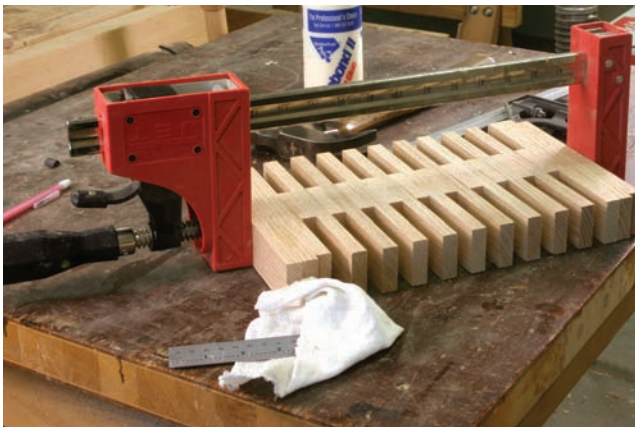
Now, set your combination square to 2 7/8", grab one of the sandwiches and reference off the end to find the edge placement for the first "spine" piece. Add glue to the backside of the spine piece, and drive the



Stand off for safety. *With small workpieces, it's a good idea to use a spacer (also called a stand-off block) between the blade and fence to keep the cut piece from getting trapped.*

LEAD PHOTO BY AL PARRISH; ILLUSTRATION BY ROBERT W. LANG

A fish ladder. *Keep stacking until all your pieces are used, then cap with one of the "sandwiches."*



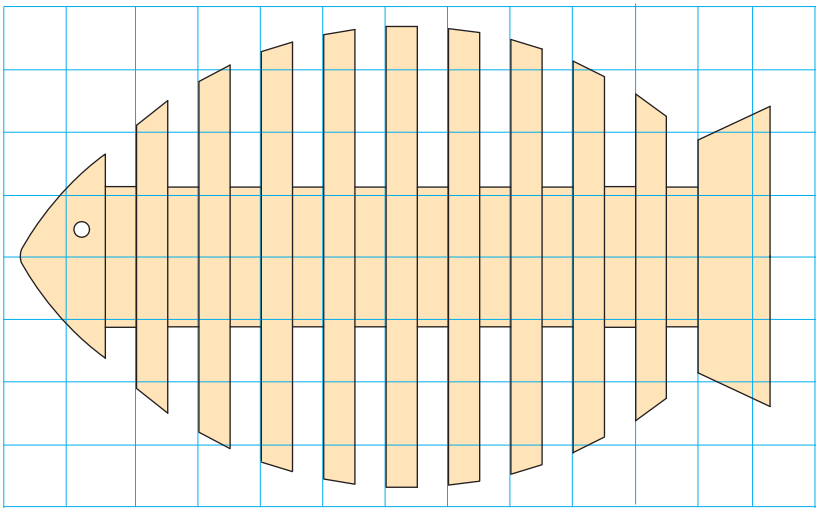
A cleaning rule. *A damp rag over the end of a 6" rule is handy to get in between the pieces for glue cleanup.*

brads home. You'll have to tilt your square slightly to register it against the first long piece as you find the placement of the second long piece. Repeat until all the single pieces are used up. Try to avoid too much glue squeeze-out – and if (when) you do get squeeze-out, wrap a damp rag around a 6" steel rule to get in between the pieces and clean it up while the glue is still wet. The final piece (the head or tail, depending on how you look at it), is simply glued in place, then the entire piece is clamped until the glue is dry.

Choose Your Animal

Now trace the fish pattern (or whatever shape you like) on top, and cut it out with a jigsaw. Clean up the cuts with sandpaper, drill a hole for eyes (and hanging), and you're done. **PW**

Megan is managing editor of this magazine. E-mail her at megan.fitzpatrick@fwmedia.com.



1 square = 1"

FISH STICKS TRIVET

Fish Sticks

	NO.	ITEM	DIMENSIONS (INCHES) T	W	L	MATERIAL
❑	15	Cross pieces	1/2	2	8	Red oak
❑	10	"Spine" spacers	1/2	2	2 1/4	Red oak

Jigsaw to shape. *To keep yourself from having to do too much end-grain sanding (not fun), use a good jigsaw blade to cut down on blow out. (We recommend Bosch "Xtra-clean for Wood" blades.)*

About This Column

Our "I Can Do That" column features projects that can be completed by any woodworker with a modest (but decent) kit of tools in less than two days of shop time, and using raw materials that are available at any home center. We offer a free online manual in PDF format that explains all the tools and shows you how to perform the basic operations in a step-by-step format. You'll learn to rip with a jigsaw, crosscut with a miter saw and drill straight with the help of our manual.

Visit ICanDoThatExtras.com to download the free manual.

BY THE POPULAR WOODWORKING STAFF

Stanley's New Premium Plane

The venerable tool company stages a comeback in the woodworking market.

It has been a long time since The Stanley Works built a handplane that was aimed at the demanding woodworker. But this year, the company shocked the hand-tool world when it announced it was producing a line of five premium handplanes.

The new line includes a redesigned No. 4 smoothing plane, a bevel-up jack plane based on the company's No. 62, two block planes and a shoulder plane.

The most interesting, unusual and useful tool in the line is the No. 4, which we'll review here. We'll review the other planes in the line on our web site.

The No. 4 is a surprisingly heavy tool at 5 lbs. (that's a half-pound more than a Lie-Nielsen No. 4 in bronze). The iron body is made in Mexico with an English-made A2 cutter that's 1/8" thick. The knob and tote are cherry. The lever cap is a lightweight alloy and the adjusters are brass.

So far it sounds like standard fare in the premium plane market. So what's different? For starters, there is no adjustable frog. The bed for the cutter and the base are all cast and machined as one piece – a radical move on Stanley's part. If there's no frog to adjust, how do you tighten up the mouth? That's the other radical part: Stanley has added an adjustable mouth plate at the toe that works like a block plane's – an almost-unheard-of feature for a bevel-down bench plane.

Also different: The adjustment mechanism for the cutter. Instead of using the Bailey-style adjuster that Stanley invented, the company opted for a Norris-style adjuster.

Stanley No. 4 Bench Plane

Stanley Works ▪ 800-505-4648 or stanleyworks.com

Street price ▪ $179.99

For more information, go to pwfreeinfo.com.

The other interesting feature is that the adjuster's lateral adjustment can be locked – I've never seen this before.

So how does the whole package work? Pretty well. The adjustable mouth works brilliantly. It's far easier to adjust the mouth this way than by shifting the frog on a standard bench plane. Overall, the plane was well machined. The sole was completely flat. All the parts fit well together, including the chipbreaker to the iron. And the iron held its edge for a good long time.

My two primary gripes are that the rear tote is chunky and uncomfortable; reshaping it would be hampered by the brass insert in the tote (it secures the tote to the body). My second gripe is the adjuster has more backlash than I like (1 5/8 turns to engage it) and it is located so you have to remove your hand from the tote to make adjustments.

The only other hiccup I encountered with the tool was I needed to disassemble the adjustment mechanism to reposition the pin that moves the blade. It was too far back for the plane to work properly. It's a minor tweak, not covered in the manual. We'll post a tutorial on this on our web site.

Norris style. *The adjuster is the Norris style rather than the Bailey (which Stanley invented).*

Once the tool was set up, it performed as you would expect a premium plane to. It was capable of removing the thinnest of shavings, which is what you want from a smoothing plane. If Stanley could tighten up the adjuster and slim down the tote I think a lot of woodworkers would be pleased with this smoothing plane.

— Christopher Schwarz

CONTINUED ON PAGE 30

PHOTOS BY AL PARRISH

Cutting-edge Grinding From Sorby

Traditional sharpening of cutting tools involves grinding, getting the tool shaped properly and honing, then refining that shaped edge. There is no shortage of devices for either task, but if you struggle with grinding, the Sorby ProEdge System might be what you've been looking for.

Many woodworkers have trouble using a bench grinder, and Sorby's machine has features that make grinding easier while reducing the risks of damaging tools. The obvious difference is the use of a sanding belt instead of a wheel. The $1\frac{15}{16}$"-wide belt (we wish it were more than 2") allows you to shape a wide chisel or plane iron without sliding it back and forth across a narrow surface. It also speeds the initial flattening of the backsides of chisels and irons.

The machine is a miniature version of those used in the Sorby factory and is solidly made, smooth and quiet in operation, and easily adjustable. Angle settings are built in to the tool rest so returning to any standard angle is a matter of putting a pin in the correct hole. The entire machine also pivots so you can find a working angle that is comfortable and allows you to see what you're doing.

Attachments for the tool rest help to keep square tools square and skewed tools at the correct angle. In addition, there are attachments that allow gouges to roll across the belt, maintaining consistent curves in carving gouges and fingernail grinds in turning tools.

Belts are available in #60, #120 and #240 grits, and changing belts is fast and straightforward, even when you factor in removing the guard. Adjusting the belt tracking takes a bit of finesse that comes with practice. The coarsest belt removes metal in a real hurry, and the finest belt leaves an edge good enough for turning.

For carving tools, straight chisels and plane irons you'll still need to hone, but honing a nicely ground edge is easier than trying to correct problems from a badly botched bench grind. This isn't an inexpensive tool, but its value lies in its usefulness. If you aren't an accomplished grinder and don't want any headaches when you do need to grind, this tool will serve you well.

— Robert W. Lang

Sorby ProEdge Plus System

The Best Things ▪ 800-884-1373 or thebestthings.com
Street price ▪ $499.95
For more information, go to pwfreeinfo.com.

A Feature-packed Trim Router from Ridgid

Around my shop, if there is edge routing to be done, I reach for a trim router. The tool's smaller size fits comfortably in your hand and turns most tasks into a one-hand operation. This frees your off hand to hold and turn the project. That saves time as you work and increases your productivity.

To be of value, a router has to have the right features to get the job done. Ridgid's R2401 trim router has everything needed to be a "go-to" router in the shop, starting with a 5.5 amp variable-speed motor that can power through most routing jobs. (Variable-speed settings are from 20,000 to 30,000 rpm and are adjusted with a quick turn of a dial located front and center on the motor housing.)

But no router is worth your hard-earned money if it's not designed to be accurate. The R2401 has an easy-to-read depth scale and a micro-depth adjustment with a zero-reset feature that is within a thumb's reach for fine-tuning the adjustment. Coupled, these two features make this router accurate and precise. Add in a work light to brighten the cutting area, and you have the complete package.

The router powers up with a slide switch that's located at the top of the tool. This might seem like a strange place to put the switch, but the location is ingenious. Once you have finished routing, simply flip the router onto its top and set it down. The switch slides to the off position as the router sits awaiting the next task.

The kit includes the router complete with a lengthy cord (12') that provides plenty of walk-around room. There's a clear, round base for most routing work as well as two wrenches to fit the $\frac{1}{4}$" collet (or you can use the spindle lock and a single wrench; it's your choice). Ridgid has also added a square base (it's also clear) for straight work along with an edge-guide assembly that enables you to tackle most router operations.

Everything is packed into a canvas tool bag that keeps things collected and ready to use. This router should see plenty of action in our shop. **PW**

— Glen D. Huey

Ridgid R2401 Trim Router

Ridgid ▪ 800-474-3443 or ridgid.com
Street price ▪ $99
For more information, go to pwfreeinfo.com.

Benchtop Table Saws

BY GLEN D. HUEY

Small but mighty. *Small in size but with plenty of power, benchtop saws have many of the features found in full-size saws. In fact, one of these machines might fulfill your table saw needs.*

Riving knives have made benchtop table saws 'new' again. Could one be the tool for your shop?

When you scanned this issue's cover and discovered an article on benchtop table saws, you might have questioned our sanity; or you might have thought, as we do, that it's about time!

Benchtop table saws have come of age. Features such as riving knives (on all the saws we chose for testing), easy-off and easy-on blade guards, and the rock-solid extension tables found on these table saws are very much in line with those found on many of the 3- and 5-horsepower cabinet saws that garner most of the press. Many of these portable machines are found in woodshops of all descriptions – you might be surprised by who uses benchtop table saws.

During the past three years, *Popular Woodworking* has published a column designed to introduce budding woodworkers to the craft. The column is "I Can Do That" (see page 24 in this issue) and with each completed project, experience and confidence builds. Before long, these woodworkers plan tool acquisitions. A small table saw is a great foundation on which to build.

If you have a small or temporary shop, a small saw may be just the ticket. And how about hand-tool users? It's not practical to expect avid hand-tool-user shops to be void of all power tools. If table saw is not going to be a primary tool in the shop, a benchtop design might be the answer.

If you're a power-tool woodworker, you know the value of a table saw. You also understand what can be accomplished with a table saw and what a hardship it is not to have the machine available when it's needed. I'll bet that at some point, with your table saw already set up for a specific cut, you discovered the need to size another piece of lumber before you could finish the task. A back-up saw is a nice addition, but adding a second full-blown setup is too expensive, and giving up the valuable real estate for a behemoth saw might not be in the cards. Bingo. There's the spot for a benchtop saw.

Seeing the improvements made on these saws and the need for information about benchtop table saws, we set out to review the examples that met our simple riving-knife requirement. Those saws arethe Bosch 4100, the Craftsman 21828 , the DeWalt DW744XRS, the Jets JBTS-10MJS and the Makita 2705.

The Power is There

Set aside any thoughts about prices and accessories for the moment. Your first thought concerning these saws has to be about power, and rightfully so. With benchtop table saws we're talking amps and not so much about horsepower as these machines are built with universal motors. But can these table saws cut hardwoods? We answer that with an emphatic yes.

We tested each saw's power with cuts in 4/4 quartersawn white oak and 8/4 cherry. All the saws are up to the task, but we admit we felt a small drag in power while using the Bosch saw. The drag was infinitesimal and could have been the result of over-feeding the stock – you can bog down the motor on any of these saws by over-feeding.

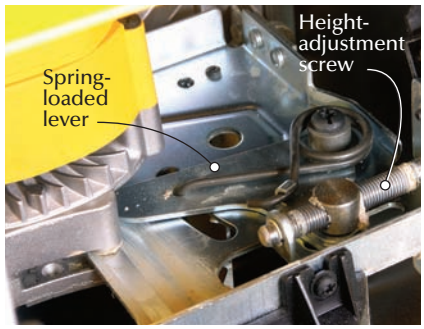
But to put any question of benchtop table saw power concerns to bed, the huntboard published in our June 2009 issue (#176) was built entirely using a benchtop model. These machines have all the power you need.

Goodbye Old Splitter

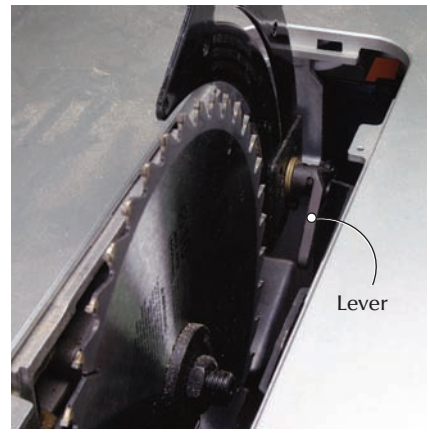
The biggest improvement found on the table saws in our review is the tool industry's switch from splitters to riving knives. To allow the riving knives to move with the blade, the motor/arbor housing has to move straight up or down. On many cabinet saws, that's done on dovetail ways, but with these five benchtop models, three different methods are used.

The Bosch, Jet and Makita saws use a two-pole slide system. The movement is smooth and stable. The Craftsman saw func-

LEAD PHOTO & PRODUCT PHOTOS BY AL PARRISH; DETAIL PHOTOS BY THE AUTHOR



Levers versus poles. *DeWalt's saw uses a spring-loaded lever to adjust the cut height. The other saws in the review have one pole or two poles on which the motor housing travels.*



Levers are better. *Adjustment of the riving knife begins by unlocking the support, then the knife is positioned appropriately. The Craftsman and Bosch (shown here) saws have a lever instead of a small knob.*

tions on a single pole and the DeWalt uses an entirely different setup on the DW744. The DeWalt unit sandwiches a plate of metal to stay in place, then raises and lowers it using a spring-loaded pivoting arm. Which design is best will be answered in time, but my gut instinct says the two-pole design is better.

The splitter on earlier saws stood above the tabletop to keep a board from pinching the blade and create kickback. But with many of the operations performed at a table saw, the splitter had to be removed – and more often than not, it was never replaced.

A riving knife travels with the blade as it is raised, lowered or tilted. The distance between the blade and knife remains constant, unlike the splitter where the gap increased as the blade was lowered. Also, a riving knife helps keep the wood tight against the fence during the cut.

How the riving knives are adjusted up and down is a major difference with these saws. As with larger saws, most of the riving knife adjustments are accessed through the saw's throat opening. We find the levered designs (on the Bosch, Craftsman and Makita models) better to work with than those with knobs. To reach through the opening is not that easy, but to do so while turning a small knob is asking a lot. Levers that disengage with a simple quarter-turn are the winner in our opinion.

Makita has a much different setup from the other two lever-adjusted saws. Access through the throat is not required. Makita has positioned its lever on the outside of the cabinet, which when pulled, releases the locking plate and allows adjustment of the riving knife. That's cool, but the lever is on the backside of the saw and you'll have to reach over the saw or walk around to the back to gain access.

The DeWalt and Jet saws have knobs, but on the Jet it's so small that a finger and your thumb is all you can use to turn the knob to lock or unlock the knife. And Jet has an issue with its riving knife design. The opening is a simple slot. There are no notches or extra holes to help secure the knife. The locking plate is the only holding mechanism. If your hand strength is suspect, there's a possibility of the riving knife changing position during a cut.

While the DeWalt saw's three-wing knob is larger, it's still a knob. But once the lock is loose, adjustment of the riving knife is easy and smooth. Simply push in on the knob as you adjust the knife. With pressure off the knob, the catch springs back to secure the knife in place. Then twist the knob to lock it.

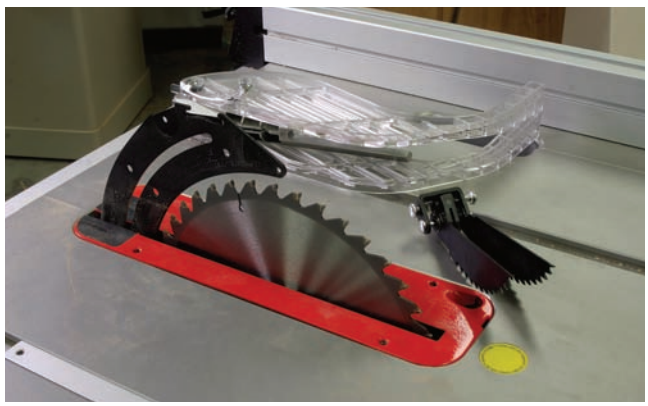
Blade Guards

The riving knives are left attached and in place or adjusted (slid down into the saw) for non-through cuts. That in turn means that the guards and kickback pawls must be removed for those cuts and replaced when making traditional through cuts. (You can't use the blade guard and pawls when the riving knife is set for a non-through cut.)

In evaluating the guards, you have to look at the design of the guards themselves and the method and ease of attachment. If installation is difficult, the guards are left on a shelf to collect dust.

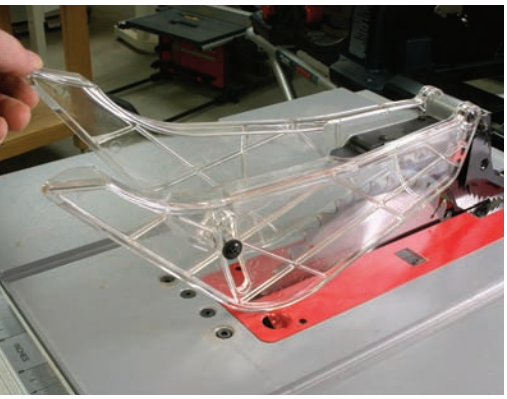
In our opinion, a good blade guard has a clean line of sight to the blade (you have to be able to see the blade so you know where not to put your hand). The side guards should lock in the up position because on thin cuts you need the guard out of the way. And the side guards should work independent of one another other. Each of the saws meets these requirements except one.

Jet seems to have missed on most of these

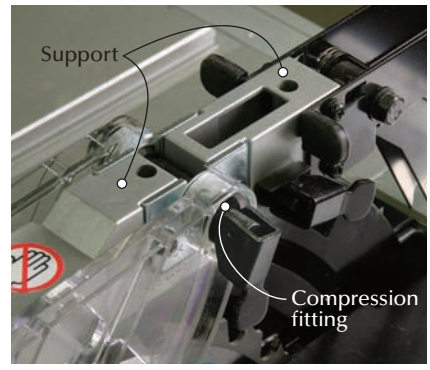


Updated designs. *The best news for woodworkers using benchtop table saws is the switch from splitters to riving knives. This design is much more user-friendly.*

A tale of two knives. *See the difference between a riving knife and a great riving knife? The lower knife cannot be removed, only repositioned in the saw while the upper knife displays a series of holes that engage with pins in the knife support. That's extra holding power when the knife is locked.*



Separate is better. *Move one of these side guards on this Jet saw and the second side moves too. A better design is side guards that work independently; each should lock up and away for thin cuts.*



A unique design. *The Makita saw uses a compression fitting to attach the blade guard to the support and the support (to which the pawls attach) to the riving knife.*

issues. While there is a clear line of sight, the side guards don't lock up and out of the way for thin work. And the sides are linked together. You can raise the right-side guard a few inches prior to lifting the left side off the table, but the left side immediately grabs the opposing guard. (If you're doing any crosscuts to the left of the blade – which is normal woodwork procedure – you're constantly going to move the entire guard system as you work.)

Four of the five saws have separate anti-kickback pawls and guards that clip onto a riving knife in some manner. The unique setup is that of Makita. On the 2705 benchtop table saw, the pawls and guard is one unit. However, you can remove the side guards with a flip of a small lever while leaving the pawls and support in place. You cannot remove the pawls without pulling the support, but Makita has designed a way to hold the pawls up if need be. They simply lip over the rear of the support.

As for installing the guards and pawls, if you're new to this operation, it might take some time to become comfortable. After you run through a couple cycles, the job becomes simple. Most of the guards latch to the riving knives and the pawls fit closely behind the guards – except for on the Makita.

Latches, for the most part, are located at the top, center of the guards. Slide the guard into position then click the latch and you're good. But that's not the case with Jet. Jet's guard attaches with a spring-loaded slide mechanism that's found between the side guard and the riving knife. It's small and difficult to use.

Table Extensions

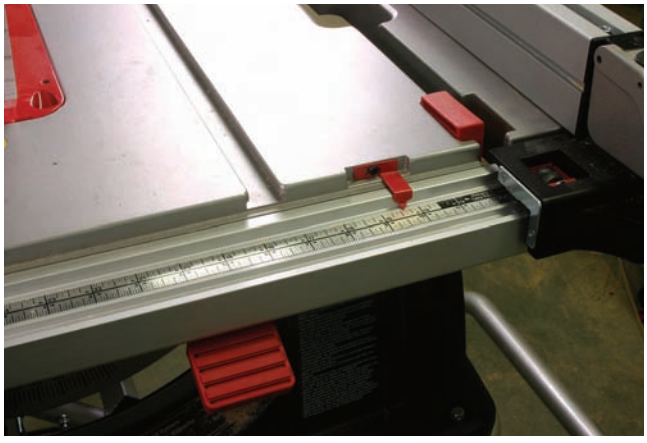
Though all of these machines have small tables, each saw in the review is designed with width extensions to the right of the blade. On most of these saws, you release a latch then pull out the extension to increase the distance between the fence and the blade and allow a wider rip cut.

While it's good to have the extra width capacity, the downside is the empty void of table surface that's equal to the amount of extension. And there are times when the fence gets in the way of the levers on some of the saws.

The best extension table in our view is on the Bosch 4100. The release is located just below the front rail; it's very easy to access. Additionally, there is a section that pops up when released. That ensures you don't begin a cut while the table isn't locked in place. It also requires that you position the fence out of the way as you extend the table.

The other saws have extension tables that work similarly to the 4100 – except the DeWalt. The DeWalt uses a rack-and-pinion arrangement to expand its cutting area. A gear located just behind the knob engages into a track that forces the fence, and just the fence, out or in. The oddity on this setup is the fact that there is no table edge moving away from the blade as it is with the other saws. It's just the fence (which is fixed to the extension rails) that adjusts.

In place of the table edge, DeWalt has added a flip feature to the fence called a support extension. Once the fence moves beyond the table edge, the support is flipped toward the blade side of the fence to catch the edge of any workpiece. When working over the table, the support is flipped away from the blade and stored.



Another reminder. *Benchtop saws have extension tables to allow wider rip cuts. The tables unlock and move to the right of the blade and must be locked before using. In addition to the front handle, the Bosch saw has a pop-up reminder that impedes the work if not locked down.*

Geared movement. *The right hand is on the lock handle. Once released, DeWalt uses a rack-and-pinion system to adjust the extension table. On this saw, the fence doesn't slide along a rail.*

Benchtop Table Saws

Bosch 4100

The Bosch 4100 saw was near perfect right out of the box. The blade-to-miter-slot parallelism was off only .001" so no adjustment was necessary. The fence is set up for jigs in that no screws or bolts extend above the top and that allows smooth sailing for any fence-riding jigs – think tenon jig. And, it needed no adjustments.

Blade changes are a one-tool task because the saw has an arbor-lock lever. Simply pull the lever up and toward the front then move the blade by hand until the lock engages. The saw comes equipped with a Bosch 10", 40-tooth general purpose woodworking blade that has an alternate top bevel (ATB) design.

The Bosch guard and pawls are smooth and easy to operate as is the table extension. And when the extension is locked, there is no movement whatsoever. Dust collection was very good through a 2" dust port and the saw handles up to a $^{13}/_{16}$" dado stack.

A test of the decibel level at the front edge of the blade guard registered 93 dB – the lowest of the saws reviewed.

BOSCH
boschtools.com or 877-267-2499
Street price: $420
TS200 Stand: $198

Craftsman 21828

The blade-to-miter-slot parallelism for the Craftsman's benchtop table saw was .042". We double-checked the readings to make sure it wasn't a mistake. The second reading confirmed the problem. But the adjustment to bring things back in line is easy to do: Loosen two bolts then turn a third bolt to effect a change. The fix brought things parallel.

What really caught our attention with this saw is that the two miter slots were not parallel to each other – there is no adjustment for that. And the height adjustment for this saw turns counter-clockwise to raise the blade – reverse of the most saws. The saw comes equipped with a 36-tooth, no-name ATB blade.

A dado stack for this saw is limited to $^{1}/_{2}$" according to the owner's manual and the company recommends a 6"-diameter dado blade. And the blade guard and pawls have to be removed whenever a blade change or riving knife adjustment is made.

This is the only saw in the group with built-in wheels and a telescoping handle. Both made moving the saw very easy.

This 15-amp motor has a no-load speed of 5,000 rpm (the highest speed in the review), which may account for the highest decibel reading (101 dB) as well.

CRAFTSMAN
craftsman.com or 800-349-4358
Street price: $300
No stand available

DeWalt DW744XRS

The great feature on the DeWalt benchtop table saw is the locking mechanism on the throat plate – this design should be adopted by all manufacturers. It's easy to use and secures the plate effectively.

The most unique feature of this saw is the fence arrangement. While the fence is positioned to the right or left of the blade, it is latched to the rails and moves only when the rails move. And due to the work-support extension, you can't use fence-riding jigs.

This saw was .020" out when discussing blade-to-miter-slot parallelism, but the four-bolt fix made it simple to align. The DeWalt 744 saw can handle a $^{13}/_{16}$" dado stack and includes a 10", 24-tooth general purpose DeWalt saw blade. Blade changes require two wrenches (included), one slips on and locks the arbor while a second wrench works the arbor nut.

The DeWalt saw is available only with one of two stands: the DW744XRS (a sturdier stand) or the DW744X (a more economical stand). There is a $120 price differential between the two setups.

The decibel reading for the DeWalt saw was 97 dB.

DEWALT
dewalt.com or 800-433-9258
Street price: $649 (DW744XRS)
$529 (DW744X)

Jet JBTS-10MJS

The news with the Jet benchtop table saw is the fact that this saw is available only with a rolling stand assembly (shown in the inset photo). The stand is very nice to work with and positions the saw at an ideal workable height. While we agree these saws should be set up on a stand to gain the appropriate working height, "apple-to-apple" price comparisons to the Jet saw are difficult.

Out of the box, this tool is easy to put together with clear assembly directions. The saw had a blade-to-miter-slot parallelism differential of only .003" when measuring from the left slot (the slot used for most applications), but when we measured the distance between the two miter slots, they were out .024". It comes with a Jet 40-tooth ATB blade.

There are a number of issues with the riving knife design (no registration points and a small lock knob are the most worrisome) and a few features with the blade guard that didn't thrill us. However, there were no issues when it came to cutting materials. This saw operates with a standard $^{13}/_{16}$" maximum dado stack.

Decibel readings for this saw were 98 dB.

JET
jettools.com or 800-274-6848
Street price: $630
Stand included

Makita 2705

Hats off to Makita for the external lever used to unlock the riving knife for adjustments. No more reaching into the small throat opening. But the location of the lever – at the rear of the saw – is suspect. Move that lever to the front and it's a winner – and takes the sting out of the fact that to remove the throat plate a screwdriver is needed.

The design of the blade guard system is distinct from the other tested saws, but the setup works and it has a couple nice features, such as the side blade guards flip completely out of the way for thin cuts and the pawls can be removed from the cut without removing them from the support – the pawls hook onto the support and are held above the cut. This saw comes with a 32-tooth ATB blade.

The most vexing problem with this saw is the inability (at least there is no information in the manual) to correct the parallelism issue. The discrepancy was only .007", but that's enough to warrant a correction. Also, the fence on this saw is difficult to properly align.

The 15-amp, 4,800 rpm at no-load motor rang up a 98 dB reading. This saw accepts a $^{13}/_{16}$" dado stack without trouble.

MAKITA
makita.com or 800-462-5482
Street price: $643
194093-8 Stand: $320

Benchtop Table Saws

	MODEL #	STAND	RIVING KNIFE THICKNESS	MAX CUT @90°	MAX CUT @45°	MAXIMUM DADO	TABLE SIZE (W x D)	WEIGHT (POUNDS)	MAX. RIP @ RIGHT	FRONT EDGE TO INSERT
Bosch	4100	Optional	0.094	$3^{1}/_{8}$	$2^{1}/_{4}$	$^{13}/_{16}$	$21^{1}/_{2}$ x 29	60	$25^{1}/_{8}$	$6^{1}/_{2}$
Craftsman	21828	NA	0.094	$3^{1}/_{4}$	$2^{3}/_{8}$	$^{1}/_{2}$	$18^{7}/_{8}$ x $28^{1}/_{8}$	56	$24^{1}/_{2}$	$4^{1}/_{2}$
DeWalt	DW744XRS	Included	0.086	$3^{1}/_{8}$	$2^{1}/_{4}$	$^{13}/_{16}$	$19^{1}/_{4}$ x $26^{1}/_{2}$	58	25	5
Jet	JBTS-10MJS	Included	0.094	$3^{1}/_{16}$	$2^{1}/_{2}$	$^{13}/_{16}$	21 x $30^{1}/_{4}$	91*	$25^{1}/_{8}$	$6^{1}/_{8}$
Makita	2705	Optional	0.094	$3^{9}/_{16}$	$2^{1}/_{2}$	$^{13}/_{16}$	$22^{1}/_{4}$ x $29^{5}/_{8}$	64	$25^{1}/_{8}$	8

Good (And Bad) Standout Features

There are a few standout features in this group. Some are impressive and a couple are not. To begin, the DeWalt saw is unique in many ways, as discussed above. But this saw has a feature we think each saw – benchtop and cabinet designs – should incorporate. The feature has to do with the throat plate and how it locks in place.

Nothing is more aggravating than having to use screwdriver to remove a throat plate. On many table saws (as in the Makita model reviewed here) you have to do just that. DeWalt has added a cam-lock knob that requires a quarter-turn to release. The plate locks in the saw, but is easy to remove when necessary.

The Craftsman saw delivers two standout features. One is good, one is not so good. On the positive side of the equation, the Craftsman benchtop saw combines the functions of height adjustment and bevel adjustment in one wheel on the front of the saw (the Jet also does this). Also, the Craftsman, Makita and Jet saws all have superior bevel-setting mechanisms. When you change the bevel setting of the arbor it stays put until you lock it. With the Bosch and Makita, the motor swings free when you unlock the bevel setting, making bevel adjustments trickier.

The undesirable feature of the Craftsman is that it's the only saw on which the blade is raised by rotating the height-adjustment wheel in a counterclockwise direction. I'm sure you could become accustomed to this, but for us the action is annoying. Plus, there's no Craftsman-specific stand available.

The Bosch saw exhibited the best dust collection when coupled with a wet/dry vacuum and the guard system is the easiest to install on the saw.

Get a Stand

For the Bosch and Makita saws, optional stands are available. The DeWalt is available only with a stand (though there are two stand options). The Jet benchtop table saw is the only saw of the five reviewed that includes a rolling stand with purchase. And the Craftsman saw, with no stand as an option, has built-in wheels and a telescoping handle to facilitate movement.

Yes, these are called benchtop saws, but positioning the saws on a stand does two things. First, the stands set the height of the saw at a workable height. We found that if a saw sat on a workbench, it felt a little high for normal table saw operations and we felt we were stretching as we pushed the pieces past the blade. And second, the stands, complete with the saws attached, collapse and are easily stored in an out-of-way part of your shop.

No extra tools required. *Hats off to the DeWalt design team. The twist lock that holds the insert plate in position is the best design of all the reviewed benchtop saws.*

Double duty. *Some of the models use the height adjustment knobs to also adjust the bevel settings after the lock is disengaged. The Craftsman saw is the only saw on which blade height adjusts with counterclockwise rotation.*

How Things Stack Up

On pages 36 - 37, there is additional information pertaining to the setup of the saws, correction needed straight out of the boxes, noise levels and more. These factors help shape any purchase decisions and should be evaluated as well.

There is quite a range of prices on these five saws. The Craftsman saw is easily the least expensive saw in the review. It's a no-thrills, nuts-and-bolts saw that lets you do basic work. The Jet saw, even with the included rolling workstand, has too many issues centered on the riving knife to win top honors. DeWalt's table saw, with the rack-and-pinion extension adjustment and fence operation, is too out-of-the ordinary to make this saw my choice – normal operations are so different from other table saws. The saw from Makita has a few setup issues that were not correctable – that pushed this saw out of the running.

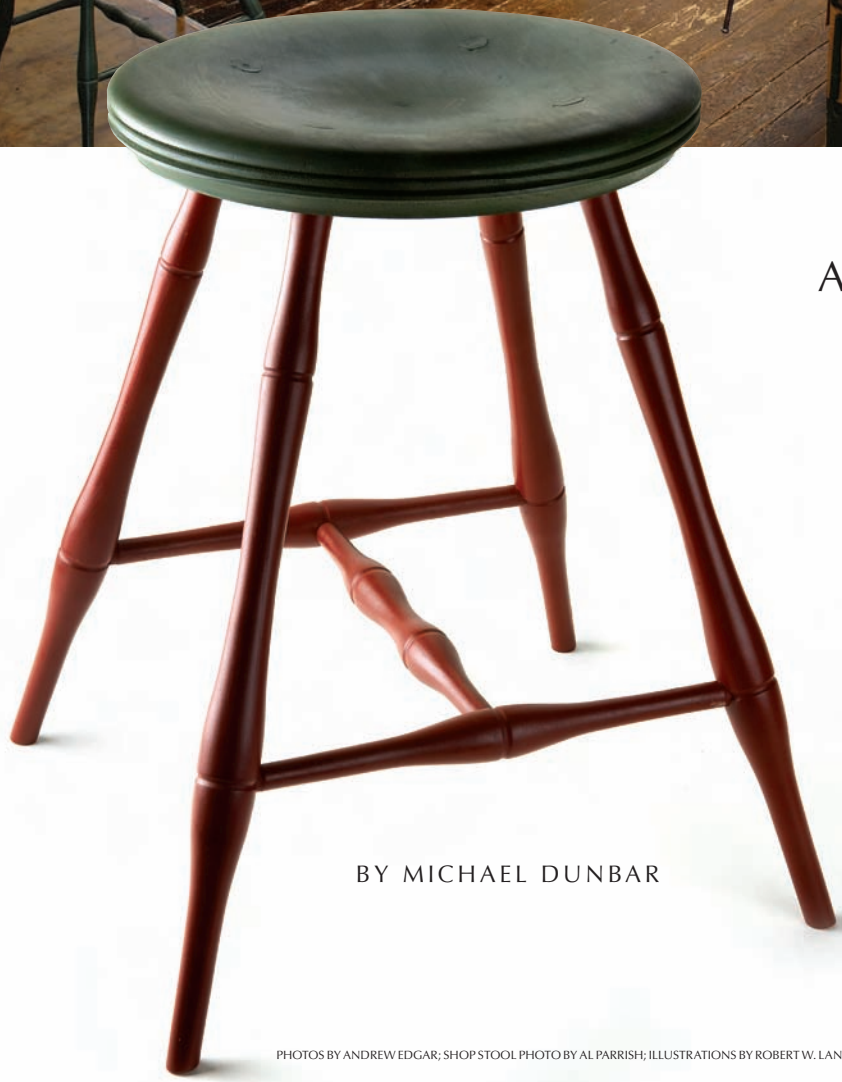
Based on the setup factors, the major features, on how these saws perform and the available accessories, the Bosch 4100 is the better saw. And we would pony-up the funds for the rolling stand (Gravity-Rise stand – model TS2000, $198) with the purchase. But bottom line: If space were not a concern and we could muster up a few hundred dollars more, we would reach for one of the available hybrid saws. But don't give up on the riving knife design. That's an important feature that will pay dividends to the end-user. **PW**

Glen is a senior editor of this magazine and the author of several woodworking books. Contact him at 513-531-2690 x11293 or glen.huey@fwmedia.com.

Get a move on. *Benchtop table saws are meant to be moved around the shop. Craftsman facilitates movement with onboard wheels. The Jet model includes a rolling base, the DeWalt comes with two base choices. Optional bases are available for the other saws.*

Important setup. *All the saws reviewed except the Bosch needed to have the blade-to-miter-slot alignments adjusted — variations were from three thousandths to 42 thousandths. Most saws were easy to adjust and the instructions were clear.*

Windsor Shop Stool



BY MICHAEL DUNBAR

A comfortable seat can make a big difference in your work.

I designed this stool for a special purpose – making chairs. The stool places a chairmaker above the chair seat. This position is more comfortable when assembling the back. We have more than 30 of these stools around our shop. There is one for each vise and a couple extras for the teaching staff and for visitors. Our students all sit on these stools when working. They sit on them when watching demonstrations and when eating. In other words, our stools get used a lot.

Have a seat. *With basic lathe skills and some angled drilling, you can make this Windsor shop stool – or 30 of them – for your own workshop.*

PHOTOS BY ANDREW EDGAR; SHOP STOOL PHOTO BY AL PARRISH; ILLUSTRATIONS BY ROBERT W. LANG

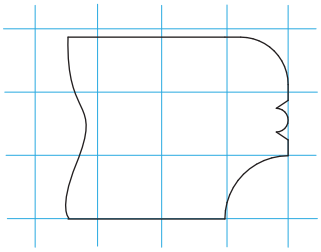
You can make this stool for your shop. It is also a handy piece of furniture to have around the house. The stool is 2" higher than a typical chair. It places a child or a smaller adult at table height. Made in the 24" version, the stool is perfect for use at a counter or around an island.

These stools are comfortable and you can sit on them a long time. Their design solves the problems that make most stools uncomfortable. The round top is big – an ample 14" wide. It will accommodate the widest backside. The top is dished to 3/4". This depth allows you to sink into the top. A flat-topped stool is very uncomfortable.

Online EXTRAS

For a SketchUp model and a photo of a 24" stool with a baluster leg, go to:

popularwoodworking.com/oct09



SEAT PROFILE

In spite of its delicate appearance, this stool is remarkably rugged. Some of mine have been in continual use for 30 years. While somewhat worn, the joints are still perfectly tight. They have stood up to hard treatment. Putting a Windsor chair together requires a chairmaker to move fast. Lots of parts have to go together at once. There is little time to gently move a stool into the desired position or out of the way. The job is usually done with the foot. The stool is kicked into place then shoved out of the way. They are frequently put on the bench. When they fall off they bounce across the floor.

These stools are a good way to get some chairmaking experience without getting in over your head. Most woodworkers avoid chairs because of complicated geometry. Most chairs involve compound angles – parts lie in two planes. This stool uses only simple angles. The parts are all in one plane. Stools are seating furniture and part of the chairmaker's trade. So, in this article I will often refer to chairs and chairmaking when talking about the process of making this stool.

One Afternoon of Lathe Work

The stool is all lathe work. If you have good lathe skills you can make one in an afternoon. The top is face-plate turned. The four legs and stretchers are spindle turned – turned between centers. I use yellow poplar (tulip) for my stool tops. This wood is

Seat layout. *Use a compass to mark a 14" circle for the seat of the stool.*

Rough shape. *Use the band saw to cut out the seat blank.*

Centered. *Mount your face plate so it's centered on the seat blank.*

Smooth edge. *Turn the blank's edge smooth.*

relatively inexpensive. It turns easily and cleanly and is stronger than pine. The legs and stretchers support a human being so they have to be strong. They require a hardwood. Maple, birch, oak and ash are fine. Choose stock with straight grain. Mahogany and walnut are not strong enough.

Thickness the stock for the top to 1¾" and if necessary, glue up a blank at least 14" square. Some additional length and width does not hurt. Use a compass to lay out a 14" circle. Cut out the rough disk on the band saw. Mount your face plate so it is centered on the circle. Most face plates have a center hole, which allows you to find and center the point made by the compass.

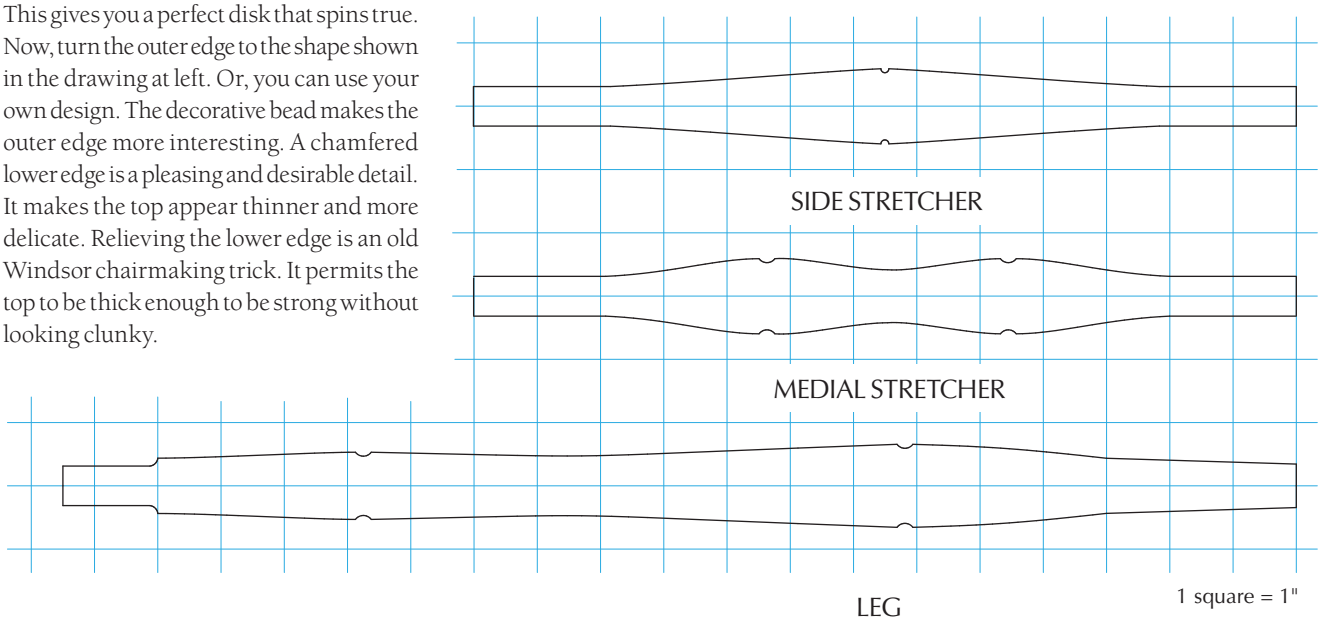
Turn the blank's edge so it is smooth. Next, flatten the top and bottom surfaces. This gives you a perfect disk that spins true. Now, turn the outer edge to the shape shown in the drawing at left. Or, you can use your own design. The decorative bead makes the outer edge more interesting. A chamfered lower edge is a pleasing and desirable detail. It makes the top appear thinner and more delicate. Relieving the lower edge is an old Windsor chairmaking trick. It permits the top to be thick enough to be strong without looking clunky.

Sand the top surface and the edge while the top is spinning. Take it off the lathe and remove the boss (the projecting wood) under the face plate with a handplane.

Shapely Legs

Turn the legs to the profile and dimensions shown in the drawing below. Windsor chairmakers introduced this style of leg about 1790. They called it "bamboo." However, around 1820 the next generation of Windsor chairmakers developed another style of turning they called bamboo, too. To distinguish between the two historical types of bamboo legs, today's chairmakers refer to this shape as double bobbin (which is the style shown below).

Four legs. *Turn the legs to the profile and dimensions shown in the drawings below.*



Shape. *Turn the outer edge of the seat to match the shape shown in the "Seat Profile" drawing.*

Easier sanding. *Sand the seat surface with the workpiece spinning on the lathe.*

Handplane. *Use a handplane to remove the boss (the projecting wood) from the face plate.*

Like Windsor chairs, the stool is made using socket construction. This means it is joined with round tenons in round holes. You can bore all the holes in a drill press. If you don't have a drill press, or want to be more adventuresome, it is easy to do by hand.

Joinery Layout

To begin the joinery, you have to locate the leg holes. Place the seat upside down and with a compass, draw a circle with a 4½" radius. The leg holes will be located on this circle. Next, scribe a diameter (a line across the bottom that passes through the center.) Scribe a second diameter at a right angle to the first. An easy way to lay out this second line is to walk off the half circle with a pair of dividers. Adjust the dividers until you have two equal divisions. These two intersecting diameters have two purposes. They locate the four leg holes and will also serve as your sight lines.

Before you drill, a word about what we call chairmaker angles. Chairmakers don't measure angles the way most woodworkers do. We use the same system as the guys who drill for oil. We assume the perpendicular to be 0°. Our angles are the number of degrees from the perpendicular. In the case of the stool top, the leg holes are at 21°. It's a lot easier to think this way than to use 111°.

Commence Drilling

Clamp the seat upside down with some scrap under it. We keep a box of 1" x 4" x 24" boards in the shop for this purpose. We call them backboards. Windsor chair leg holes are through-holes. The backboards protect the benchtops from the bits. Set a bevel square to 21°. Place the bevel square's handle so its slot runs along the sight line. Use the edge of the bevel's blade to align your bit while you sight the bit along the line. There is no need for jigs or other aids. In fact, these things are more effort than they are worth. Using these simple techniques, chairmakers can accurately drill an angle over and over.

Be gentle when your bit begins to break through the top surface. You can feel it happening. If you push too quickly you risk blowing out a chunk of the surface around the hole.

Insert the four legs into the holes and stand the stool upright. Do not worry if it rocks. You will trim the legs later so it sits flat. In this position, you can measure the stretchers. The four legs should describe a square. In a perfect world, the distance between each pair of legs should be the same. If not, don't fret small variations. If you have a big difference, put the bit back in the hole and use it to ream the hole to the desired angle and location.

The stretchers will be connected to the legs at the location of the lower rings. This is where you measure and where the joints will be drilled. On all my stools, the distance between legs at the lower ring is about 11".

Locate the leg holes. *The first step is to mark a 4½" radius.*

Divide and find. *A simple way to find the location for the second diameter is to walk off the half-circle with a pair of dividers.*

Two purposes. *The two diameter lines locate the leg holes and act as sight lines.*

A matter of degree. *The leg holes are at 21° off perpendicular.*

By eye. *Use the bevel's blade to get the drilling angle, and sight the bit along the line – no jig needed.*

Stretchers. *The stretchers will connect at the lower ring locations; turn the stretchers as needed, to fit.*

Stretcher holes. *I use a 9/16" brad-point bit to drill 1 1/8"-deep holes for 1" tenons.*

It is important to understand that in a measured drawing of a chair, stretcher lengths are always an approximation. These lengths vary slightly from chair to chair. Like boats and barrels, chairs tell their makers important dimensions as they are being made. For that reason, make the stretchers for your stool as you go along, not beforehand.

Think Square

Remember, the four legs describe a square. Think of the two side stretchers as opposing sides of a square. The distance between them is the same as the distance between the legs. This means all three stretchers – the two sides and the medial – should all be the same length. Turn the three parts to the shapes shown in the drawing and to your lengths.

Before you begin to turn the stretchers I need to let you in on chairmaking's dirty little secret. We use socket construction – round hole and round tenon – only because it can be done so quickly. It really speeds up our work. This is, however, the second-worst joint you can make. The worst is gluing end grain to end grain. Think about a hole drilled in wood. Its inside surface is almost completely end grain. The only edge grain is on the tangents. If you rely on glue, the glue will eventually fail. You know this from your own experiences. What is the first thing friends and neighbors ask when they find out you are a woodworker? "Can you glue my kitchen chairs?" Why? Because factory chairs always fall apart.

This is the important point. If we want to take advantage of the speed and ease of socket construction, we cannot rely on glue alone. This is what factories do. They use socket construction to hold their chairs together. In other words, the joints are in tension. When the glue fails they pull apart. While we too, glue the joints, we use a completely different principal. We still use a technique that was worked out by Windsor chairmakers 250 years ago. We do not use stretchers to hold legs together. We use them to push legs apart. Our joints are in compression. When the glue fails, they remain tight.

To put the joints into compression, we need to make our stretchers over-long. We are going to add some extra length called preload. This is really simple. Before you turn the stretchers add 3/8" overall (not for each tenon) to the distance between the legs. We call this length shoulder-to-shoulder. Shoulder-to-shoulder is not the overall length. You still have to add a 1" tenon on both ends. So the math in my case is 10 5/8" plus 3/8" equals 11". This is my shoulder-to-shoulder. When I turn the stretcher, I will add 1"-long tenons to both ends.

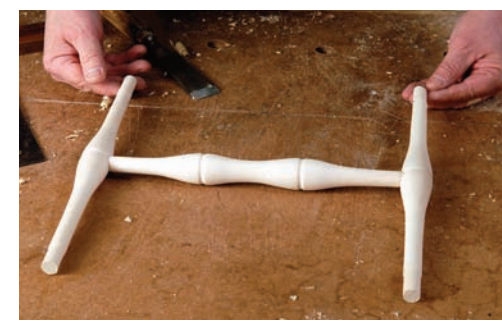
Commence Assembly

You are now ready to assemble the stool. It will be easy. The holes in the side stretchers are 90°, right angles. I use a 9/16" brad-point bit. I drill the holes 1 1/8" deep for 1" tenons. The deeper hole ensures that my shoulders are tight to the leg. The shoulders do the pushing apart, not the end of the tenon.

Grip the stretcher in a vise and drill. It will not rock if you make a simple cradle like the one in the picture below. Now, assemble the side stretchers to the medial stretcher. I glue only the inside of the hole. If you glue the tenon, the glue gets all over the place. Check to be sure the assembled "H" lies in a plane. Then, set it aside while you drill the leg holes.

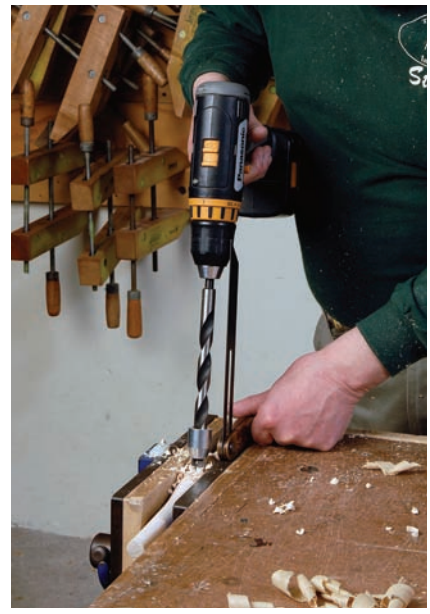
You need to first determine the stretcher-hole angles. This is another case where the

Cradle. *This simple cradle keeps the stretchers from rocking as you drill.*



An even plane. *Check to ensure your assembled "H" lies all in one plane.*

Workpiece determines angle. *A straightedge clamped across the legs at the rings will help you find the correct hole angle.*



Chairmaker's mantra. *Notice that I'm drilling from the top of the leg. To avoid drilling upside down, remember the mantra: "Top of leg to top of leg."*

Test-fit, then glue. *If the test-fit works out, go ahead and glue the legs into the top, tapping them lightly in place with a hammer.*

project gives you the information. Clamp a straightedge across the two legs at the decorative rings, as shown in the picture above.

The straightedge and the leg's centerline form the angle. Take the angle with a bevel square and use the tool to guide you while you drill the holes. (Here's another chairmaking secret: Sometimes chairmakers don't even know the angles they are using. They just measure from the chair.)

It is possible to drill the holes in the legs upside down. Notice in the picture above that I am drilling from the top of the leg. The tenon is sticking me in the thigh. To avoid drilling upside down, chairmakers repeat this mantra while drilling: "Top of leg to top of leg." Top of stool leg to top of chairmaker's leg. Do that and you'll always be safe.

Glue and Wedges

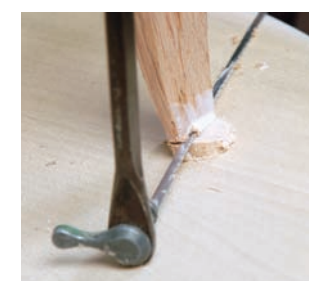
Glue and assemble. When all four legs are on the "H," test-fit the dry assembly to the top. If it works, take the stool apart and glue the legs into the top. Use a hammer to tap them tightly into place. The 12-ounce double-faced hammer I use is a traditional chairmaker's tool, called a framing hammer. Assembling the back was called "framing the chair." The hammer was also used in this process, which chairmakers called "legging up."

The leg tenons will not rely on glue alone. They need to be wedged. The wedges will serve two purposes. They spread the tenon and make it conform to the hole. Also, they key into the seat. This keying resists the torque caused by the shifting weight on the stool. Make your wedges so they taper both in width and thickness. I whittle my wedges from strips of scrap oak. Chairmaking creates piles of this scrap. We make so much that we have to burn it to avoid choking on scrap. After I drive a wedge and cut it off, I whittle the next wedge on the same piece of oak. I do not make individual wedges. It takes too long. Trying to cut wedges on the table or band saw is too risky for me.

Split the end of each leg with a chisel. (I never understand why some guys go through all the work of cutting a kerf on the band saw. The wedge has to fill the kerf before it can begin to fill the joint.) Make the splits run at right angles to the grain of the seat. Otherwise, the wedges can pop the seat into two pieces. Use a gouge to trim the excess

Chisel, not kerf. *I split the ends of each leg with a chisel – this takes far less time than moving to the band saw for a kerf cut.*

Tapered wedges. *Your wedges should taper in both width and thickness.*



Drive, then cut. *After I drive a wedge and cut it off, I whittle the next wedge from the same piece of oak.*

Shim to level. *Use shims to level the stool and measure the height from the top of the bench to the top of the stool.*

and to make the leg tenons flush with the seat. Sand the joints smooth.

Place the stool on a level benchtop or a table saw. Shim the bottoms of the legs until the top is level. Measure the height from the top of the bench to the top of the stool—not the bottom. That's another one of our mantras. Chairmakers measure top to top. Set a compass to whatever amount you need to trim (measured height minus 19) and scribe a line around the leg. Use a backsaw to cut on these marks.

Do some finish sanding and apply whatever finish you want. In our shop we like our stools in cheerful colors and use milk paint to achieve this.

Mark. *Mark a line around each leg to locate your cut.*

Gouge flush. *Use a gouge to trim the excess off the tenons, flush with the seat, then sand smooth.*

We also make a 24" stool. I have four of these around my kitchen counter. You do not have to make a lot of changes to make the taller stool. The first change is the leg shape. I like a baluster leg (see the photo at popularwoodworking.com/oct09). The 24" stool is a lot bigger than our shop stool. The more elaborate leg looks better. The hole angle is 17° in the top. If you use 21° like on the shop stool, the longer legs end up so far apart, you trip over them. The stretcher length is typically 11". The stretcher tenons are $1\frac{1}{8}$".

Now that you have a comfortable stool to sit on, it is time to think about using it to make a complete chair. **PW**

A chairmaker since 1971, Michael is the founder of The Windsor Institute in Hampton, N.H. (thewindsorinstitute.com).

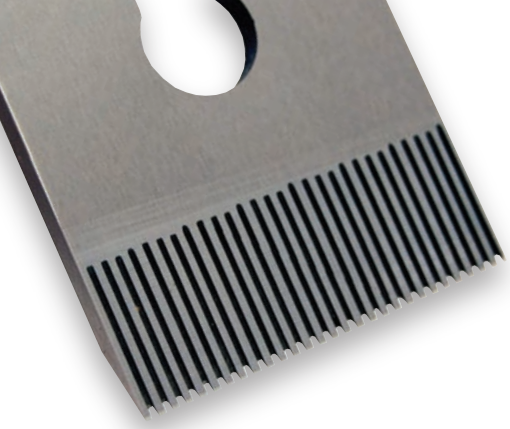
Cut. *Use a backsaw to cut the legs to length at your marked lines.*

Paying for Past Mistakes

When we are young we all make stupid mistakes that come back to haunt us the rest of our lives. I made a whopper and it has dogged me for years. In 1984, I published a book titled "Make a Windsor Chair with Michael Dunbar." In the book I described a wet/dry system of construction I had dreamed up. It was not an historical process. It came out of the ravings of my fevered brain. It involved turning the legs and stretchers from green wood. I then dried the tenons in hot sand. The idea was to let the wet joints shrink around the dry tenons. The method sounded good and it was one of those things that really wows other woodworkers.

I have since realized how stupid it is. I do not do it any more. I have not done it for years. I cringe when anyone brings it up. I repudiate it every chance I get. There is no way to reverse my mistake. It's out there in print. Every time someone else puts it in print, it continues to pursue its cursed life. Please forgive me. Please help me. Please pass the word. If you see someone doing it, tell them the idiot who started it begs them to stop.

I accept my fate. When I die I will spend an eternity in Chairmaker's Hell drying tenons in hot sand. It will be the only way to atone for this blunder. Don't condemn yourselves to sharing in my punishment. Turn chair parts out of dry wood and put your joints in compression. — MD



Machined teeth. *The teeth on this blade are .030" wide and spaced .030" apart. The teeth on the Veritas version are identical.*

Tiny Teeth Tame Tear-out

The grooves that smooth. *A toothed blade isn't just for prepping stock for veneer. You can also use it to eliminate tear-out.*

A toothed blade in your handplane magically eliminates ugly tearing.

BY DENEB PUCHALSKI

The recent renaissance of low-angle, bevel-up planes reintroduces us to a little-known plane blade: the toothed or grooving blade. There is written documentation from the early 19th century that this type of blade was used to flatten stock that had difficult grain. I am not sure why it fell out of general practice, but most people to whom I show this blade and working technique have never seen it before.

My first exposure to it came about four years ago, when Thomas Lie-Nielsen handed me a blade and told me to try it out. I was blown away by what it enabled me to do in woods that had previously been a struggle to work with.

A toothed blade gives you the ability to take very heavy shavings and remove a great deal of material quickly with little risk of tear-out. Slots in the back of the blade create "teeth" at the cutting edge when a bevel is ground on the blade.

The fact that the entire edge does not engage the wood continuously is what allows the toothed blade to succeed in situations where the wood is likely to tear out—such as when you are working against the grain, in highly figured material or in wood with an interlocking grain structure. The small chisel points, or teeth, do not cause the same lifting and tearing that a full-width blade does. The blade is also effective in very hard wood that will often resist an aggressive cut.

Why a Bevel-up Plane?

Traditionally, a toothed blade would be used in a standard bevel-down plane. Before Lie-Nielsen Toolworks reintroduced the No. 62 Low-angle Jack plane this was really the only option. The original Stanley No. 62 wasn't readily available to everyday woodworkers.

My preference for the low-angle or bevel-up planes comes from a few factors. There

The problem at hand. *Difficult woods, such as this curly maple, are vexing to surface with a standard blade. Tear-out, shown here, is a common malady.*

The solution. *Here's the same board after a few passes with a toothing blade. The tear-out has been removed, which will make less work for the next plane.*

PHOTOS BY SARAH EWING

Two planes in one. *One of the nice things about a bevel-up is how simple it is to swap the irons. I use one toothed iron for rough operations and follow up with a standard iron (shown on the bench).*

The traditional approach. *A common operation for a toothing iron was to use it in a scraping plane, or in a plane that was dedicated for a toothing operation.*

is no chipbreaker to jam up with the heavy shavings, and the changeover from a regular blade to a toothed one is very quick and simple – as is the adjustment of the throat from a normal narrow opening to a wider opening needed for a rough cut. Because these planes have a low bedding angle there is also less resistance to an aggressive roughing cut than there is in a bevel-down plane with a frog.

When working rough stock I use a jack plane for the initial leveling of the board. You can use a toothed blade in any size plane, but I find it most effective in a jack plane because of the length of the tool's sole. This ensures that as you remove material quickly you also introduce flatness to the piece due to the bearing surface of the plane.

Make no mistake, this toothed blade will not leave a clean finished surface. However, you will not be making more work for yourself by causing tear-out at the roughing stage. When working in woods with a tendency to tear out, the heavy cuts needed to get the job done quickly can also cause a lot of problems. The toothed blade will virtually eliminate those problems.

This is not your grandfather's veneer-prepping blade, which is the most common application for a toothed blade. Used in a scraping plane, a toothed blade creates more glue surface for applying veneer. This is more necessary when using hide glue than when using modern glues, which actually work better with a smooth surface. By its nature, a scraping plane does not allow the aggressive removal that you can get from the low-angle plane, though the basic cutting principals remain the same.

When it comes to rapid stock removal, simply setting your plane for a heavy shaving will let you remove material quickly. If you are going to use a regular blade for this you should put a heavy camber or radius on the blade. A cambered blade is easier than a straight blade to push through a heavy cut, but does not help stop tear-out if the stock has that tendency. If you are using this method you should make traversing cuts, meaning you are moving the plane at 90° degrees to the length of the board. Any diagonal or lengthwise cuts will result in

Create a cross hatch. *Work at 45° to the grain in one direction. Then work 45° to the grain in the other direction. The result will be a cross-hatch pattern that will help guide your next step.*

Clear the hatch. *Then remove the cross-hatch pattern by using the plane with the grain of the board.*

tear-out. This is where the benefits of the toothed blade begin to show. You can plane in any direction, regardless of grain direction or structure. Very quickly you will render the board flat. Then you will be able to clean up the tooth marks with surprisingly little effort, leaving a beautiful smooth surface.

Even if you are doing all your roughing with machines (such as a power jointer and power planer) you will still find a use for the toothed blade. Invariably when you process figured wood you end up with chip-out in the surface of the board where the grain acts up. These problem areas can be very difficult to clean up with a normal blade arrangement. You end up having to take very fine shavings to avoid tear-out and it takes a long time to get rid of the problem without causing more damage.

The toothed blade allows you to remove material very quickly without causing more problems and it saves you from resorting to your sander. A random-orbit sander will allow you to clean up some of these problems, but not, in my opinion, leave as desirable a finish as does a plane.

Sharpening and Setup

You might think that sharpening would be a problem, but it is no different than any other blade. I use a 30° secondary bevel, which gives the teeth a bit more durability and helps hasten the sharpening process. I recommend using a honing guide for these toothed blades because the tiny chisel teeth can easily gouge a stone if it is sharpened freehand.

When setting the blade up for use in a plane, set it for a heavy cut, but not as heavy as you will ultimately want. You want to create the tooth pattern in the stock before you try to go to your final depth of cut. That final depth will be as deep as you can manage without losing the effect of the toothed blade.

Beware: If you have more than half the depth of the teeth exposed out of the mouth of the plane, then you will begin to use the non-slotted portion of the blade. This will result in you taking a full-width, very heavy, shaving and cause the tear-out you were trying to avoid.

I prefer to do my rough flattening at a 45° angle, so that every pass is flattening the board in both length and width. I work evenly from both 45° directions to create a cross-hatched surface. The toothed blade

Then a light touch. *Before switching to a standard blade, put a light cross-hatch back on the board to make the next step easier.*

leaves behind a series of grooves that you can "read" to tell what is happening on the piece of stock. When you get a continuous cut in every direction, you know that the board is reasonably flat and it is ready to clean up. I then plane the length of the board to ensure that it is flat in both length and width.

My last passes with the toothed blade will leave long continuous grooves in the length of the board. As a final step with the toothed blade I make one more series of passes at a 45° angle across those grooves with just the weight of the plane making the cut. This will reintroduce a cross hatch, but it also gets rid of half of the material that needs to be eliminated to achieve a smooth surface.

To get a board from its rough toothed state to a smooth finish you will probably want to use a plane with a high cutting angle. The material is more than likely prone to tear-out or you would not have needed the toothed blade to begin with.

To achieve a high-angle cut with the same low-angle jack that you were using for the rough work, simply sharpen a secondary bevel on its normal blade that will give an

Final cleanup. *With the board flat and free from tear-out, you can then switch to a standard blade to produce your finished surface.*

appropriate working angle. The blade is bedded in the tool at 12°, so subtract 12 from whatever your desired angle is to determine the secondary bevel angle. I will work as steep as 62° if the material is particularly hard or nasty. (A 50° secondary bevel would give you a 62° working angle.) Typically, a 50° working angle is enough, though. To achieve a 50° working angle, use a 38° secondary bevel.

If you have never tried a toothed blade, you will find that it is a very valuable and versatile addition to your quiver of tools. It gives you the ability to quickly and safely work down some stock that you may not have been able to or dared to work before. **PW**

Deneb Puchalski is senior sales representative and show coordinator with Lie-Nielsen Toolworks in Warren, Maine.

Sources

Lie-Nielsen Toolworks
lie-nielsen.com
or 800-327-2520

- Sells toothing blades for both bevel-down and bevel-up bench planes, block planes and scraper planes

Lee Valley Tools
leevalley.com
or 800-871-8158

- Sells toothing blades for bevel-up, block and scraping planes

Tools for Working Wood
toolsforworkingwood.com
or 800-426-4613

- Sells Ray Iles toothing blades for block planes

It only looks easy. Successful gluing is a complex process involving many factors and decisions.

Understanding

GLUES: PART 2

Prepare your wood, pick the right glue and prevent problems.

BY MARC ADAMS

Baseball bats, utensils, turned items and small carved objects are usually made from one piece of wood. But most woodworking projects are made under the premise of "some assembly required." Face it: Most everything we make with wood involves one or more boards joined together. Without something to tie those boards together there is no gain in structural integrity.

There are several ways to secure boards together. The first is with a mechanical fastener such as nails, screws or bolts. Mechanical bonds are point-specific and once the fastener is removed the bond is lost. The second way is worked joints, where interlocking or fitted wood pieces join together. Worked joints include dovetails, mortise-and-tenons, dowel joints and housed joints. The third way to join wood is to use some kind of glue. When properly used, most modern glues are stronger than the wood they are used on. A fourth way to join wood is to combine two or more of these methods.

Glue is the most often used means of joining wood and by far the most misunderstood. Cutting a dovetail is a learned skill. Gluing two boards together is much easier. But in the long run it's the glue between those dovetails that locks them together and it's the glue that will continue to hold them together throughout time.

If the glue fails you can bet that the joint will fail. However, if the joint fails it might not mean that the glue has failed as well. I believe that understanding how to glue wood together is an inherited trait – we just know how to use it. Nobody ever teaches us how to put the stuff on or explains how it works.

And the two most common factors of gluing two pieces of wood together are almost never considered: the wood and the glue. Before you grab a bottle of glue for your next project ask yourself these simple questions. How should the wood be prepared? What glue is best for this specific task? What is the correct procedure for applying glue, and how can I avoid gluing problems and correct them if they happen?

Prepare the Wood for Gluing

Any wood that is to be glued together should have the same moisture content and be at the same ambient air temperature. Good practice is to place both the wood and glue in the same environment for at least 24 hours before machining and gluing to allow both the wood and glue to acclimate. This will take place automatically if you store everything in the same relatively warm place.

The moisture content of the wood when glued should be the same moisture content that it will have once the glued pieces are put into service. The average moisture content for interior woodworking is around 8 percent, but that can vary a few points depending on where you live. Exterior wood averages between 12-18 percent moisture content. The higher the moisture content, the more challenges there are with curing.

How wood is machined before gluing is especially important. Mating wood surfaces should be smooth, flat, have parallel surfaces and be free from damage to make good contact. Machined wood, such as wood processed on a jointer or planer, has a rough uneven surface when viewed under a microscope. When two pieces of machined wood are brought together the surfaces only touch at certain places and can easily be pulled apart. However there have been times when I've handplaned the surface of two pieces of wood and set them on top of each other and had a difficult time separating them (this is called "specific adhesion").

Imagine the effectiveness of a glue joint if you have a perfectly cut surface of the mating parts. At one time I was told that you should roughen the surfaces of the mating parts, but this can damage the wood cells and add dust fibers to the pores and hinder the wettablilty of the glue. A smooth, knife-cut surface is best for bonding.

Glue manufactures recommend that you glue your wood together when it is freshly cut. A good rule is to try to cut and glue in the same day. The longer the wood has to set before being glued, the more opportunity there is for damage, contamination and moisture changes at the surface. Gluing wood sooner rather than later also minimizes the chance for any distortion in the wood. A clean and dry surface is essential.

It's a good idea to make a trial assembly. All joints and parts should fit together without excessive clamp pressure. If you have to force a joint together you will be gluing stresses into the project that may cause the joints to fail. A test run will ensure that your clamps are open and ready and that you have thought through the gluing sequence.

It's a good idea to use small blocks of wood between the clamp and wood to protect finished and exposed surfaces and disperse the point pressure.

Selecting a Glue

More than likely you have in your shop a half-empty bottle of yellow glue with no cap on it. I guess the crusty glue around the spout serves a purpose after all. Don't worry, this qualifies you as a typical woodworker.

However, I have to ask a few questions: Is yellow glue really the best choice when it

PHOTOS BY AL PARRISH

comes to bending wood or veneering? Would it be the best choice for gluing together green wood for bowl blanks or exotic woods for a cutting board or for outdoor furniture?

Would you use yellow glue for gluing down a laminate countertop or a plastic cover over a fixture? Is yellow glue the best glue for inlay work which might involve wood, stone, shell, metal or leather? Is it the best choice for restoration, conservation or repairing a chair? Or what about the joinery on fine furniture? Would it be the best choice for cabinets that will be subjected to high heat or moist environments?

Don't get me wrong, yellow glue is a great product, but for many woodworking situations there is a better choice. Choosing the right glue can be a tough decision, especially with so many choices. Work-ability, bond-ability and price are key considerations. The following is an explanation of the seven families of glue used in woodworking.

Hide Glue

Hide glue comes from animals and is one of the oldest known glues. It's sold by gram strength, a complex test of physical characteristics and rigidity under specific conditions. There are grades of hide glue ranging from 85- to 512-gram strength. Woodworkers typically use hide glue at a gram strength between 164 (longer assembly time) to 251 (fast assembly time).

Flake or pearl hide glue must be mixed with water and heated in a double boiler or glue pot to about 140°. The goal is to make a liquid of about the viscosity of white or yellow glue. As the water in the glue pot evaporates you need to add in more. In the old days you could tell where the cabinet shops were by smell; hide glues can have a strong odor if not prepared or used properly.

Rub the right way. *Hide glue grabs as it cools, making it possible to make complex assemblies without the use of clamps.*

Hide glue bonds as it cools to create a strong union that is reversible and resistant to creep in the joint. Because it grabs as it cools, the need for clamps can be eliminated, so complicated angles can easily be glued. It sands well, can take stain, has an indefinite shelf life in dry form, and what you don't use today can be recycled for future use.

It's a resilient glue that is great for interior furniture and cabinets but it has no ability to withstand exposure to water. Hide glue is one of the glues of choice for period furniture makers, conservators, musical instrument makers and fine furniture makers. With practice it is a great glue for veneering.

Hide glue is available in traditional form and in a ready-to-use liquid. Liquid hide glue has anti-gelling agents to prevent it from getting hard in the bottle and it cures through moisture loss rather than cooling so it has a longer open time. Liquid hide glues have a shelf life of about a year.

PVA and Aliphatic Resins

White (polyvinyl acetate) and yellow (aliphatic resin) glues are in the thermoplastic family and are made from synthetic compounds. Both are ready to use from the bottle, water-based, have low to no odor and are non-flammable. White and yellow glues are temperature sensitive, have a high degree of strength and are used for interior work.

They're best suited for well-seasoned wood and have about the same bond strength. They cure in about 24 hours in normal conditions. Neither is water resistant; chemically they have similar characteristics. Both shrink while curing as they lose water. Neither is hard enough for structural bonds. There are cross-linking polyvinyl acetates (PVAs) available that are rated as weather-proof (Type II) or waterproof (Type III).

White glues were introduced in the late 1930s and are one of the handiest glues available. They dry clear (not transparent), have great strength, provide some gap filling properties and cure at room temperature. White glue has a longer working time than yellow glue. It is also a little thinner and has a little less initial tack than yellow glue. Some furniture makers prefer white glue for these reasons. Some downsides are that it is not stainable and it can allow the wood to creep when movement takes place. White glue also tends to clog sandpaper.

Good old glues. *Polyvinyl acetates (White) and aliphatic resins (Yellow) are standard all around woodworking glues.*

Yellow glues hit the scene in the early 1960s. They are white glues with additives (resins) that give them different characteristics. Yellow glues are thicker, tack faster and can be applied in cooler temperatures than white glues. They have a shorter work time and a faster clamp time and offer slightly better resistance to heat, but they are still temperature sensitive. Yellow glues are less likely to allow joints to creep. They sand much better than white glues (but still can clog sandpaper). Yellow glues have a better ability to bond to woods with slightly higher moisture contents.

Some downsides of yellow glues are that they dry with a yellow line that is noticeable in light-colored woods. They also have a shorter working time which can cause some urgency when applying. Yellow glues are great for interior furniture and cabinets, especially in production work.

"Cross-linking" and "Specific Purpose" PVAs are formulated to be water resistant or waterproof, and some can be cured by radio frequency. There are special glues with non-drip formulas, extending agents which allow for a greater working time, gap filling, non-bleeding glues for veneering and even a version that shows under UV light. They even make PVA glues with glitter in them.

Urea Formaldehyde

Urea formaldehydes (also referred to as plastic resins) are water, heat and creep resistant. They are great glues for most indoor furniture and cabinets. They are in the family

of thermoset plastics that cure chemically and require mixing to harden. They spread easily and are impervious to most solvents once they cure. Resin glues tend to generate heat as they cure which can cause issues with some inlay materials. They have a long working time which causes the clamp time to be long as well, up to 12 hours.

They are temperature sensitive during curing and must be applied at 72° Fahrenheit or more. After they cure, temperature is not an issue. They are not the best gap-filling glues and they have a darker color, although some manufactures sell additives that lighten the resin. Resin glues can also be cured through a process called "high frequency gluing," which takes the normal cure time from 24 hours to just a few minutes.

Urea formaldehyde is one of the best choices for veneering, laminate bending, structural applications, and cabinets and furniture that could be exposed to excessive heat or higher humidity.

Some of the downsides are that they have a short shelf life and can cause health problems. They require carbide cutters when cutting because the cured hardness is brutal on tools (as is cured squeeze-out on hands). Wear safety glasses and a dust mask when working, machining or sanding.

Epoxy

Epoxies are great waterproof glues. They are two-part glues that produce strong bonds on many different materials including some plastics, stone, metals, ceramics, plastic laminates and resinous woods such as teak or rosewood. Epoxy loses about 1 percent of its volume as it hardens so there is basically no shrinkage, which makes it a good gap-filling glue. It dries with a clear or slight yellow color, but non-yellowing and high-clarity epoxies are available. It's also possible to add dyes to turn it any color you wish.

Epoxies can be rolled, brushed or troweled and they can penetrate wet surfaces well, but they have little or no initial tack, so clamping is important to keep parts from sliding. Clamp pressure should be light with epoxies to prevent total glue squeeze out. Epoxies sand easily and are solvent-resistant but they are not heat- or UV-resistant.

Epoxies are a great choice for outdoor furniture, boatbuilding, working with exotic lumbers, inlaying just about anything and structural applications. They are shock resistant and thus perfect for gluing together items like wooden mallets.

Polyurethane

Polyurethane glues have been around for quite some time but didn't hit the American woodworking market until the early 1990s. Polyurethane glues have about the same cured strength as yellow glues and stick to just about anything. They foam during the curing process, and the foam that fills gaps is largely air, not solids.

At first they were touted as waterproof but they are only water-resistant. Polyurethanes

Filled with foam. *Polyurethane glues foam as they cure. This adds no strength to any gaps and can be a pain to remove.*

are heat-resistant and rigid so they are good at resisting creep along joint lines. They are activated by moisture so dry wood should be moistened first and they offer about a 45-minute working time.

Because polyurethane glues have a tendency to sit on the surface of the wood instead of being absorbed into it as with water-based glues, they won't create a staining issue if cleaned off properly. However any polyurethane that remains on the surface will not accept stain. It's a good glue choice for outdoor furniture. Polyurethane glues are difficult to clean up while they are still liquid but once cured they can be sanded or chiseled off. They work well with exotic woods and do not have a tendency to become brittle with age like most glues. They have a short shelf life and are expensive.

Wear gloves when you apply it and be prepared for some real challenges during cleanup around the joint because of the expanded foam created as the glue cures. Polyurethane glues will bond anything to anything and they excel at gluing woods with higher moisture contents.

Cyanoacrylates or Super Glues

Super glues were developed at Kodak Laboratories in 1942 but were shelved for several years until the 1960s when they were introduced through the TV show "I've Got a Secret." They were submitted to the FDA as a material to hold human tissue together for surgery. Today super glues have found their way into every imaginable application.

Super glues cure to a solid that is similar to a sheet of acrylic. They can be activated by many ways depending on the formulation but the most common way is by reacting with the water in the wood. If you choose to use an activator or accelerator be aware that the bond will be slightly weaker and

Flat forever. *Plastic resins form an ideal bond for complex veneering (as in this table made by Markee Adams) and other tasks where creeping is an issue.*

more brittle. They are expensive, have a short shelf life but set in a matter of seconds. They have great pull strength but not very good shear strength. Super glues come in different viscosities and the thicker formulations have good gap-filling properties. They resist moisture but can't handle heat. They sand fairly well but don't take stains.

They are great in woodworking for quick fixes and repairs, and are often used as wood filler with veneers and woodturnings. Be careful using accelerator on woods that are finished. CA glues are not suited for most wooden joinery but are handy for craft items. It is now believed that CA glue bonds get brittle in a very short time period which can cause varying degrees of failure.

Quick fix. *Cyanoacrylates (super glues) don't have much strength, but are ideal for quick repairs.*

Under pressure. *Contact cements grab immediately, but need pressure applied to form a complete bond.*

Contact Adhesives

Contact adhesives are made from synthetic rubber compounds. They offer an initial tack better than any other glue, and are typically used to bond laminate or veneer to a substrate, or to bond any other impervious surfaces. There are two primary types: solvent-based and water-based but both offer the same characteristics when cured.

Do not use water-based contact to bond anything to steel or iron. In the long run, contact adhesives have a low resistance to heat, cold and solvents. Contact adhesives are not structural and have no strength. They do not restrict the movement between the parts, so the core or substrate moves independently to whatever is bonded to it.

Contact adhesives are applied to both surfaces by brushing, rolling, spraying or using a trowel. As the solvents evaporate, water can condense on the surface of the rubber. This water must be removed through heat or evaporation before the bond is made. Contrary to most articles that say that pressure is not necessary, it takes 45 pounds of pressure per lineal inch to make a bond. This is typically accomplished by rolling the surface with a "J" roller.

The Gluing Process

When properly used, most modern glues are stronger than the wood. But the method you use can dramatically affect the results. If you are using a specific glue for the first time read the instructions, do some research, ask questions and consider doing a test glue-up. Each step in gluing, from selecting the best glue to the correct ways to apply it, to the final cure is a factor in attaining the full potential from the glue. Do a dry run and consider the effect of air temperature and humidity on the entire process.

Glue doesn't just go bad from one day to the next. But it loses some of its effectiveness over time – especially if incorrectly handled, stored or misused. For the most part, glues are usable as long as they are spreadable according to the instructions from the manufacturer. A good rule when buying glue is to only purchase what you think you will use within the next year. I write the date on my glue bottle with a marker when I open it. If your glue is unusually thick, has changed color, smells funny or is lumpy it's probably time to dispose of it.

Pot life is similar to shelf life, but is much more immediate. Pot life applies to glues that get mixed and the proportions of that mix. Once mixed the glue will start to coagulate and set. There is a definite time between being spreadable and becoming hard.

Surface Prep and Spreading

Make sure the wood to be bonded is dry, clean and free from dust and debris. Ideally, wood should be freshly cut with smooth surfaces. The joint should have intimate fiber contact between pieces. I consider the best joint to have slight friction between the mating parts – not so tight that they have to be hammered together and not so loose that they have no fiber contact.

Properly cut surfaces help ensure the glue can be spread and absorbed uniformly over the mating fibers of each piece of wood.

A uniform spread of glue that covers the surface of both mating parts is important. Glue can be applied to one surface (a single spread) or to both surfaces (a double spread) and can be applied with a brush, roller, stick or right from the bottle. Some people use their index finger to spread the glue. Luthiers use their little finger to keep the index finger clean for handling the wood and clamps.

Regardless of the method, the purpose in spreading glue is to distribute an adequate amount with uniform thickness over the entire area to be bonded. When pressure is applied the glue will flow into a uniform thin layer. A thin glue line is the best glue line. The amount of glue on the surfaces to be joined depends on the wood species, moisture or resin content, type of adhesive, temperature and humidity, and whether you use a single or double spread.

Getting the right amount of glue is hard to control. Too much is wasteful, hard to clean up and can add excess water to the joint. Too little can reduce needed working time or result in a starved joint and poor bond.

Open and Closed Assembly Time

Assembly time is the total time between spreading the glue and applying the clamps. Open time is the time between when the glue is applied to the time the two surfaces

Online EXTRAS

To download a list of Marc's tips for successful gluing, visit:

popularwoodworking.com/oct09

Spread the pressure. *Blocks between the clamps and the work prevent damage, and increase the area under pressure.*

are placed together. Closed time is the time the pieces remain in contact before pressure is applied.

During open time, glue on the surface of each part is absorbing into the fibers while at the same time evaporating in the surrounding air. This causes the spread to change consistency and become tackier. When the boards are brought together and before the clamps go on (closed time), the glue is still absorbing into the fiber but evaporation stops. Curing of water-based glues involves both absorption and evaporation. Open time to closed time is a critical part of the curing process but is usually never considered.

Clamping boards together after closing the joint serves three main purposes. First it brings the mating boards tightly together forcing out the excess glue; a thin glue line or tight joint results in a stronger and inconspicuous joint. Second, pressure is used to force the glue to penetrate into the wood surface for more effective mechanical interlocking. And third it helps hold the wood together while the glue cures.

Clamping pressures should be adjusted according to the density of the wood, and at normal room temperature it is important that the glue is still fluid when the pressure is applied. Use a protective pad or caul to help keep the clamp from damaging the wood, and – more important – direct and distribute clamping pressure over a broader area. When pressure is correctly applied, a small bead of glue will squeeze out along the glue line. This should be allowed to dry then scraped away.

Clamp Time

Wood should stay clamped until the joint has gained enough strength to withstand handling stresses that might knock the pieces apart. Under normal conditions, clamp time can be as little as 15 minutes but it can also be as long as 24 hours depending on the temperature of the room, the curing characteristics of the glue, the design and fit of the parts, and the thickness, density and absorptive characteristics of the wood.

Heat can be used to speed up clamp time, such as turning up the heat in your shop, placing an electric blanket over the joint, or hitting the joint with a blow dryer. Don't place freshly glued wooden items in direct sunlight. Clamp time is almost always listed on the label as a guide to how quickly you can remove your clamps. There's nothing wrong with leaving the clamps overnight. If you do leave your clamps on for extended periods of time, put wax paper between the clamp and the glue to prevent staining.

Cure time is the time it takes for the glue to reach its final state. Most glues reach total cure within 24 hours, but of course that depends on all the steps. Usually during this process water from the glue is distributed throughout the joint and equalizes with the surrounding wood. It is at this point that the glue will start to fulfill its obligation for strength, durability and performance. Once the glue has cured machining can begin.

Gluing Problems

One way to avoid gluing problems is to do every step in the process perfectly. Well that eliminates just about all of us. Gluing problems are the nightmare of all woodworkers and if you've done your share of woodworking, you have likely experienced some kind of glue failure. When a problem occurs, as painful as it is, it is a great opportunity to learn. Start by asking what caused the problem and what can be done to prevent it from happening again. Usually joint failure, specific to glue, is caused because of one or more of the following reasons:

Did you choose the best glue for the application? For example if you are gluing teak with white glue it will probably fail. Make sure the glue you use is fresh, looks and smells right, and spreads normally.

Wood preparation is also important to successful gluing. Is your wood properly conditioned, dry, clean on the surface, well cut and does it mate with the other piece of wood without creating any additional stresses?

Pressure and clamping issues are another reason glue joints fail. The purpose of pressure is to bring the mating faces tightly together forcing out the excess glue. The total amount of pressure varies for different reasons including the density of the wood and the type of assembly. Pressure can be responsible for either a starved glue joint or a thick glue joint – either will fail in time.

Fit of the joint. Face it, if the joint is sloppy or overly tight the glue joint can fail. Remember the ideal joint involves intimate fiber contact between the mating pieces.

Joint design is sometimes the main reason a glue joint fails. A joint under extreme stress can fail regardless of the type of glue. The weakest point of any structure is at the joint. Also keep in mind the direction of the grain in a joint, such as end grain to end grain, long grain to long grain and long grain to end grain. Remember some glues can allow creep to take place in these conditions.

The environment is usually the most punishing problem with glue joint failure. Heat can destroy thermoplastic glue joints. Direct water, intermittent water, and high and low humidity can take their toll as well. UV light is often overlooked and just plain air can oxidize wood in ways that we might not believe. **PW**

Marc Adams is the founder of the Marc Adams School of Woodworking in Franklin, Ind., one of the largest woodworking schools in the world. For details, visit marcadams.com or call 317-535-4013.

Scholars question whether or not these boxes actually held the family's Bible. Regardless, this Pennsylvania-designed box deserves high praise.

Inlaid (Bible?) Box

BY GLEN D. HUEY

From the minute I brought this lidded box into the *Popular Woodworking* office, debate began. I called it a Bible box, but some wondered where that term originated. Is it a name coined by those interested in building an interest in these boxes so they could sell them for a profit? Or is that term what the original owner used in 1730?

You can call it a Bible box, a lidded box or whatever you like. I'm going to call it a great project that is an introduction to, or a chance to practice and improve upon, many woodworking techniques, from lathe work to shop-made herringbone inlay to half-blind dovetails. And it's a project that I've had on my "to build" list for many years.

Four Dovetailed Corners

This box is assembled with half-blind dovetails at both the front and rear. Half-blind dovetails are required on the front, because you need an un-interrupted surface for the inlay. You could join the rear corners of the box with through-dovetails as was done on the original, but I chose to keep the joinery the same at both front and back so I could choose the best-looking joints for the front of my box after it was assembled.

Whether it's pins first or tails first for you, the pin boards should be the front and rear box pieces. Cut your tails in the end pieces. I set the marking gauge to leave 1/8" thickness between the pins and the face of the boards. As I worked on the dovetails, I had no troubles. Later, however, as the grooves were cut for the inlay, I found that this thin area was rather delicate and weak. So when I build another box, I'll mark the thickness at around 3/16" (if you leave it too thick, the tails begin to lose their holding power, especially if you're using a 1:6 dovetail ratio – I use a 12° dovetail angle).

Thin, but not too. *With 5/8" material, you'll want to leave an area beyond the dovetails that's thick, but anything extra is pulled from the dovetails and that causes tedious work at the joints.*

Go past the line. *Over-cut lines are found on many, if not most, of the antique pieces we hold in the highest esteem. The extra sawing pays dividends as you remove the waste material to form the pins.*

If you're new to dovetails, there's tons of information available, scads of articles written and more than a few videos that will walk you through the dovetail process. So as not to be redundant (and for brevity), I'll relate just a couple dovetail pointers that I find helpful.

First, do the layout work on your box pieces. To this day, I saw lines that are drawn on the workpieces and extend the saw cuts beyond the baseline on the face of the pin board – hold to the lines on the pin board ends.

Second, as you begin to remove that waste, take small cuts at the corners of the dovetail area and work slowly. As your chisel displaces the waste, it drives the material upward against the pin – any damage is there forever. If you work slowly and in small steps, the chisel drives the waste upward and along the beveled edge of the pin; this process keeps the pins intact. Work both corners of the waste, then remove the center portion as you progress to the scribe line.

Tweak the corners. *Work carefully as you remove the waste to create the pins. If the edge becomes damaged, it shows forever.*

Pinpoint accuracy. *Lip the marking gauge cutter just past the end of the tail socket to ensure the tails are the correct length.*

Another tip for half-blind dovetails deals with how you set your marking gauge when establishing the baseline for your tails. It's best to set the gauge wheel or cutter just past the previously scribed baseline of the pin board as shown in the photo at left. This ensures the resulting tails are the exact length needed to fill the area without any small gaps in the fit.

Scribe your box end pieces on both faces, then position the pin board to transfer the layout to your tail board. It's helpful to find

LEAD PHOTO BY AL PARRISH; STEP PHOTOS BY THE AUTHOR; ILLUSTRATIONS BY ROBERT W. LANG

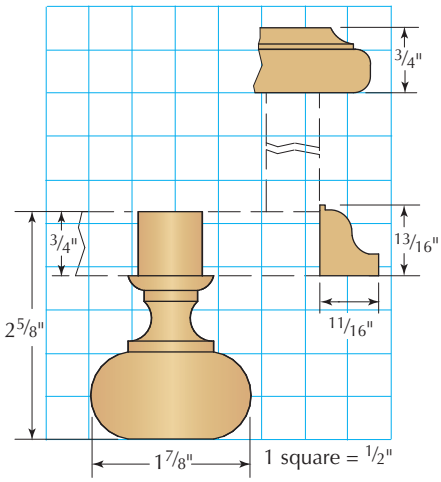
a way to hold the pin board vertical so you can slip the tail board into position (just at the scribe line) while you keep your hands free from a balancing act as the layout is transferred.

Complete and test-fit your joints, but don't glue up any of the corners yet. There is still work to do to prepare for the herringbone inlay.

Bottoms Up

With final dimensions available from the completed box, we can size the box bottom and turn and install the ball feet.

The ball feet in this project are a great introduction to turning. The sizes are small, but the turning is detailed. Chuck your stock into the lathe and turn four feet to profile, keeping these thoughts in mind as you turn: The four feet are positioned at the corners of the box, set away from each other. In fact, each foot is located away from the corner, as well, presenting a shadowy overhang that covers a portion of the foot. Also, the feet are 1 7/8" tall, so it's all-but-impossible to see more than two of the feet at any one time as the box sits.



FOOT & MOULDING DETAILS

Perfectly matched. *Make sure your tail board is matched to the pin board as you transfer the layout. Any variations affect your joint fit.*

What I'm driving at is that you should turn the feet as close to the provided profile as you can, but please don't get caught up in the idea that each foot should be perfect. Don't get bogged down in the process and become discouraged. The feet aren't the focus of the piece. Just get them turned as nicely as you can then move on.

That said, there is one part of the turning that should be accurate – the tenon that's used to attach the feet to the box bottom. The tenons need to be properly sized so you can drill a hole (3/4"), slide the feet into the bottom and have a snug fit. A trick I like when sizing turnings to a specific measurement is to use an open-ended wrench as a gauge. Turn the tenon area to an approximate size, then continually check the size with a wrench that matches the specific measurement you're after.

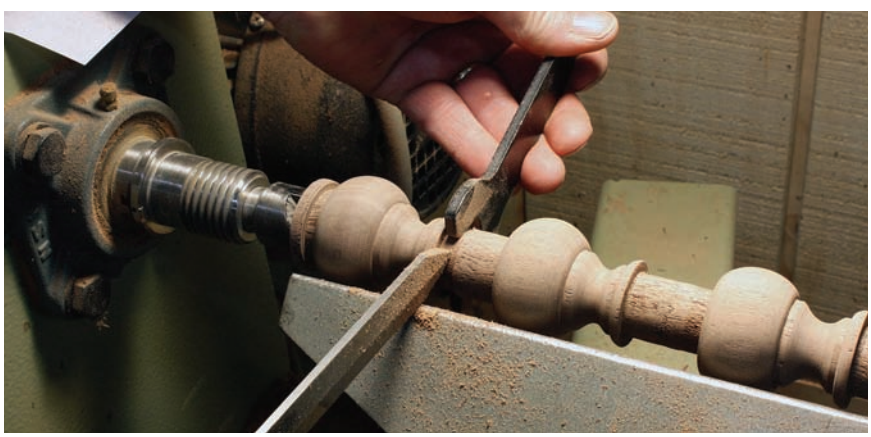
Mill your box bottom to size (based on your joined box) and to thickness. This is a place to use lesser-quality lumber. My box bottom contains several areas of sapwood that I would never use in a "show" position.

Set your marking gauge to 1 3/4" then find the location for each of the four feet as shown below. After the lines are set, the holes need to be bored completely through the bottom. If a drill press is your tool of choice, there are no worries. But if you're into hand tools and plan to use a brace and bit, make sure the hole is bored at 90° to the face. The foot has to fit square to the bottom to keep the look right.

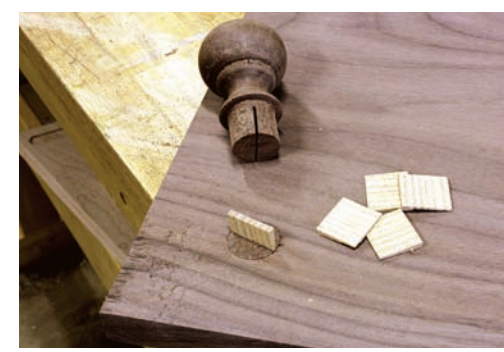
Slide each foot tenon into its hole then cut the length of the tenons to match the thickness of the bottom. Each tenon is wedged after it is installed through the box bottom. (I made the wedges from a scrap of oak I had in the shop, but any wood does the job.) Make a single cut across the grain of the foot for the wedge. Placing the cut across the growth rings allows the tenon to expand and tighten to the hole as the wedge is inserted without the possibility that the foot could split as the wedge is driven – as might be the case if the cut was parallel to the growth rings.

Slide the tenon into the hole ensuring that the foot is tight to the underside of the

Marked for boring. *A marking gauge easily sets the location for the feet tenons. Mark from each corner to find the hole's center.*



Wrenched to size. *Feet tenons need to fit tight, so an easy measurement setter is an open-ended wrench. Work slowly; as the wrench slides over the tenon, the tenon is the right size.*



Tight fit becomes tighter. *The fit of the foot tenons to their holes should be snug, but add a wedge in each saw cut and the fit is locked in place. Cut the wedge flush after installation.*

bottom, add a small amount of glue on the wedge then drive the piece into the tenon. Complete the installation of all four feet, trim the extra wedge length from each wedge then set the assembly aside.

Inlay Preparation

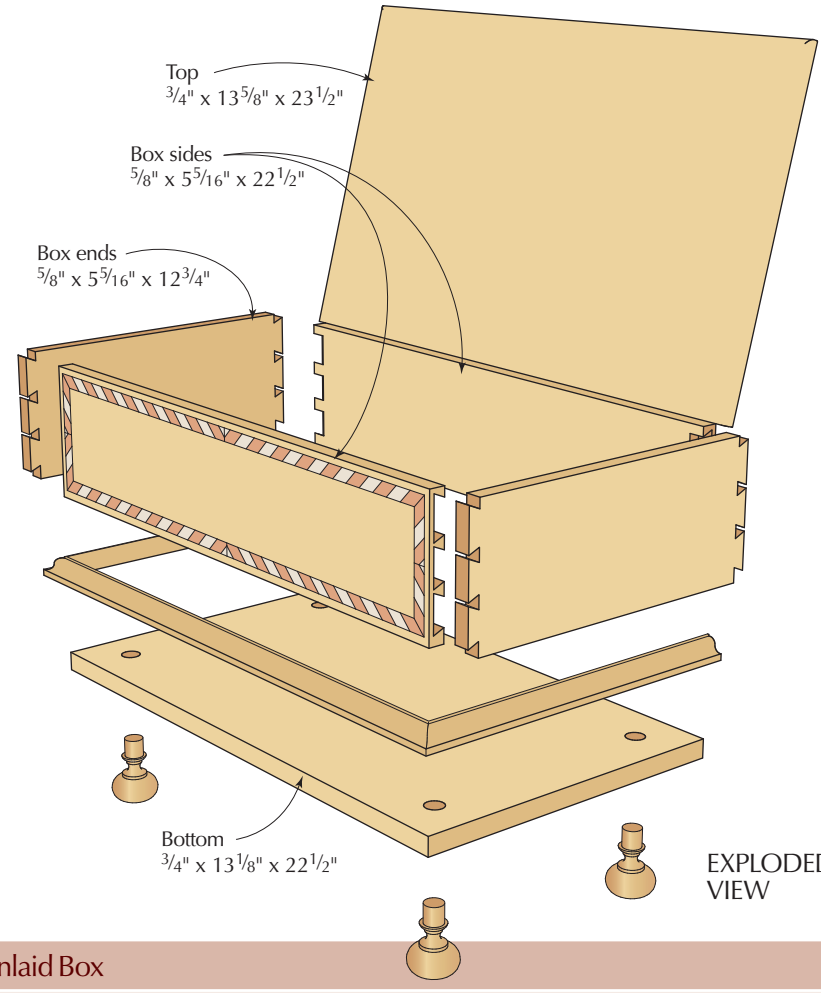
The grooves for the inlay are cut at a router table with a drop-cut action. The process is not difficult, but does require accuracy in set-up. You may wish to make the grooves with a plunge router – if you're more comfortable using that tool, go for it.

Step one is to position the router table fence after a bit is installed. The groove is 1/2" wide and 3/32" deep and any straight 1/2"-diameter router bit works. Position the fence with a 1/4" between the blade and the fence. Use a scrap to test and adjust the fence setting; the final position is important.

Next mark lines on your fence to indicate the exact cut of the router bit – one mark on each side of the bit. To find the lines, slide a square end of an offcut to just touch the router bit cutting edge (with the tool unplugged, of course). Rotate the bit until the cut-off stops being pushed away from the bit. Mark that location on your fence. Repeat the same process on the other side of the bit.

There is some layout work on the front piece to establish the start and stop lines of the router cut. With the distance between the fence and the router bit set at 1/4" (that leaves a 1/4" of box front before the inlay begins), you need to match that distance with the start and stop lines. Pull in a 1/4" from each corner and make a pencil line on the backside of the box front.

The idea is to drop-cut the workpiece onto the router bit with the start line aligned



Inlaid Box

	NO.	ITEM	DIMENSIONS (INCHES) T	W	L	MATERIAL	COMMENTS
❑	2	Box sides	5/8	5 5/16	22 1/2	Walnut	
❑	2	Box ends	5/8	5 5/16	12 3/4	Walnut	
❑	1	Bottom	3/4	13 1/8	22 1/2	Walnut	
❑	4	Feet	1 7/8	1 7/8	2 5/8	Walnut	
❑	1	Top	3/4	13 5/8	23 1/2	Walnut	
❑	10	#1 Inlay	3/4	7/16	12	Cherry	
❑	10	#2 Inlay	3/4	7/16	12	Maple	
❑	1	Stringing	3/4	3	12	Maple	1/16" strips
❑	4	Wedges	3/4	1/8	5/8	Oak	Cut from wide piece

Define the cut. *It's important to establish the router bits start and stop cut lines to accurately create the inlay grooves. Rotate the bit to determine the edge of the cut then mark both locations on an auxiliary fence that's locked in position.*

Plunge cut at the start. *Layout lines on the rear of the box front are matched to the layout lines on the fence in order to accurately cut the inlay groove. The start of the cut is shown here.*

Move with slow and steady hands. *As the trailing line aligns with the second fence line, the groove is complete. It's better to stay short of the lines and finish the groove with a chisel.*

with the proper line on the router table fence. Continue through the cut until the stop line aligns with the opposite fence line, then remove the workpiece from the cut.

I've found that it's best to stay shy of the fence lines whether you are at the start or the stop end of the cut. That way you won't cut away too much wood, and you can clean up and straighten the grooves with your chisels. You'll need to square each corner by hand anyway.

The grooves for the long sides of the box front are easy to rout. It's the short ends that are a bit trickier – it's harder to keep the box front square and tight to the router fence as you work. Work these two cuts with care. After the grooves are complete, straighten any lines and square the corners.

Scraps of design. *There's nothing more satisfying than to use shop scraps. Here you see the beginning of the shop-made inlay. Positioning the pieces at a 45° angle as assembled increases the yield of inlay.*

Shop-made Herringbone

Most of us have scrap piled high in our shops. The inlay used on the front of this box puts some of that scrap to work. The process is simple. You add a personal touch to the box and you'll save money because you don't have to purchase the inlay.

For starters, select a couple woods that complement your box. I like cherry and maple for inlay into a walnut box, but the original piece only had white cedar as the inlay. Whether you use hardwood or softwood, the creative steps are the same.

Begin with 10 strips of each color that are 3/4" thick and 7/16" wide; wider strips begin to look too bulky in the completed inlay. Alternate the species then assemble the pieces into a plank. To save material (even scraps are valuable!), glue the pieces at or near a 45° angle as shown at left.

After the glue-up dries, flatten both faces parallel to one another, keeping the panel as thick as possible. Cut the assembly at 45° to create an edge to take small rips off of. Next, slice the 3/8"-thick pieces from the panel. Why 3/8"? You need to work the inlay to fit into the 1/2" groove cut in the box front, so with the herringbone at 3/8" you can add a 1/16" piece of string to both sides to arrive at the 1/2" size.

To make the 1/16" stringing pieces, rip pieces from wide stock at your table saw. Mill and square a piece of stock then just cut the stock at the table saw so as to clean up the second edge – note the fence setting. Next, slide the fence toward the blade enough to

Not a random rip. *Sizing the pieces of assembled scraps is important to the overall task. All the parts of the inlay add up to match the width of your groove.*

Thin is in. *String pieces border the herringbone strips. Set your fence to leave the string pieces as cutoffs – that's the safest method to produce multiple thin pieces.*

It's good to be strong. *Inlay pieces assembled with glue and clamped with rubber bands are slightly wider than the groove size.*

The last step. *Strips of herringbone inlay are ripped at a band saw to produce the final pieces. Plane the faces before work at the band saw commences and keep the pieces thicker than the groove is deep.*

Check the fit. *The key to fitting the inlay is to use sandpaper to work the edges so the fit is tight and to begin at the corners to establish the color matches.*

It's a quick trim. *With the inlay design at 45°, the fit at the corners is easy. Use a square block end to guide your saw as you make the initial cut.*

compensate for the blade thickness and provide a 1/16" strip – stay on the thick side more than thin. It's better to have the assembled strip a wee bit stronger than 1/2". Repeat the steps to produce the second string strip.

Now it's time to assemble the pieces. Add glue to both faces of the herringbone pieces, position a 1/16" strip on each side and add clamps. For this type of work, my favorite clamps are ordinary rubber bands. Twist the bands around the glue-up a number of times until tight, then slide the band along the inlay so there are no small gaps when complete.

After the glue is dry, clean up the faces with your handplane then, using a band saw, cut pieces that are slightly thicker than the grooves are deep (3/32"). Clean up the face after each cut. You'll need five or six pieces of finished inlay to complete the box front. Each group should yield three or four pieces, so assemble at least two.

Inlay Installation

With the pieces of inlay in hand, you'll need to fit the pieces into the grooves of the box front. This step is pretty self-explanatory, but here are a couple hints to smooth out any small bumps.

With the inlay matched closely to the groove width, there should be little work to do on the pieces to get them to fit. A piece of #120-grit sandpaper adjusts the inlay where needed on the edges. Work carefully and check the fit as you progress.

As the pieces are fit, the corners need to be trimmed. A square end of a block is a big help to get the cuts just right. Mark where you wish to cut the inlay, position the block, add a bit of downward pressure on the block to hold everything in place then make the cut keeping your saw tight against the block. The worst that could happen is you tilt away from the block as you make the cut and that would cause the inlay to have the slightest bevel. That's great when fitting two pieces of inlay together, but don't overdo it. This allows the top edges of the inlay to meet for tight seams.

A block works great when you need to trim the inlay with a chisel as well.

Take a close look at the photo below. The inlay reverses at the middle of each run. This was common practice when the box was built. Fit the inlay to the corner first. Find the center point of the run then trim the piece with a square cut. If you match opposing hardwoods at the corners, the center meeting point should be mirrored images.

After the inlay is fit to the box, remove the pieces, apply glue to the grooves and to the back face of the inlay, then place the strips back in position. Add a piece of waxed paper

Fine-tune for looks. *That same square block end acts as a guide for your chisel when fine-tuning the fit of the corners. If you undercut the end just a bit, the fit at the top of the inlay is sure to be tight.*

There's a method to the madness. *The inlay is not randomly added to the front. Notice each corner has two opposing colors matched and that each run is split at the center with the half-runs being mirrored images.*

over the inlay to stop potential glue transfer, position another similar-sized piece on top then apply a few clamps to hold everything while the glue dries.

As the front comes out of the clamps, it's a great time to prep for the installation of the lock and the escutcheon. Of course, you can do that after the box is assembled, but the area is more confined and the work requires a bit more patience.

Wrap Up Construction

So far, all the work has been on individual pieces. It's time now to assemble the box. Add glue to the dovetail joints (remember those, from a few pages back?) and slip the joints together. Use a square to check the box, or measure the diagonals, then set the box aside.

As the box dries, mill the material for the top according to the schedule. Use your favorite router bit profile on the ends and front edge. I used a cove and bead bit on the top edge and a small roundover bit on the bottom edge to complete the profile.

After the glue has dried, attach the bottom/feet to the box. Nails are the answer for this job because the nails allow for some seasonal movement. Drill pilot holes for the fine finish nails then drive the nails through the bottom into the box. Set the nails just below the surface.

Sand the assembled box through #180-grit making sure to level the inlay and to true up the bottom edges to the box on all four sides.

After the sanding is complete, it's time to make and install your bottom mouldings. Profile the edges of a wider piece of stock with a small-diameter Roman ogee router bit, then rip the moulding off that stock. The moulding wraps three sides of the box and is attached with glue and brads. Notice that the moulding is taller than the thickness of the box bottom. The extra $1/16$" makes sure the joint between the box and bottom is hidden.

The top is a snap. Mill the top according to the schedule – or size it to your box so that there is a $1/2$" of overhang on the front and ends. Next, profile those same three edges. I used a cove-and-bead bit on the top edge of the piece and a $3/16$" roundover bit to shape the bottom edge, leaving a bullnose profile behind.

After the work is complete and the top is sanded, mount the hinges that join the top to the box. I like to waste away as much of the area as possible then finish the work with hand tools. Set the hinges to the top first then position the top to the box and transfer the hinge location. Fit the lid tight to the box, but without any binding.

Supplies

Rockler
800-279-4441 or rockler.com

1 pr. ■ fixed pin hinges
#57108, $15.99 pr.

Whitechapel Ltd.
800-468-5534 or whitechapel-ltd.com

1 ■ lock, #176LBC2, $17.65

1 ■ escutcheon, #182E11A, $5.68

Prices correct at time of publication.

Nail, don't glue. *The bottom of the box is attached with nails. The nails hold tight, but allow for seasonal movements in the cross-grain application.*

The finish is as easy as the box. *There's no need for stain or dyes that would color the inlay. Boiled linseed oil (one coat) and shellac makes the walnut sing and the inlay stand at attention.*

Finishing the Box

Stain or dye is not a wise choice in my opinion. These would color the inlay and that's not a good thing. A natural finish is best. I chose shellac as a topcoat after a single coat of boiled linseed oil. A few coats, either brushed, ragged or sprayed on, and you're done. Sand the surface between coats to keep things smooth and use #0000 steel wool to knock the high sheen off the box when the application is complete. There is no finish on the inside of the box.

This box is a great place to store the family Bible – but if you're not a member of the "Bible box" crowd, it's still a fun piece to build and an excellent test of one's woodworking skills. **PW**

Glen is a senior editor of this magazine and the author of several woodworking books. Contact him at 513-531-2690 x11293 or glen.huey@fwmedia.com.

How Sandpaper Is Made

BY CHRISTOPHER SCHWARZ

In all likelihood sandpaper isn't made the way you probably think it's made.

In fact, what is most unusual about sandpaper manufacturing is how similar it is to publishing a magazine. Like publishing, making sandpaper begins with picking the right thickness of paper. There's ink (the words on the back of your sandpaper). And then there's the grit and the glue, which to me is similar to the stories we print in the magazine.

If the sandpaper manufacturer uses the right grit and the right glue, then the sandpaper will last a long time, it will cut quickly and it won't clog. Use the wrong paper, grit or glue and the sandpaper will quickly end up in the trash.

We visit a manufacturing facility to get the nitty-gritty on making abrasives.

Here at the magazine if we pick the right stories, then the readers keep the magazine for years, and refer to it to build furniture and buy tools. If we choose the wrong stories, the magazine ends up on the floor of a birdcage or around a dead fish.

This spring we took a tour of Ali Industries Inc., a sandpaper manufacturer in Fairborn, Ohio (gatorfinishing.com). Founded in 1961, Ali Industries makes the Gator-brand sandpaper for home centers and hardware stores.

A tour of the Ali plant brought a lot of surprises. I've been on dozens of plant tours to see how everything from nail guns to miter saws to universal motors are made. But this is the only tour where the plant seemed a combination of magic tricks and a candy factory.

Pick Your Paper

Sandpaper can come on different thicknesses of paper (or cloth). The paper's thickness is graded between A and F, with "A" being the

LEAD PHOTO BY AL PARRISH; STEP PHOTOS BY GLEN D. HUEY

lightest and most flexible and "F" being the heaviest paper. Lighter paper is more flexible, but it also can tear more easily. Heavier paper can be more durable, but it can be stiff depending on the glue used and how the sandpaper is made.

The sandpaper at Ali Industries is "C" weight. Gary Carter, the senior director of sales, says C-weight paper is a premium weight that they've treated to get good performance when hand and power sanding.

The paper is in giant 55"-wide rolls and can vary in length from 180 to 500 meters. It begins unspooling on a large horizontal spindle and is pulled first into a large printing press. There the grit number, the brand name and other information is printed on it – then it's baked with ultraviolet heat so it's instantly dry.

Glue, Grit Then Baking

From the ultraviolet heater, the paper gets its first coat of glue, which can be a phenolic resin (for sanding discs and belts) or a urea resin, for hand-sanding sheets. During our visit, the resin was a pure red and looked like the Plasti Dip stuff that some homeowners coat tool handles with.

The paper descends into the resin on a giant roller that dips the unprinted side into the bath and rolls it immediately upward. From there the flypaper-like stuff rolls into a little room where the magic trick occurs.

In a low-ceilinged room under the giant rolling machines the glued paper is brought down parallel to a conveyor belt – about 1" above the conveyor. On the belt is the loose grit, which could be anything from garnet to aluminum oxide.

At a certain point on the conveyor, the grit is statically charged and it leaps (yes, leaps) up and embeds itself in the resin on the paper above it.

Carter explains that the static charge does two things: One, it causes the stuff to jump in the air. Two, it makes the individual particles orient themselves so the blunt part of the grit becomes embedded in the resin and the sharp point is facing your work.

You can see the grit jumping up into the resin, which is a bit mesmerizing. Any excess grit (there isn't much) is captured at the end of the conveyor.

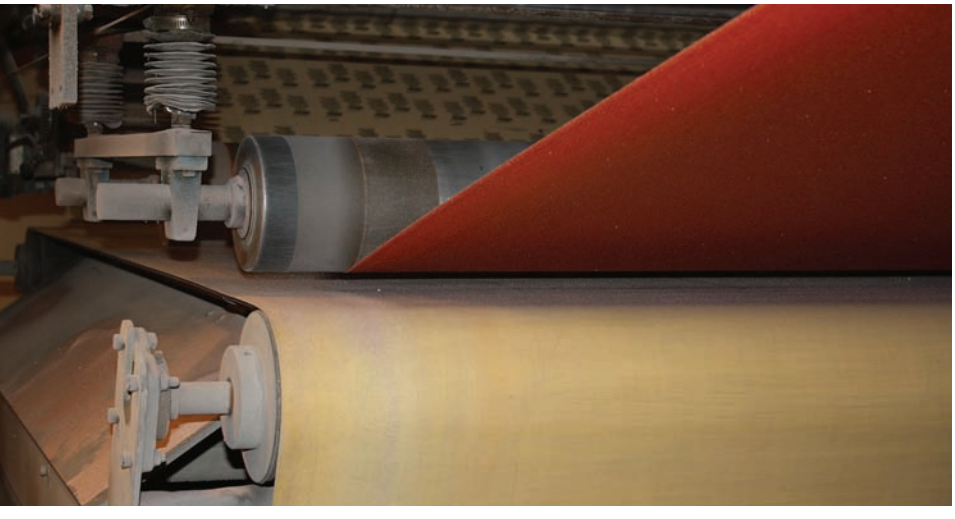
It's officially sandpaper now, but the resin is still wet so the roll of paper has to go into an oven to be baked. The oven looks a bit like a huge taffy puller. Giant mechanical arms loop the paper up and down like ribbon candy and move steadily through the warmed room to the end and back.

More Glue, More Baking

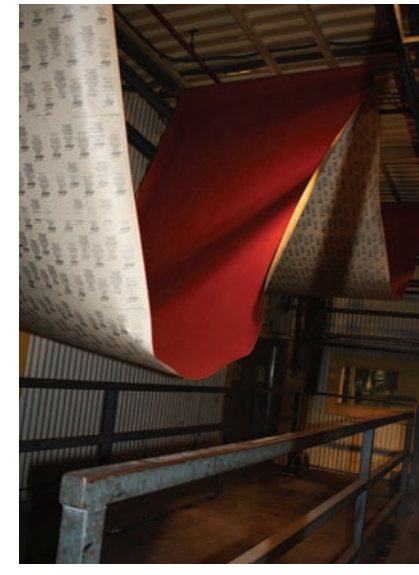
After the resin is somewhat cured, the paper is coated with another layer of resin, which improves the durability of the paper (only the cheapest sandpaper has one layer of resin). Then it's baked again and spooled back into

Roll it out. *Here you can see the 55" rolls of paper as they are fed into a printer that inks the grit and brand on the backside of the paper.*

A pot of glue. *The red stuff in the tray is the resin. The glued paper travels up out of the tray and into the room where it gets its grit.*



Jumping oxide! *The stuff on the top rollers is the paper with the resin. The conveyor below it carries the grit. When the grit reaches a certain point it jumps up and embeds itself in the resin.*



Enormous oven. *The paper, grit and resin all come into the oven on arms that fold the stuff in undulating curves through the warmed rooms.*

A sharp turn. *This machine flexes the finished paper several times to increase its durability. Then the paper is rolled back up.*

a roll. These rolls are heated some more in small rooms to fully cure the resin.

At this point the paper is quite stiff and will crack if bent. So the Ali employees run the rolls of paper through a machine that flexes the paper. These machines bend the paper like a ribbon through a series of turns that makes the product less likely to crack on you.

Then It Gets Complicated

After that, lots of different things can happen to the sandpaper. Employees can add a cloth backing so the sandpaper will be compatible with hook-and-loop sanders. Or they can add a sticky-back coating. But the real variety kicks in when it goes into a warehouse with die-cutting machines.

Each of these machines is about the size of a small SUV. Five or six rolls of paper are ganged up at the back of the machine. The sheets are pulled into a chamber where a robotic die-cutter punches out the different-sized discs or shapes – for random-orbit sanders, for example.

Making the belts for sanding belts is a little more complicated: They start that process with a parallelogram of paper that is then glued into a tube with some Kevlar tape. The tube is then sliced into the correct widths.

Then employees snatch the stacks of finished products, put them in their packages, and the finished goods are boxed up and go off to their final destination. The whole manufacturing process is pretty quick. A typical sheet of sandpaper starts as raw ingredients on one day and within 10-14 days can be ready to ship.

Not only is the manufacturing process fast, but historically speaking, the end product is amazingly inexpensive. Early sandpaper – called "glasspaper" – was pricey, used sparingly, flimsy and never wasted. Nowadays, everyone can afford as much sandpaper as they need, which makes the world a very smooth place. **PW**

Chris is editor of this magazine. His latest book, "The Joiner and Cabinet Maker," will be available this fall from LostArtPress.com.

Online EXTRAS

For a behind-the-scenes look at Ali and the sandpaper-making, watch our video at:

popularwoodworking.com/oct09

Acres of loops. *The white stuff is the "loop" part of hook-and-loop. It's glued to the back of the paper on this large machine, which also applies the sticky-back glue if need be.*

A giant punch. *An Ali employee stacks finished sanding pads as they come out of the die-cutter. The cutter can slice through five or six sheets of sandpaper in one swoop.*

The leftovers. *Here's what the paper looks like after the die-cutter.*

BY BOB FLEXNER

Five Common Finishing Problems

Bleeding, blushing, blotching, orange peel and fish eye.

The basics of wood finishing are really quite simple: You use one of three tools – a rag, brush or spray gun – to transfer a liquid stain or finish from a can to the wood. Finishing becomes more complex when problems occur.

Here are five common problems, together with how to avoid them – and how to deal with them when they happen.

Bleeding

Bleeding refers to an oil finish oozing out of pores after being applied and wiped off. It is more likely to occur on large-pored woods such as oak or mahogany than on tight-grained woods. And it is more common with thinned commercial blends of oil and varnish (Watco Danish Oil, for example) than with pure oils such as boiled linseed oil or tung oil.

Bleeding is also more likely on hot days, especially if you move the wood into warmer temperatures or sunlight before the finish has totally cured.

If you allow the bleeding to dry and harden, it will form glossy scabs that can't be removed without also removing (by abrading or stripping) the finish around each. Sometimes, however, you can disguise the scabs adequately by rubbing the surface with #0000 steel wool then applying another coat to even the sheen.

To prevent the scabs from forming keep a close eye on your project and wipe over the surface with a dry cloth every half hour or so until the bleeding stops.

Once the wood is sealed, meaning the first coat has cured, there shouldn't be any more bleeding. So bleeding is usually limited to the first coat.

Blushing

Blushing is a milky whiteness that occurs in fast-drying shellac and lacquer finishes in humid weather. It's caused by moisture in the air condensing onto the finish as the solvents evaporate and cool the surface. The moisture then evaporates, leaving air voids that refract light rather than let it pass through.

Blushing doesn't occur in varnish because it dries so slowly, or in water-based finish.

To avoid blushing you have to slow the drying of the finish. Do this by adding lacquer retarder to the lacquer or shellac. (Brushing lacquer has already been retarded enough so that blushing is very rare.)

Adding retarder slows the drying of the finish, so don't add more than needed. You will have to experiment to find this amount because retarders use different solvent formulas and humidity can vary.

CONTINUED ON PAGE 68

Bleeding. *The shiny spots on this oak panel show where an oil/varnish blend has oozed out of the pores and dried on the surface. To keep this from happening, check your project every half hour or so after you apply the finish and wipe off any bleeding before it dries.*

Blushing. *The milky white area in the center of this panel is called "blushing" and occurs often during the application of shellac or lacquer on humid days. To keep it from happening, slow the drying of the finish by adding a little lacquer retarder to it.*

Blotching. *The darker spots on this oak panel are areas where the stain dried before it was wiped off. To keep this from happening with fast-drying water-based and lacquer stains, work faster or on smaller areas at a time, or get a second person to wipe off quickly after you apply the stain.*

PHOTOS BY THE AUTHOR

CONTINUED FROM PAGE 66

Blushing will sometimes clear up on its own. Otherwise, spray some retarder onto lacquer, or alcohol onto shellac on a drier day. Or let the finish harden and sand or rub it with a fine-grit abrasive paper, pad or steel wool. The blushing occurs right at the surface of the finish, so it doesn't take much abrading to remove it.

Blotching

Blotching is uneven stain coloring usually associated with uneven densities in the wood. (See "Battling Blotching in the finishing section at popularwoodworking.com/.) Blotching can also be caused by not getting all the excess stain wiped off before it begins to dry.

This would be very rare with an oil stain because the drying is so slow, but it is common with water-based stains and lacquer stains. (Lacquer stains are fast drying stains used by professional finishers who usually spray the stain and have a second person following closely behind wiping off.)

Once the blotching occurs, quickly apply more stain, or the thinner for the stain (water or lacquer thinner), to soften the hardened stain so you can wipe it off. If you use the thinner for the stain, you will lighten the color on the wood, and you may have to restain it.

To avoid the blotchy drying, work in smaller areas at a time, work faster or get a second person to wipe off.

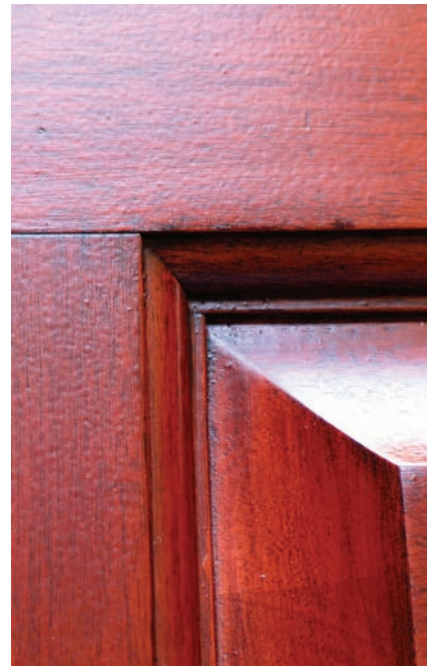
Orange Peel

Orange peel is the spraying equivalent of brush marks left when brushing. It can occur with any finish and is usually caused by spraying too thick a liquid with too little air pressure. When stated this way, the solution is obvious: thin the liquid or increase the air pressure.

If you're using a spray gun with air supplied by a turbine rather than a compressor, you won't be able to increase the air pressure. You'll have to thin the liquid.

Another cause of orange peel is holding the spray gun too far from the work surface or moving the gun so quickly that you don't deposit a fully wet coat. The best way to determine the proper distance and speed is to watch what's happening in a reflected light.

By positioning yourself so you can see a reflection on the surface, you will see when the finish is going on too thin and you can make the necessary adjustment.



Orange peel. *A common spraying problem is orange peel, caused by spraying too thick a liquid with too little air pressure, or moving the spray gun too fast or holding it too far from the work surface. To keep it from happening, thin the finish, increase the air pressure, and watch in a reflected light while spraying to get the speed and distance correct for the best results.*

Other than stripping, the only way to remove orange peel after it has occurred is to sand it out. Once you have leveled the surface, you can either rub it to the sheen (gloss, satin or flat) you want using abrasives, or spray another coat being sure to make the necessary adjustment so you don't get orange peel again.

Fish Eye

Fish eye, which is also referred to as "cratering" or "crawling," is caused by a surface tension (slickness) difference between the finish and oil that has gotten into the wood. The oil that causes the greatest problem is silicone oil, contained in many furniture polishes, lubricants and skin-care products.

You're unlikely to experience fish eye when finishing new wood, but it's common when refinishing old wood and occurs most often when applying lacquer or varnish. To prevent fish eye, use one or more of the following procedures (for really bad cases of contamination you may need to use two or even all three).

Fish eye. *An increasingly common problem when refinishing furniture or woodwork is fish eye, or craters, which is usually caused by silicone-containing furniture polish having gotten through cracks in the finish and into the wood. Because it has already happened you have to deal with it. Do so by washing the stripped wood thoroughly, sealing the wood with a coat of shellac, and/or adding fish-eye eliminator (silicone oil) to the finish to lower its surface tension so it flows out level.*

- Wash the bare wood thoroughly with mineral spirits or naphtha, or with household ammonia and water or a strong oil-removing detergent such as TSP.
- "Seal in" the silicone oil by applying a first coat of shellac. It will flow over the oil in the pores and form a barrier so you can apply another finish on top.
- Add a fish-eye eliminator, which is silicone oil sold under various trade names (the most common is "Smoothie") to the finish. This lowers the surface tension of the finish enough so it flows over the oil already in the wood. When adding this product to varnish or polyurethane, thin it first in a little mineral spirits or naphtha, then add it.

Once fish eye has occurred, it's usually best to wash off the finish with the appropriate solvent and start over, taking one or more of the precautions discussed above. Decide quickly, as "washing off" is easy if done right away, before the finish has totally set up.

Alternatively, you can sand out the craters and add silicone oil to your next coats. Or if you're fast enough with sprayed lacquer, you can add silicone oil to your next coat and spray within a minute or two. Once you've added silicone oil to any coat, you have to continue adding it to each additional coat or it will fish eye. **PW**

Bob is author of "Understanding Wood Finishing" and contributing editor to Popular Woodworking.

BY PETE KNAPP

IWF 2059

Fifty years in the future, MDF will be a luxury 'wood.'

As if all the new tools and technology shown at this year's International Woodworking and Furniture Show (IWF) weren't exciting enough, we decided to jump into the *Popular Woodworking* DeLorean, fire up its flux capacitor, and see what is going on at the Big Show 50 years in the future.

One of the biggest changes in woodworking was the recent lawsuit by PETT (People for the Ethical Treatment of Trees), which banned all commercial logging. Fortunately, genetic engineers have made it possible to grow a 200-board foot hard maple in a small apartment in three or four days. As a result, highly-figured wood is now used for junk, and aficionados now speak longingly about the enchanting look of MDF, collecting it and hoarding it for "just the right project."

New to the public is the Ludicrous Industries Laser Table Saw. Thanks to a petawatt (1,000,000,000,000,000-watt) laser cutting system, developed with the help of the Department of Defense, the saw is able to cut precisely down to about 1/81922". Still, the company promoting it admits that it will require special wiring in most home shops, and despite the precise nature of the saw, most home woodworkers will still not be able to build an acceptably square box with it. Many woodworkers at the show reported that they were waiting for the saw to be fitted with a riving knife before buying. In the event of kickback, the high-power laser throws the workpiece out of the saw faster than the speed of light, causing it to strike the unsuspecting woodworker the week before.

Consolidation in the tool industry has continued, with the two remaining tool companies both showing exciting new tools at the show. Thanks to another lawsuit, Delta/Porter-Cable/Milwaukee/DeWalt/Bosch/Makita/Skil/BlackandDecker/Jet/Powermatic/SawStop introduced a new version of its Unisaw, which is a true Radial Arm Reciprocating Circular Scrolling Jig/Band/Table/Miter Saw. This was in response to a civil matter claiming that it wasn't a unisaw, unless it could perform the function of all other saws.

In addition to the Unisaw, the company also unveiled the latest version of its SawStop table saw. This version not only stops the saw's circular blade from cutting any errant appendages, but also resuscitates the user's eighth-grade shop teacher to give a really serious talk about shop safety. Sales for this item, however, look bleak because it has become so easy to replace fingers, thanks again to genetic engineering. Many woodworkers simply use their fingers to prevent chip-out, and get new ones at the end of the project.

The other remaining tool company, Festool, released the final piece to "the system:" a complete line of underwear and socks, each of which comes in its own custom-fitted Systainer. Fans rejoiced at the announcement, noting that they can finally throw away the last thing left in their house not made by their favorite company, and distributed and stored in a convenient modular case. Festool also hinted at things to come, talking obliquely about the Sysshop, Syshome, and Sysoffice; but insisted that people would need to come to IWF 2061 to see what that was all about.

Despite recent efforts over the past year by the industry as a whole to broaden its demographics, the key age group remained males between the ages of 100 and 150. Analysts hoped this would be the year that some of those people would be able to finally retire, and spend more time and money on their favorite hobby.

That's about all we can report for now. As Doc Brown would say, nobody should know too much about their future. You'll just have to wait 50 years to find out the rest.

A night and weekend woodworker in Polk City, Iowa, Pete enjoys new tools and starting whatever projects are necessary to convince his wife to let him buy them.

ILLUSTRATION BY DAVE COVERLY