The Workbench

A Complete Guide to Creating Your Perfect Bench

Lon Schleining

The Workbench


Weldwood
Contact Cement
Top
HAFELE
HAFELE

The Workbench

A Complete Guide to Creating Your Perfect Bench

Lon Schleining

Photography by Randy O'Rourke

The Taunton Press

The Taunton Press
Inspiration for hands-on living®

The Taunton Press, Inc., 63 South Main Street, PO Box 5506, Newtown, CT 06470-5506
e-mail: tp@taunton.com

Distributed by Publishers Group West

Editor: Helen Albert
Jacket/Cover design: Mike Sund
Interior design and layout: Carol Petro
Illustrator: Charles Lockhart
Photographer: Randy O'Rourke

Library of Congress Cataloging-in-Publication Data
Schleining, Lon.
The workbench : a complete guide to creating your perfect bench / Lon Schleining.
p. cm.
Includes index.
E-Book ISBN: 978-1-60085-665-5
1. Workbenches--Design and construction. 2. Furniture making. 3. Woodwork--Equipment and supplies.
I. Title.
TT197.5.W6S35 2004
684'.08--dc22
2004003555
Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

Working wood is inherently dangerous. Using hand or power tools improperly or ignoring safety practices can lead to permanent injury or even death. Don't try to perform operations you learn about here (or elsewhere) unless you're certain they are safe for you. If something about an operation doesn't feel right, don't do it. Look for another way. We want you to enjoy the craft, so please keep safety foremost in your mind whenever you're in the shop.

Dedication

To the hundreds of woodworkers I've met in my travels, especially those who've taken my classes over the years. Your brilliant questions and suggestions have taught me more about woodworking than you know.

Acknowledgments

Producing a book requires the talents and hard work of scores of people. Thank you all, especially those who work behind the scenes.

Scott Landis'original work on workbenches laid the foundation for any subsequent work on this topic. Many current and former Taunton contributors have provided insights on benches, including Tage Frid, Frank Klausz, Garrett Hack, Bob Flexner, Mario Rodriguez, Bruce Hoadley, Gary Rogowski, Mike Dunbar, Phil Lowe, Niall Barrett, Nick Engler, and Scott Gibson.

The good folks who staff *Fine Woodworking* magazine made a huge contribution, including Tim Schreiner, Anatole Burkin, Matthew Teague, Tom Begnal, John White, and especially Asa Christiana whose advocacy was invaluable.

This book would certainly not be in your hands without the support of people at Taunton Books, including Jim Childs, Carolyn Mandarano, Marilyn Zelinsky Syarto, Wendi Mijal, Rosalind Wanke, Chuck Lockhart, and Jenny Peters.

Numerous personal perspectives on benches are blended into this work, including Gary Chinn's world view, Carl Matthews' amazing work on Emmert vises, Graham Blackburn, Mack Headley and Marcus Hansen's historical perspectives, Jerry TerHark's practicality, Tom Lie-Nielsen's love of tools, David Charlesworth's love of the craft, Rob Cosman's fierce defense of tradition, and Marc Adams' dedication to education.

Among those who let us interrupt their work to take photos include Brent Merkley, John Allison, Curt Erpelding, Paul Breskin, Arron Latt, Steve Grimminger, Paul Schurch, Kelly Mehler, Russ Filbeck, Harry Williams, Bob Gelson, Hank Holzer and Judith Ames, Ejler Hjorth-Westh, George Levin, Harold Foss, Doug Betts, Yeung Chan, Brian Boggs, Dennis Treffry, Jim Robbins, Rick Gunderson, Harold Greene, John Wiedner, and Clyde 'Bubba' Richardson.

Andy Rae, Sandor Nagyszalanczy, Terry Nelson, the late John Sheldon, Asa Christiana, Roger Van Maren, Maureen Nilsson, and others contributed some of the great photographs you see on these pages.

Dozens of people contributed their thoughts and projects to the book, including Dick Need, Bob Gabor, Jim Croker, Ana Carter, Jim Wiley, Jon Brooks, Jim Heavy, Robert Abrams, Don Feher, Cliff Trimble, Scott Jost, W. F. Bill Judt, Geoffry Killin, Dave Padget, Chris Morgan, John Graves, Charles Durham, Cindy Vargas, Keith Kidd, Jeff Smith, Jim Strapulos, Bill Miller, Tony Fucci, Warren Casto, Ron Goldman, Mike Steinfelt, Carl Stammerjohn, Pat Edwards, Pat Warner, Thomas Moser and Thomas Bunn, Gary Blaise, John Stair, Lark King, and Jon Leppo.

Manufacturers and suppliers of materials and equipment are the life's blood of our craft. Thanks to Leonard Lee and Wally Wilson, Jeffery Noden, Torben Helshoj, Leif Carlsson, Daryl Kiel, Howard Card, Gabi Baski, Laguna Tools, and Sjöbergs of Sweden.

Special thanks to Sam and Beverly Maloof for their hospitality. Roz in the office, Larry White, Mike Johnson, and David Wade in the shop all went out of their way to accommodate our numerous visits.

I simply cannot thank John Barbee and John Nyquist enough for their patience and hard work. They each burned a great deal of their valuable time building projects for this book. Brent Merkley and Tim Boswell each lent a helping hand at exactly the right time.

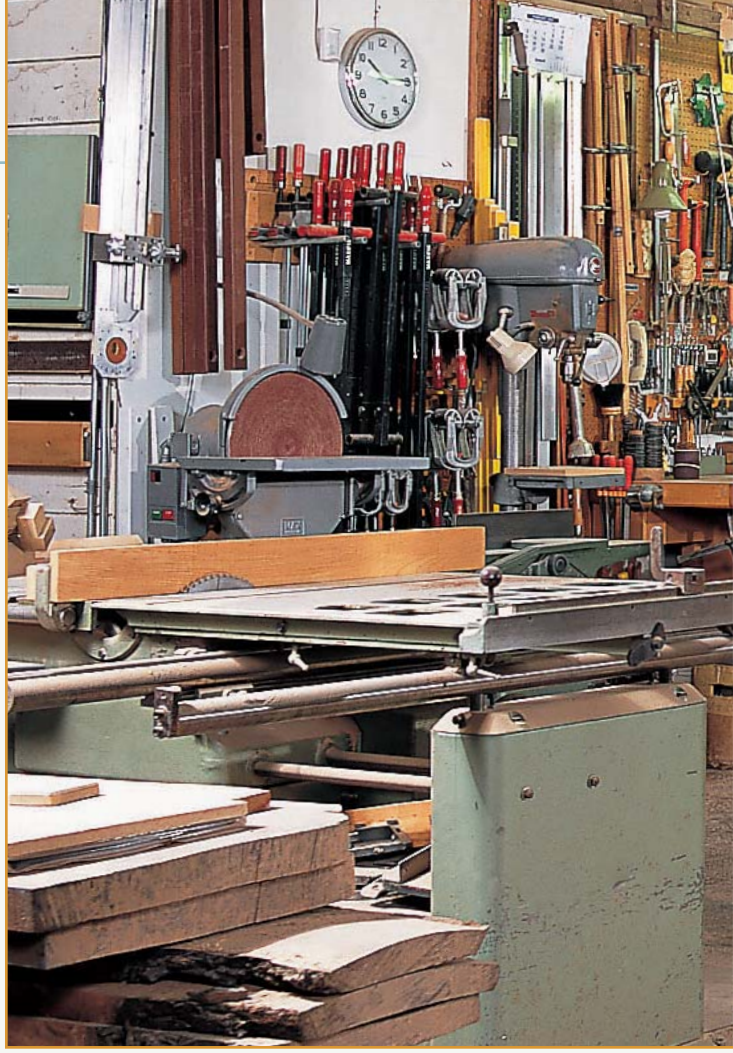
The majority of the photographs in the book were shot by Randy O'Rourke, surely the world's most talented, hard-working, and easygoing photographer. Thanks for another beautiful job, Randy.

To say that my friend Helen Albert somehow managed to translate my manuscript into English vastly understates how much heavy lifting she did to make this book possible.

My wife, Anne, frequently reminded me to dwell on how good it would feel when the book was actually finished; precisely the sort of thing an author needs to hear on a regular basis. Thank you, Annie. I couldn't do it without you.

Contents

Introduction



"For some people, building their own bench is almost a woodworking rite of passage."

In its simplest form, a woodworking bench is nothing more than some sort of raised platform so you can work standing up. Even a piece of plywood on sawhorses would fit this definition. Such a bench would certainly be inexpensive, fast to build, and very portable. If it got rained on, or stained by spilled coffee, no big deal. Though less than ideal, this may be all the bench some woodworkers would really need. But what they really yearn for is another matter entirely.

Woodworkers' notions of the ultimate bench are as diverse as their activities. What's ideal for one woodworker is wholly impractical for another. A great bench for a furniture maker may not work for a carver and vise versa. A boatbuilder's bench is utterly different from a violin maker's, yet they all work wood and they all need benches.

Much as woodworking pundits might like to say their particular workbench is the only proper configuration, many of the choices in design are simply a combination of familiarity and personal taste. If there is a common thread, it's a tendency to think the bench you learned on is the best bench. A shoulder vise, for example, is a device some woodworkers simply could not get along without. For others, it's a somewhat fragile appendage of little use in a modern wood shop. Such is the subjective and very personal nature of the workbench.

The "classic" workbench originated centuries before the invention of the equipment modern woodworkers take for granted. These days, rare indeed is the woodworker who does not use an electric drill or surface planer. A perfectly suitable bench for the type of work people did 300 or 400 years ago may not be the best one today.

Some things haven't changed. Virtually every woodworking tool, power or otherwise, requires two hands to operate safely. Holding the board securely is, if anything, *more* important with power tools than with hand tools since the consequences of a slip could be more serious. Woodworkers who think a traditional bench has no place in a modern shop need only consider how difficult it is to hold a furniture part with one hand while belt-sanding it with the other two.

Woodworkers of today do work differently. We often work with large panels and sheet goods and so need to clamp our work somewhat differently. We have access to hardware that can speed construction. Modern materials like Melamine and laminates are better than solid wood for some applications. Vacuum pressing

makes building large torsion boxes easier. Throughout this book, I have tried to point out how modern methods and materials can be applied to workbench design and construction.

For some people, building their own bench is almost a woodworking rite of passage. Their bench is an expression of the pride they take in their work, an opportunity to demonstrate their skills and to show off a little. These folks probably envision a solid-maple behemoth with intricately constructed vises, a gleaming finish, lots of accessories and cool hardware. Sure it cost a bundle and took months to build. Yes, there may be just a bit of reluctance about actually using the bench for fear of getting that first scratch or dent. But for those bench builders, the satisfaction of having built it is justification enough.

Then there are the folks who sit down and do the math. They figure the cost of lumber and hardware, then estimate (or should I say underestimate) the time it will take to build the bench. They compare their figures with the cost of having a finished bench shipped to their doorstep. It slowly sinks in that it's entirely irrational to build a bench from scratch. For these practical souls, the only logical choice is to buy the finished bench outright.

The bottom line is that however you get your hands on it, you need a good bench to do your work safely. You need some vises and hold-downs for joinery, fitting pieces, and finish work like installing hinges. At the very least you need a true flat surface for gluing.

This book is intended as a guide for asking the right questions and then making the right decisions about what you really need and what you really want. A workbench is a very personal choice. Your opinions and personal preferences are the most important. Take your time pondering the questions. And remember; only you can provide the answers.

1

The Perfect Bench

THE PERFECT BENCH for furniture maker and hand-tool expert Garrett Hack is an eighteenth-century classic, complete with a twin-screw front vise and a board jack to support long boards when planing.

The perfect workbench for you is simply the one that works best for you most of the time. That means enabling you to do the tasks you do most often with a minimum of fatigue and discomfort. Since any kind of woodworking requires a wide variety of activities from planing to routing, that's a tall order. It's probably no surprise to you that designing the perfect bench is about making smart compromises. It's a balancing act to get the best combination of functionality and comfort.

To strike the right balance, you'll need to consider several key factors: what you build; your working style, including your preferences for hand tools or power tools; the size of your shop and location of the bench; and even how your own height fits into the equation. The place to begin finding the answers is to ask the right questions. That's exactly what this chapter will help you do.

For the time being, try to put your mental pictures of the "proper" bench aside. Instead, concentrate on asking yourself what *you* need in a bench. *Proper* means nothing if it's not right for you.

Smart Solution

CONSIDER DEDICATED BENCHES

If you do a wide variety of woodworking, one bench may not serve all your needs. Many woodworkers have a general-purpose bench suitable for most woodworking tasks as well as dedicated specialized benches for assembly, carving, or sharpening. Don't be surprised if you find more than one workbench on your drawing board.

CLYDE RICHARDSON specializes in small boxes. Seated at his bench, he finds that it's at just the right height for close work. The unique bench dogs he makes are ideal for holding the small parts with his tail vise, and the natural light from the windows provides great illumination.

What Kind of Woodworking Do You Do?

Ask any experienced woodworker what makes the perfect bench and the answer will be, "It depends." What it depends on, first and foremost, is what you build and how you like to work.

If you're a fan of hand tools, you may need a very solid surface for chopping dovetails or mortises with a chisel and a mallet. Perhaps all you really need is space to spread out parts for assembly. Maybe your bench needs to be portable so you can move it from job site to job site. What if you intend to build a boat and need to work on planks that are 20 ft. long? All these tasks imply different requirements for a workbench and will determine the size and configuration of the right bench for you.

What Do You Make?

What you plan to build at your bench is the first question to ask. Are you more inclined to build entertainment centers or clocks? If you are a chairmaker, you don't really need a bench designed for assembling large cabinets. If you want to build a boat, you need a different bench from the person who is planning to build Windsor chairs with lots of circular parts. Your diminutive carving bench will be quite unsuitable for larger projects.

The scale of the woodworking you do will determine the overall scale of the bench. If you primarily build stand-alone furniture, the classic workbench dimensions of 2 ft. wide by 6 ft. long, may be just right for you. If you build on a larger scale—floor-to-ceiling bookcases, or cabinets—you may need a longer or wider bench. A wider bench is useful to support

pieces when working with panels. You may also may need more than one row of bench dogs holes to secure panels. On the other hand, a carver may require only a small bench, but one that's outfitted with special vises and holding devices.

DENNIS TREFFRY builds fine kitchen cabinets. His assembly table houses frequently used tools and hardware below the top. He uses the lower bench on the left for taller pieces. When not in use, the table rolls back into its garage, which doubles as his table saw outfeed.

JOHN BARBEE'S BENCH is perfectly suited to his specialty—cutting minute dovetails. When seated at his front vise, with tools carefully laid out to be within easy reach, he can saw and chisel comfortably. Lacking natural light, he relies on his movable lamp to provide light exactly where he needs it.

CALIFORNIA WOODWORKER Sandor Nagyszalanczy is a power tool fan. He designed his bench with cabinets to store his portable power tools and added a power strip for plugging in more than one tool at a time.

How Do You Work?

The tools you use most play a large role in how you should design your bench. Modern electric power tools, like sanders and routers, share a significant number of characteristics with handsaws and chisels. They each require two hands to operate. They each need a solid work surface. The same sort of vise will probably work whether you are cutting dovetails with a router or a handsaw. Bench dogs are equally useful whether belt sanding or handplaning.

If you work primarily with power tools, you'll want to consider access to electrical outlets when placing your bench in the shop. You may also decide to build a power strip into the bench to make it easier to plug in more than one tool at a time.

Your working preferences affect other specific details as well. If you like to clamp work to the bench, a continuous overhanging lip is going to be an important design priority. A wide vertical apron across the front of the bench, favored by many woodworkers, offers a place to support the long end of a board while it is being planed, but it makes clamping pieces down to the top more awkward.

Locating the Bench

If, as in most shops, your space is limited, it is all the more important to do a little planning. If you have a large shop, you may have a number of options regarding where your new bench can go. If, like most woodworkers, your workshop is a bit cramped, your choices will be more restricted.

If your bench will go against a wall, its configuration could be fundamentally different from one at which you plan to work on both sides. Many woodworkers store tools in a wall-mounted cabinet or on pegboard system behind the bench. The wider the bench, the more

IN A SHOP as large as Harold Foss's, the benches could be located almost anywhere. He's chosen to designate a specific section of the shop, in the far corner, as his bench area, where he keeps two of his several benches.

A SHOP IN A ONE-CAR GARAGE can be cramped, but Tennessee woodworker Matthew Teague made the most of a tight space by putting the bench against the wall and creating a good work-flow plan.

difficult it will be to reach the tools. And if the bench is freestanding, you lose the convenience of wall-mounted tool storage. Whichever you choose, it is important to consider how the bench fits into your work flow.

Freestanding

Larger shops tend to place benches in the center of a work area, whereas smaller shops tend to place them against the wall. Benches in the middle of the shop, or at least positioned to provide access all around, provide a surface for clamping projects wider than the benchtop.

Against the Wall

Placing a bench at the wall means that you have access to only three sides of it. Any piece wider than the overall width of the bench must hang over the front edge.

If there is flat wall space behind the bench, it is a great and natural spot for tool storage either in a cabinet or hanging on the wall. Tools are handy, visible, and very accessible. A good choice for a bench against a wall is one on the narrow side, 24 in. or under in width. Any wider, and it will be difficult to reach over the bench to get a tool hanging on the wall.

If you can place the bench below a window, there will be wonderful natural light. And while you contemplate your next cut, you can look out the window, rest your eyes, and take a sip of coffee.

Work Flow and Clearance

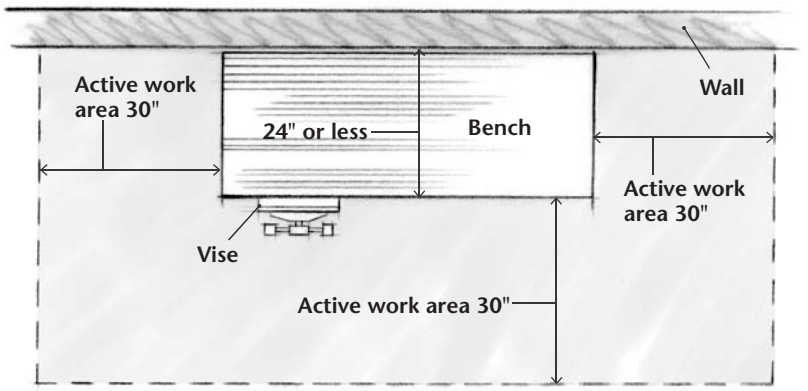
In any workshop, there is a natural flow of materials in and finished projects out. Using a simple floor plan, you can try different positions for the bench without actually moving equipment. Cut out pieces of colored paper representing machines, benches, and commonly used materials like plywood panels or 12-ft. boards, all drawn to the same scale as the floor plan.

Once you begin to place the items on the drawing and move boards and panels through the typical operations, you begin notice a natural flow of boards from a storage rack, through the rough milling operations to the joinery. Make sure you also account for comfortable working clearances around the bench in your plan.

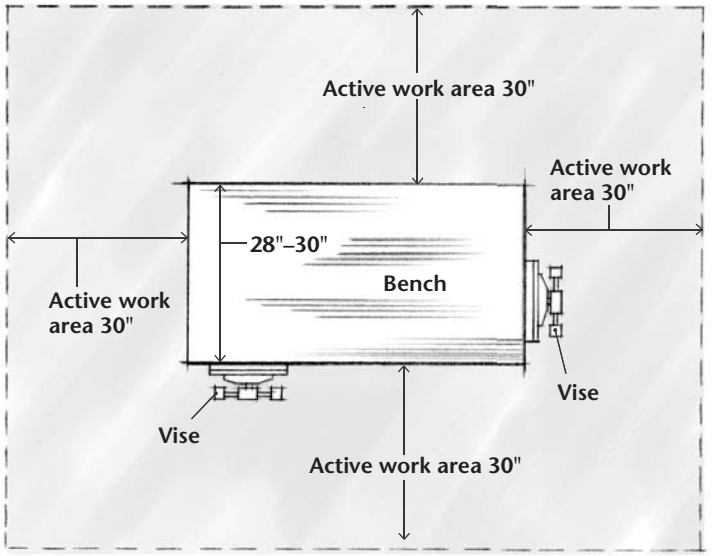
Clearances around a Workbench

The minimum clearance between any active working face of the bench and an obstruction is 30"; 3'–4' is preferred.

AGAINST THE WALL



FREESTANDING



Bench Size

Once you have decided the location of the bench, the next step is determining its size. As we've seen, the space in your shop and where you chose to locate the bench place some limitations on size. If the space you have for a bench is 12 ft. in length between two walls, an 8-ft. bench will allow only 2 ft. on either end to work. A 6-ft. bench length would work much better.

In a very large shop, where working clearance is not an issue, ergonomics and the kind of woodworking you do play a larger role in deciding bench dimensions. Space-challenged woodworkers have fewer options. A tiny shop must have a workbench in scale with its size or there will be no room left for other critical equipment. Even when space is not an issue, there are practical limitations to bench size.

HAROLD GREENE'S COMPACT, but fully outfitted, shop called for a small bench. To save space, he's located it against the wall where his hand tools are just an arm's reach away.

THIS BENCH, built by Steven Thomas Bunn in Thomas Moser's shop, was inspired by the classic benches found in Shaker workshops. Longer than most modern benches, it features roomy cabinet and drawer space below.

Length

The Shakers built very large benches, some as long as 15 ft. The Shakers, who lived communally, often made large built-ins for members to share and tall shelves and cabinets to occupy narrow areas on the wall. No useful space was wasted. A long bench helps support the long uprights that were used in this type of furniture and provides space enough for more than one person to work at a single bench, which was the Shakers' working style.

These days, benches are commonly in the 5-ft. to 7-ft. range, a useful size for building stand-alone furniture for an average-scale room. But if you plan to build a boat or a circular staircase, you'll commonly use boards over 20 ft. long. In that case, you may think you need a very long workbench. But If you plan to build only one boat or one staircase, there are short-term solutions that will work for the duration of the project, including joining two workbenches of the same height or setting up a series of sawhorses as supports.

On the other side of the spectrum, a woodworker who makes only small boxes or toys can make do with a relatively short bench. A woodcarver whose projects are on the small side would probably prefer an equally small bench that's close to square in shape and provides many ways to anchor the work.

LEE GRINDINGER, who builds carved furniture in Montana, uses a specially designed bench from Lee Valley Tools for carving moldings. The bench tilts and rotates.

A TOOL TRAY SERVES TWO PRACTICAL PURPOSES: keeping the tools close at hand but below the surface and adding width to the benchtop. Curtis Erpelding likes tool trays, but many woodworkers think they are good for little beyond collecting dust.

Width

As we've seen, wall-mounted benches have limitations in width. A bench wider than about 2 ft. makes it difficult to reach tools stored on the wall. Freestanding benches can be wider, which is helpful when gluing up large panels. But exceeding an arm's reach to the center is impractical, because the extra space can't be used.

Freestanding benches are usually 28 in. to 30 in. wide, including any tool trays. If your bench seems a bit too narrow, the addition of a tool tray or even an extension arm may accommodate your project.

Again, work style is the deciding factor. Michael Fortune prefers a 14-in. bench for good access to his furniture from all sides. Sam Maloof, on the other hand, likes using a bench that's over 38 in. wide! Though both Fortune and Maloof build chairs, their approach to benches is, to say the least, different regarding width. The main requirement for Maloof is to have a large work surface with a broad overhang so he can clamp various parts to the front lip of the benchtop.

Weight

It's hard to cut a moving target. The greater the total weight of the bench, the less apt the bench is to move when you apply pressure to a tool. Nothing is more annoying than trying to make a cut with a handplane and have the bench move with each cut. With a massive bench, the friction against the floor of the shop is greater than the lateral pressure of a heavy cut with a tool, so the bench stays in place instead of sliding across the floor. Of course, all of this depends on having a very solid base, something we'll discuss at length in Chapter 3.

Generally speaking, heavier is better where workbenches are concerned. But there are exceptions. Many woodworkers routinely haul their benches across town. Portable workbenches must be not only strong but also light enough to transport easily. Chapter 10 has several examples.

Assuming your primary workbench will stay in one place, there are two practical means for increasing the weight of the bench: add ballast or build on-board tool storage.

Adding Ballast

Adding ballast to the base can considerably increase the stability of a bench that is on the light side. The most straightforward method is to build a simple box, fill it with sand or bags of concrete, and screw the lid on. Plywood or medium-density fiberboard (MDF) make good materials for the box. Join it with simple butt joints, reinforced with glue and drywall screws about 4 in. on center (o.c.). Bolt the box securely to the base from the inside. To contain concrete dust, line the box with heavy plastic sheeting.

Smart Solution

BOLTING TO CONCRETE

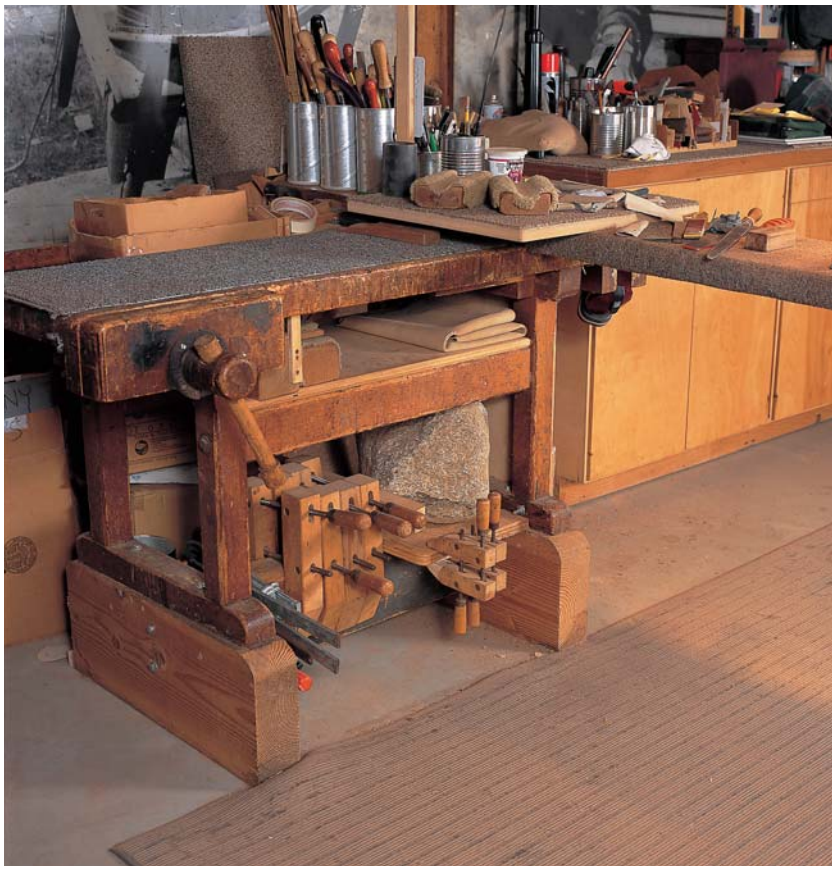
If adding mass to the bench itself is not an option, you can stablize it by bolting it to the floor or wall. These female concrete anchor nuts fit flush with the floor. It is a simple matter to drill into the concrete with a hammer drill and masonry bit and then set the anchor in place with a small tool. Nothing sticks up above the slab when the bolts are removed. Sets of anchors placed in different areas offer flexibility with shop layout by making it easy to relocate the bench.

Or you can do what Larry White did: Place a large rock on the base. It is a simple way to easily increase the weight and mass of just about any bench.

On-Board Tool Storage

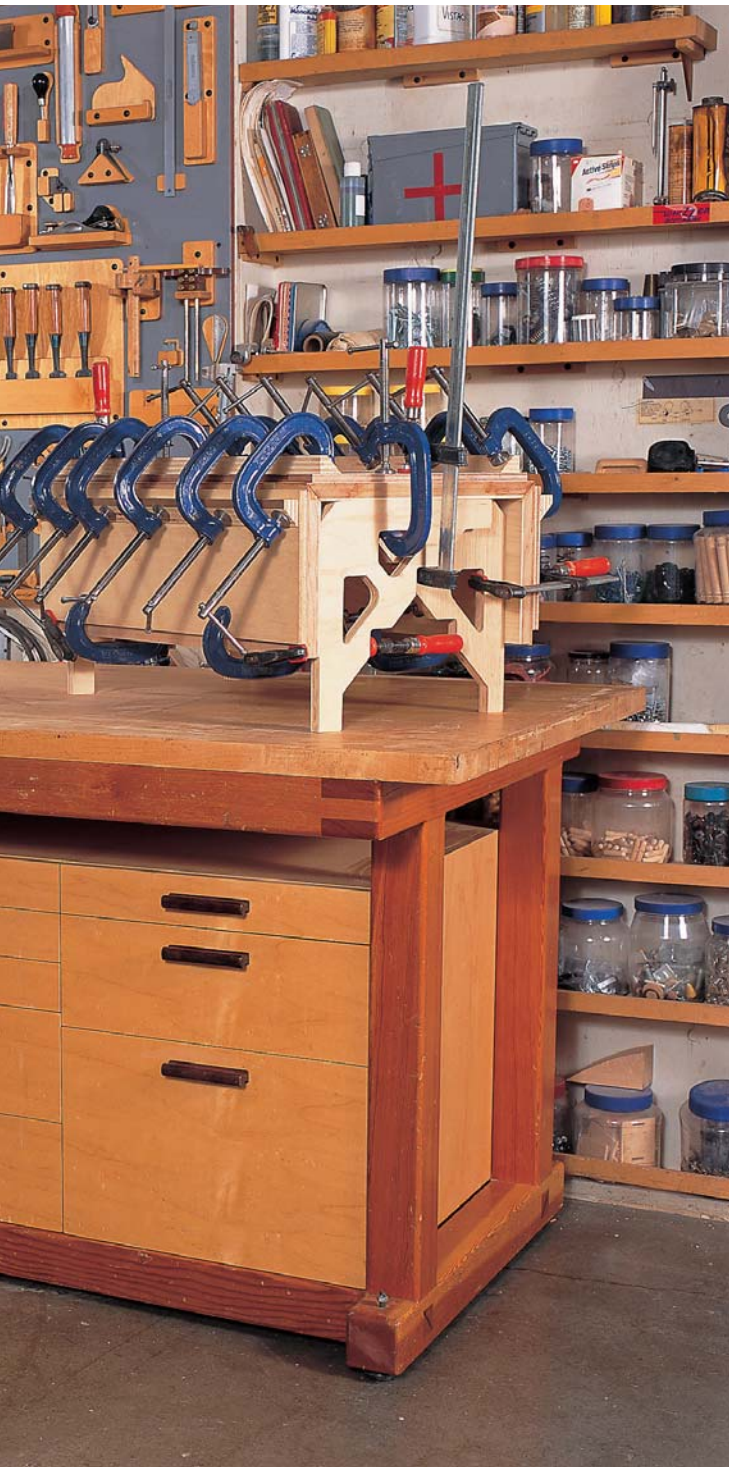
Using the base of a bench to store tools offers a two-fold advantage. Not only are tools handy and within easy reach but their weight acts like built-in ballast, making the bench heavier and more solid. The cabinets and drawers on their own will add weight to the bench—and even more when they're loaded with planes, chisels, and marking tools.

The tool cabinet serves another useful purpose: It helps make the base rigid. So long as the base is rigid, the top will not wobble. Handplaning, for example, requires having a solid bench to hold the board steady while you concentrate on planning smoothly.



ADDING BALLAST TO A BENCH can be as simple as finding a big rock to sit over the base stretchers, a solution Larry White uses. A more conventional approach to ballast is attaching a box to the base and filling it with sand.

TOOL-STORAGE CABINETS AND DRAWERS below the bench surface not only add mass to the bench but provide rigidity as well. Brent Merkley's well-organized bench cabinet keeps his tools close at hand.



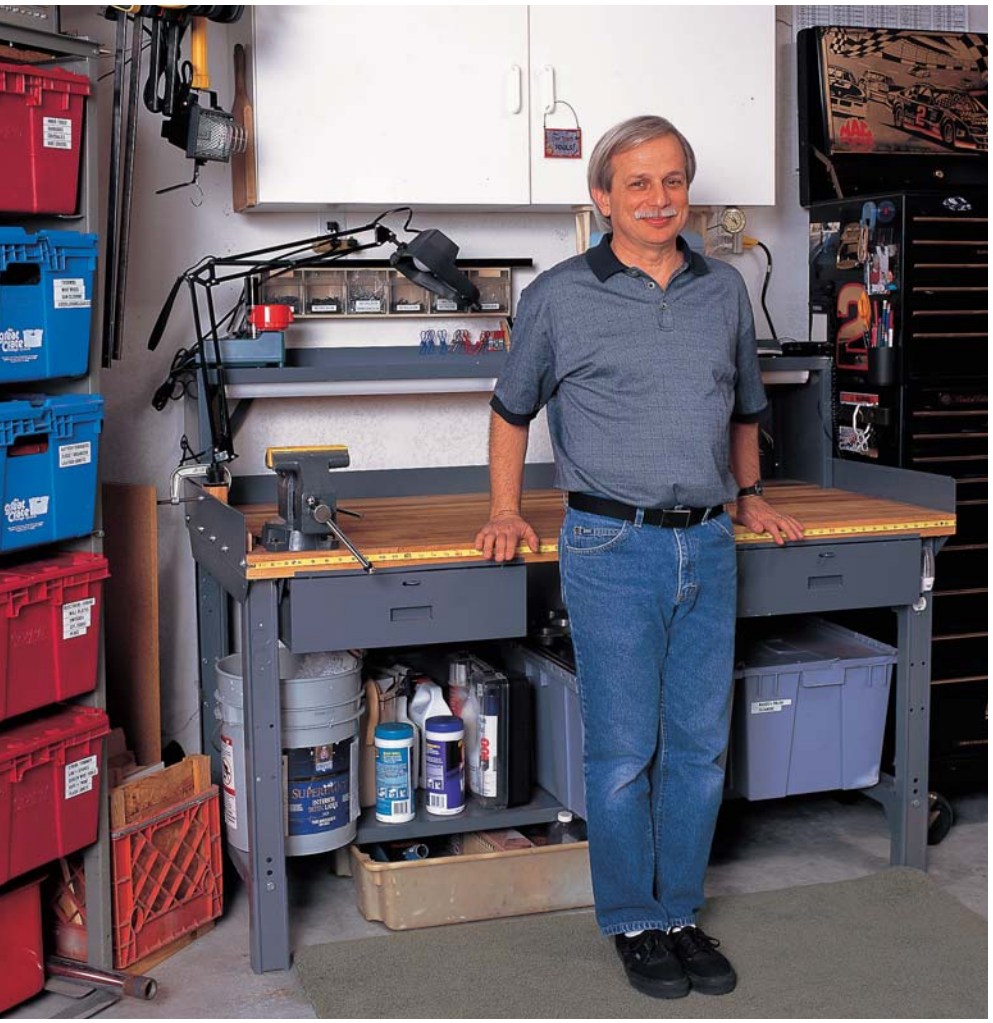
JOHN BARBEE TOOK A METHODICAL TRIAL-AND-ERROR APPROACH to establishing the ideal height when he built his bench. He worked at different benches and changed the relative height by standing on pieces of ¾-in. plywood. He varied the number of pieces until he found a comfortable working height.

Height

Experienced woodworkers would agree one of the most critical factors in workbench design is elevation. What they will not agree on is an actual number of inches. Plenty of rather tall woodworkers like relatively low workbenches and an equal number of shorter woodworkers prefer benches higher than usual. Once again, the purpose of the bench and the kind of work and tools you use help make this decision.

The lower the bench, the more pressure you can apply to a plane, thereby increasing your power and control. This is an important factor not only for using a handplane but also for working with many modern power tools. But the lower the bench, the more difficult it will be to perform delicate operations without stooping. The solution, of course, is to sit or even kneel at the bench, but this is often impractical.

You find the perfect height for one task, say planning a board, but when you begin to assemble a project, suddenly you find that the bench is too high. So how do you find the right compromise?



THE OLD RULE OF THUMB, measuring from a down-turned palm to the floor, worked for John Allison. His workbench is at a comfortable working height for most tasks.

Better Short than Sorry

Vermont author, handplane fan, and furniture maker Garrett Hack offers some good advice. He suggests building the bench a couple of inches shorter than you really think it ought to be. Then if it does not feel comfortable, it is a fairly simple matter to either prop the legs up on blocks or add blocks between the top and base to raise it. Reading between the lines, it is not difficult to imagine the hesitation one would have thinking about chopping the legs off a bit if the bench proved to be too high.

Determining Bench Height

The classic rule of thumb for determining bench height is simple. While standing, turn your palms downward and measure to the floor. For a person of average height, this will be 34 in. to 36 in. This distance is as close to a single ideal height as you will likely find. This is a comfortable working height for most people. So it comes as no surprise that 36 in. is also the standard height for kitchen counters.

But you should test the rule of thumb measurement empirically. Work at benches at different heights to see what suits you best; add blocks under the bench to raise it or stand on stacks of plywood to effectively lower it. Keep track of the heights that work best for certain tasks.

If you tend to do meticulous work, like small hand joinery, chances are you are in the market for a bench that is on the high side, especially if you prefer to work standing as opposed to sitting. The reason, according to Garrett Hack, is as the work gets more delicate, you tend to want both your hands and the work itself closer to your eyes.

Adjusting the Height

A compelling reason to get the height right the first time is the daunting task of raising or lowering the bench afterward. Blocks added under the feet make raising the bench fairly easy, but lowering it is another story. And by setting blocks under the feet of the bench, you introduce the likelihood that if you apply enough lateral pressure to a tool, the bench could slide right off of the blocks. Fastening the blocks with screws is one method, but suppose you later find you need to lower the bench? A more permanent solution is an adjustable-height benchtop.

Bench Options

Going Up?

Woodworkers tend to be an ingenious lot and have come up with some pretty clever mechanisms to to raise and lower a benchtop. Some elevator benches rely on hydraulics. By pumping fluid into an expandable hydraulic cylinder, a person can lift tons of weight.

A commercially available scissors jack makes adjusting the height of Harold Foss's workbench as easy as pressing a button. A hydraulic cylinder lowers and raises the bench, depending on whether Harold is assembling a piece of furniture, when he might want it on the low side, or sanding a panel, when having it higher is more comfortable.

Curtis Erpelding is nothing if not an inventive woodworker. Almost as comfortable working with metal is he is with wood, he designed an adjustable bench to suit the needs of San Francisco keyboard instrument maker Gary Blaise.

Blaise's specialty involves very meticulous work for which a high bench is perfect. This one cranks up to nearly 48 in. But he also does a considerable amount of joinery and needs to have a bench at a more conventional height, around 36 in. All it takes is a few cranks on a hand wheel.

This chain-driven mechanism rotates four sprockets attached to bench screws to raise and lower the benchtop. The base stays stationary while the top raises and lowers. Something like this could be readily adapted to nearly any conventional benchtop. Mail-order houses, like McMaster Carr and Johnston Supply, offer parts for just such a setup. (See Resources on p. 196.)

HAROLD FOSS FOUND A SOLUTION from an unexpected source. The hydraulic scissors jack that allows the height of this bench to be adjusted is more commonly seen in industrial applications, but the wooden benchtop turned it into a woodworking bench.

ON GARY BLAISE'S ADJUSTABLE-HEIGHT BENCH, which Curtis Erpelding custom-built for him, each leg has a threaded rod linked together with a chain hidden under the benchtop. By rotating a single crank, the entire benchtop raises and lowers.

JUDITH AMES'S SHOP is wonderfully awash in natural light from two windows above her workspace. By positioning her workbench right under the windows, she rarely requires artificial light.

NOT ONLY DOES THE POSITION OF GEORGE LEVIN'S BENCH under a window flood his work with natural light but it also allows a pleasant view of the outdoors. When doing close work, it's beneficial to rest the eyes by periodically viewing objects in the distance.

A Comfortable Bench Area

The bench itself is only part of the formula for a comfortable work area. Good lighting, a padded surface to stand on, a reasonable room temperature, and adequate ventilation all contribute to a safer and healthier working environment. As an added bonus, you are not only protecting yourself from injury but also enjoying the craft all the more.

Workbench Lighting

It is difficult to imagine eighteenth-century woodworkers working without artificial light. Workdays must have been awfully short, especially in northern areas with already short winter days. But Mack Headley, an expert in eighteenth-century woodworking at Colonial Williamsburg in Virginia, says natural light in the shop is quite adequate most days. He should know. There is no artificial light in the cabinet shop where he and his associates work. So when it is cloudy and dark, they simply switch to rougher work, like preparing stock, leaving finer work, like joinery, for days when visibility is better.

Thankfully, as long as the electricity stays on, having enough light to work in is not as big a challenge these days. Modern woodworkers routinely work after dark and in areas far from a window or skylight. Even in a basement shop, where there may be no natural light at all, artificial light supplies sufficient brightness to see. But as most experienced woodworkers have learned the hard way, there is no substitute for

natural sunlight. We just see better in the broad spectrum of natural light, a real advantage as our eyes age and need all the help they can get.

Natural light provides true color, a real advantage when finishing. Many a woodworker has applied a dye or stain under an incandescent or fluorescent light only to find the piece a totally different (and unwanted) color when it is brought into daylight. This experience can be very unnerving, especially after investing so much work in a project.

Light from outdoors can come from windows or skylights. In some parts of the country, the climate allows working outdoors or opening a large door to bring in both natural light and fresh air. Most woodworkers will get their natural light from strategically locating their bench near a window. Once again, the bench against the wall arrangement provides an advantage.

Task lighting gives extra visibility at those times when ambient light simply isn't enough. Cutting fine joinery by hand often demands strong directed light to see pencil markings. Some task lamps, such as those designed for drawing boards, clamp right to the bench surface or can be adapted with simple fixtures.

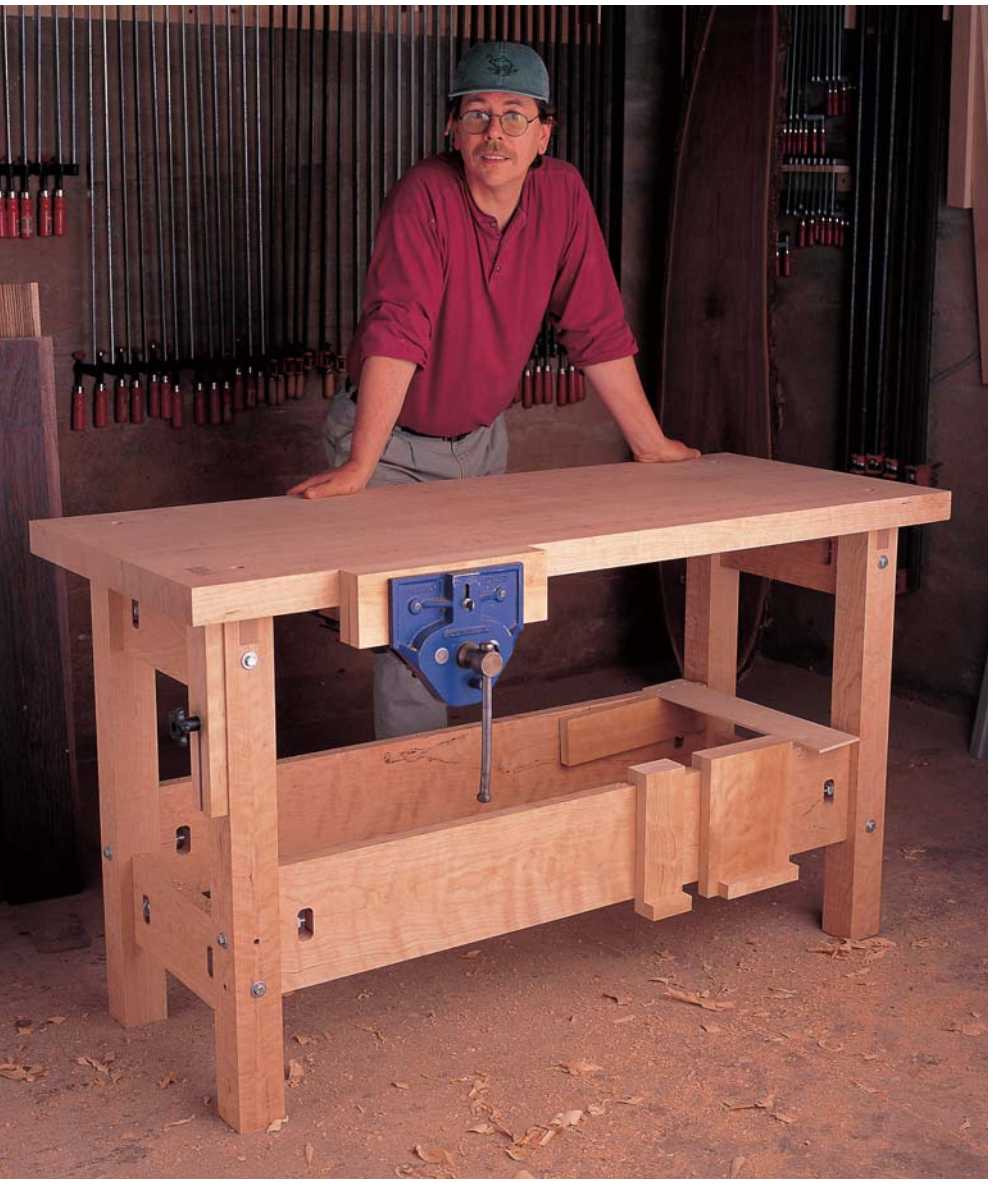
Antifatigue Mats

Unfortunately, many shops are located in industrial buildings, garages, or basements and are finished with concrete floors. A long day of standing in one place on a hard floor can affect your legs and back long after you've left the shop.

To prevent stiffness, place some kind of cushioning on the floor in the area where you most often stand. Many companies manufacture rubber mats or interlocking rubber tiles for this purpose. But you can also make a galley-style slatted wooden platform or simply put down a piece of carpet. Whatever you use, consider whether it will catch dust and shavings and how easy it will be to sweep or clean with a shop vacuum.

STANDING ON CONCRETE for long periods is not only hard on the feet but hard on the back as well. A simple pad of carpeting makes working at the bench much less tiring in John Allison's garage workshop.

IN ONE OF HIS BRILLIANTLY SIMPLE SOLUTIONS, Yeung Chan made a solid wooden bench dog and drilled a hole in it to fit the base of his lamp. He can position the lamp anywhere he likes by inserting the special dog in any hole on his bench.



EXPERIENCED, PROFESSIONAL WOODWORKERS like Niall Barrett often find that a very basic bench mounted with a large commercial vise is all they need.

Designing Your Bench

Once you have considered your needs in a workbench and evaluated the options for tops, bases, and hardware presented in the following chapters, it's time to begin designing your bench. While you may have specific ideas in mind when you start the process, don't be surprised if the end result looks quite different.

Your Skill Level

If you are just starting out in woodworking, a workbench may not be the first project to undertake. Among your other challenges will be a surprising dilemma: You need a workbench to build a workbench. That's exactly why I've offered some simpler benches in Chapter 8, but even these benches require some basic woodworking skills, not to mention tooling. If you've never cut a dovetail before, maybe this isn't the time to build a dovetailed tail vise.

If you're determined to build a workbench early in your woodworking career, start out with something very simple like a premanufactured slab sitting on some cabinets. Use butt joinery reinforced by screws where you can. Install an off-the-shelf or kit vise instead of attempting to build a vise from scratch. And, as you'll see in Chapter 6, there are components—and even whole kits—that will make workbench construction quicker and easier. And until you have a bench to work on, try an inexpensive off-the-shelf portable bench or build the components of your bench in the shop of a woodworking friend or public shop.

Drawing a Plan

It's entirely possible to build a bench absent plans; many woodworkers would admit to having done just that. But if you mean to have your bench look a certain way, have particular features, be large enough to handle your biggest projects, or small enough to fit through the door, having a plan is the way to go.

Drawing a workbench is no different from drawing any other woodworking project. Three simple views (front, top, and end) are all that's required. Whether you draw on graph paper or use a computer-based drawing application, the time to iron out the details is on the drawing board, before you begin to slice up that expensive pile of lumber. This is also an opportunity to look at several versions of the bench design

to see which best addresses your needs. A full-size plan will take a lot of paper; but for difficult parts, like vises, having the dimensions shown at actual size could save hours of remaking a critical part.

Predrawn Workbench Plans

Predrawn workbench plans are widely available in books, magazines, and catalogs and on the Internet. Even if you intend to design your own bench, studying predrawn plans is useful because you'll see different joinery options and perhaps ideas you hadn't considered. The directions for building often offer invaluable tips on gluing, joinery, and other useful woodworking techniques. If you decide to build from an existing plan, you need not follow it to the letter. Within reason, you can modify the dimensions to suit your own needs. Just make certain that you recalculate all the measurements affected by your modification.

Some of the better plans include several from Lee Valley Tools, the Acorn bench, based on a popular kit that is unfortunately no longer available, and the economy bench plan from Rockler Woodworking. There is even a plan for a workbench designed by woodworking icon Norm Abrams. Just make sure you get the video to go along with it, since it fills in some much-needed detail.

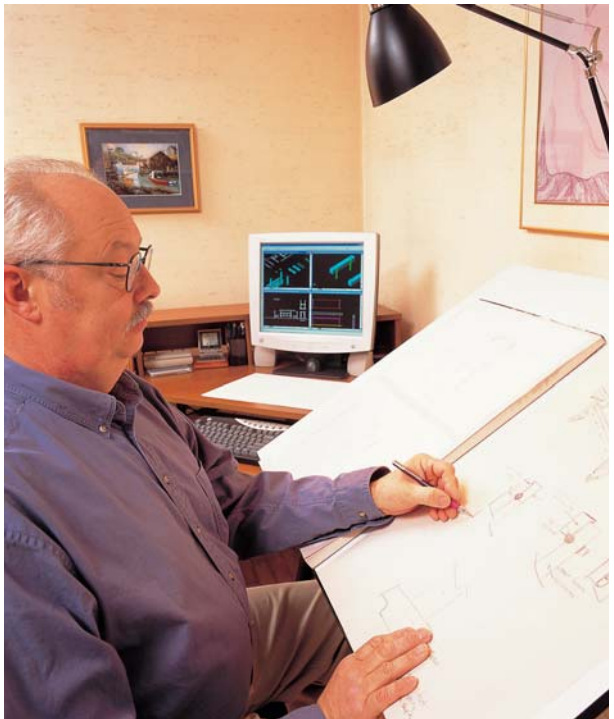
EVEN IF YOU INTEND to make your own drawings, buying a set of plans is a good starting point. Commercially produced plans like these from Lee Valley Tools detail joinery, provide a materials list, and help you visualize the finished product.

Other Resources

If you need more inspiration to develop your plans or to find technical data, there is certainly no lack of information available. Books, like Scott Landis's classic *The Workbench Book,* offer workbench plans as well as fascinating background information and history.

The Internet is loaded with bench resources. You can find not only drawings on a number of sites but also fun and useful bits of information, like original installation instructions for an Emmert vise. (See Chapter 4 for more on Emmerts.) An Internet search on *workbenches* will produce literally thousands of hits. Discussion groups by the dozens; companies that sell hardware, complete workbenches, and components; and individual Web sites with more information than you would ever imagine on the fine points of vise installation can all provide an almost endless array of excuses to sit at the computer instead of getting any work done.

RICK GUNDERSON, like a lot of woodworkers, has an inquisitive nature. Designing a hydraulic adjustable-height workbench is his current challenge.



2

Workbench Tops

PAT EDWARDS'S TRADITIONAL WORKBENCH features a removable center tool tray to provide access for clamping, a shoulder vise, and a traditional end vise. The French carving vise in the foreground bolts to the benchtop through any dog hole.

The top is easily the *most* important part of a workbench. The main function of the benchtop is to provide a stable and flat surface to hold your work. A flat top is essential as a reference surface for cutting joinery or gluing. The top must also provide an anvil-like table for chopping with a mallet and chisel. The essential holding devices—vises, bench dogs, hold-downs—attach to the benchtop. Beyond these practical requirements for the bench is the statement the benchtop makes about you and your work.

Every decision about the benchtop is critical. The size and configuration of the benchtop must be tailored to the kind of work you intend to do. The type and placement of holding devices can mean the difference between a secure workpiece or constantly wrestling with your work. The materials you use to construct the benchtop, how it will attach to the base, and even the finish you use will affect the performance of the bench. You'll have to ponder how movement may affect the joinery you use to construct the top. In this chapter, we look at the options in benchtop configuration and construction to help you make the best choices.

SAM MALOOF'S BENCHTOP, at 39 in. wide by 84 in. long, is on the larger side, but since he likes to work from both sides of the bench, it is narrow enough to easily reach to the center.

Benchtop Dimensions

Woodworkers often lament that their carefully crafted, very expensive bench is either too narrow or not long enough. Rarely do you hear complaints about a benchtop being too big. The length and width of your bench are directly tied to the dimensions of your shop and what sorts of projects you intend to build. Most experienced woodworkers would recommend the largest bench that would fit in your shop, as long as it leaves room for you to work.

A longer bench facilitates work on longer projects, both on the edge of the board and on its surface. If you were to try to sand the face of a 6-ft.-long board on a bench shorter than that, of course it's a simple matter to flip the board end for end. But if the bench is long enough to support the entire length of the board, working on it is much more efficient.

FURNITURE MAKER AND BOATBUILDER Ejler Hjorth-Westh needs an exceptionally long workbench to fashion boat planks. For furniture-making tasks he also has a more conventionally sized bench in his shop.

A NARROW BENCH with a full-width end vise and a double row of bench dog holes might be ideal for planing panels, but many woodworkers would find it too narrow for general projects.

Bench widths average around 30 in. Common lengths average between 5 ft. and 7 ft. There is a limit, of course. A bench the width of a Ping-Pong table would be very awkward to work on no matter how solid or flat. Reaching even the center of it, much less the other side, would get old very quickly.

A benchtop must also provide a solid surface for pounding. When using a mallet to chop dovetails, the energy of the mallet blow on the chisel is partially wasted if the top bounces. A thick, solid, heavy top keeps the force focused on the point of the chisel, offering greater effectiveness and control. For a solid-wood top, 1 in. at the center is a minimum thickness. A better size is between 1½ in. and 4 in.

Big is good, when it comes to benchtops. But remember that the larger and thicker the top, the more the bench will weigh, making it a chore to move.

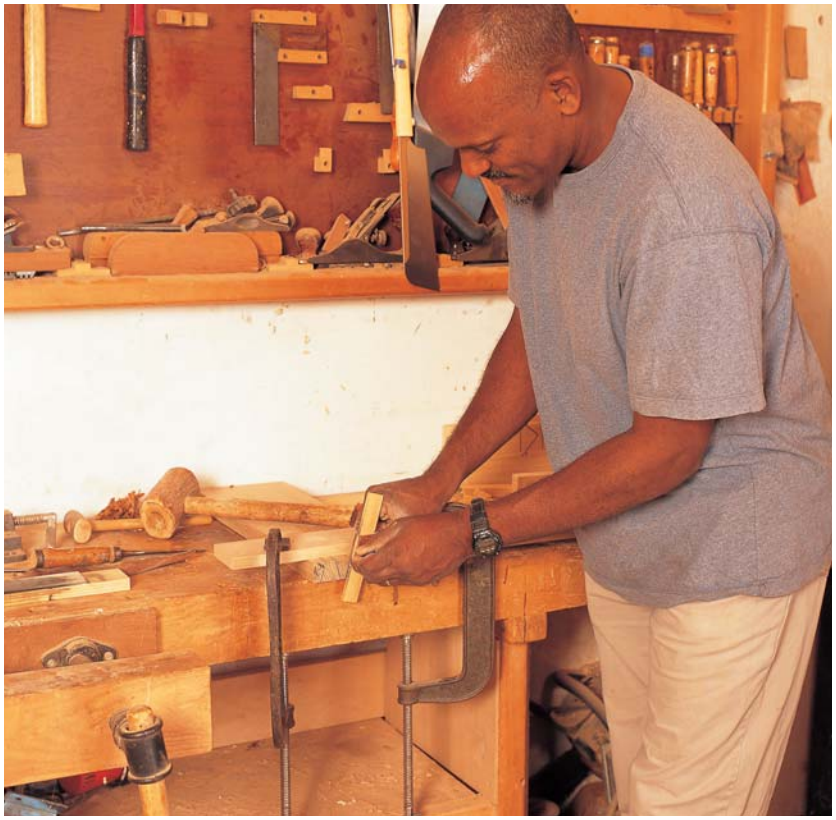
THE TRADITIONAL TAIL VISE on Garrett Hack's workbench enables him to secure parts closer to the center of the bench and keep them flat. Overhanging the edge allows him to profile this shaped workpiece with a scratch stock.

Top Configuration

A bench performs many functions, but its main job is to hold the piece you're working on securely enough so that you can guide whatever tool you're using with both hands. The configuration of the top includes the locations and variety of vises and hold-downs and options like tool trays. Your style of working affects the bench configuration as well. If, for example, you like to clamp work to the front edge of the bench, you'll want the front lip to be the same thickness as the rest of the bench.

Choosing and locating vises and hold-downs is one of the first decisions you'll have to make. Classic benches and most stock benches have a front vise on the left of the bench as you face it, an end vise or tail vise on the right, a single row of dog holes, and a couple of spots for hold-down placement. But there are many options beyond this the typical configuration. There's no rule saying the end vise has to be on the right or the front vise on the left. If you are a left-handed woodworker you might consider just the opposite.

It's safe to say you'll prefer the types and locations of vises to be similar to the bench you learned on. If you are accustomed to a shoulder vise you'll probably want one on your new bench. If you find shoulder vises slightly quirky, as many woodworkers do, you will probably opt for a conventional front vise. You may find a conventional cast-iron or perhaps a chain-



HAROLD GREEN LIKES TO CLAMP WORKPIECES to the edge of his compact workbench. Two C-clamps and a batten board hold the work securely.

Bench Profile

A Bench to Honor Many Traditions

Pat Edwards trained as an *ebeniste*, a veneer and marquetry specialist, at the prestigious École Boulle in Paris, where classical French cabinetmaking traditions influenced his preferences in workbenches. One side of the bench is a version of Roubo's French eighteenth-century bench design. Holdfasts hold the work. On the other side is a version of Frank Klausz's nineteenth-century German bench. On the German side, bench dogs and a traditional tail vise secure workpieces.

There are four vises in all: shoulder vise, tail vise, leg vise (with a sliding jack), and parallel jaw vise. All the vises have large wood screws, made by Tom Branch in Canada. The massive 4-in.-thick top is 39 in. by 104 in. and features a center tool tray that is removable. The tray opens to provide a way to clamp pieces in the center of the bench using a conventional clamp.

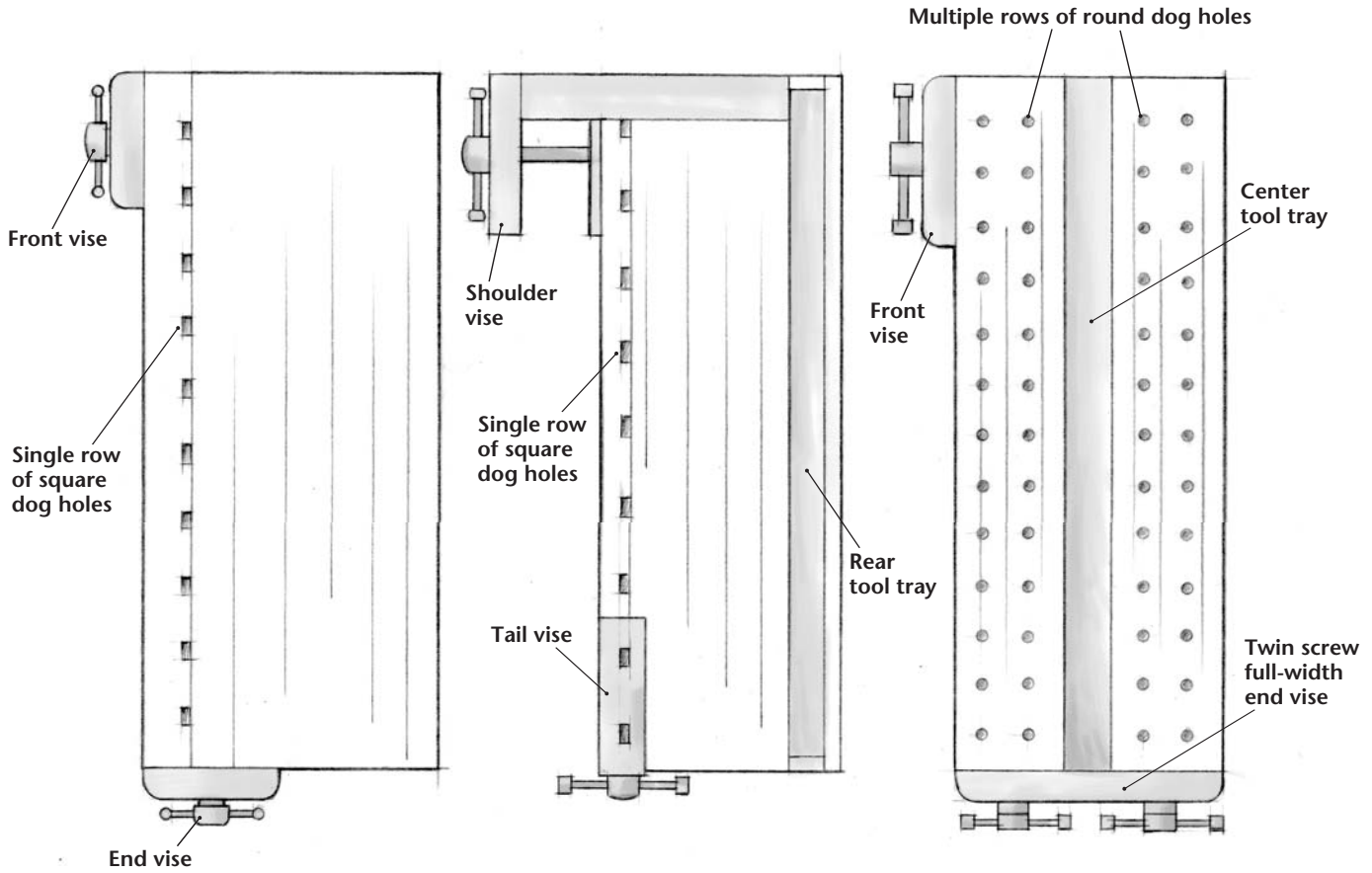
Edwards had some time to think about what features to incorporate. He built this workbench in the spring of 1989 to celebrate two decades of business. The lumber came from the beech tree he cut in Pennsylvania in 1978 and seasoned for over 10 years. He proudly signed and dated the bench on completion at exactly 1:23:45 p.m. on June 7, 1989.

driven, twin-screw vise works fine as an end vise, unless, of course, your experience is with a tail vise. Then you'll want a tail vise for sure.

The hardware you choose may affect configuration and, in turn, the configuration may affect hardware. Some hold-downs need only a drilled hole to do their job. Others need a metal flange let into the benchtop. First try to figure out the likeliest places you'll need to use a hold-down, then mentally sketch them in. The hold-downs that require only a drilled hole will fit into a ¾-in. round dog hole.

Before you start choosing brands and hardware, consider what you plan to do on the bench, what sorts of parts you'll be working with, and what kinds of operations you'll set up on your bench. Carvers will find a pattern-maker's vise useful. Chairmakers will get a lot of use out of a tail vise. Box makers or those who work with sizable panels will like having more than one row of dog holes and should take a close look at different end vises. There are many to choose from, as you'll see in Chapter 4. For now try to picture what vises you'd like and where and what hold-downs you'd like and where, and meanwhile contemplate the pros and cons of tool trays.

Typical Benchtop Configurations



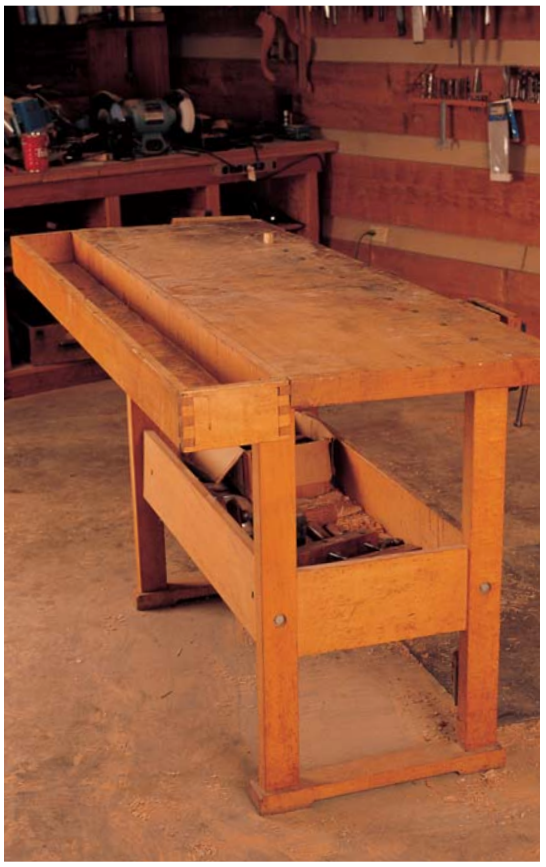
THE INTEGRAL TOOL TRAY on rear of this bench is the most typical configuration. The edge of the tray is usually at the same level as the bench surface, effectively increasing the useable area of the bench.

Tool Trays

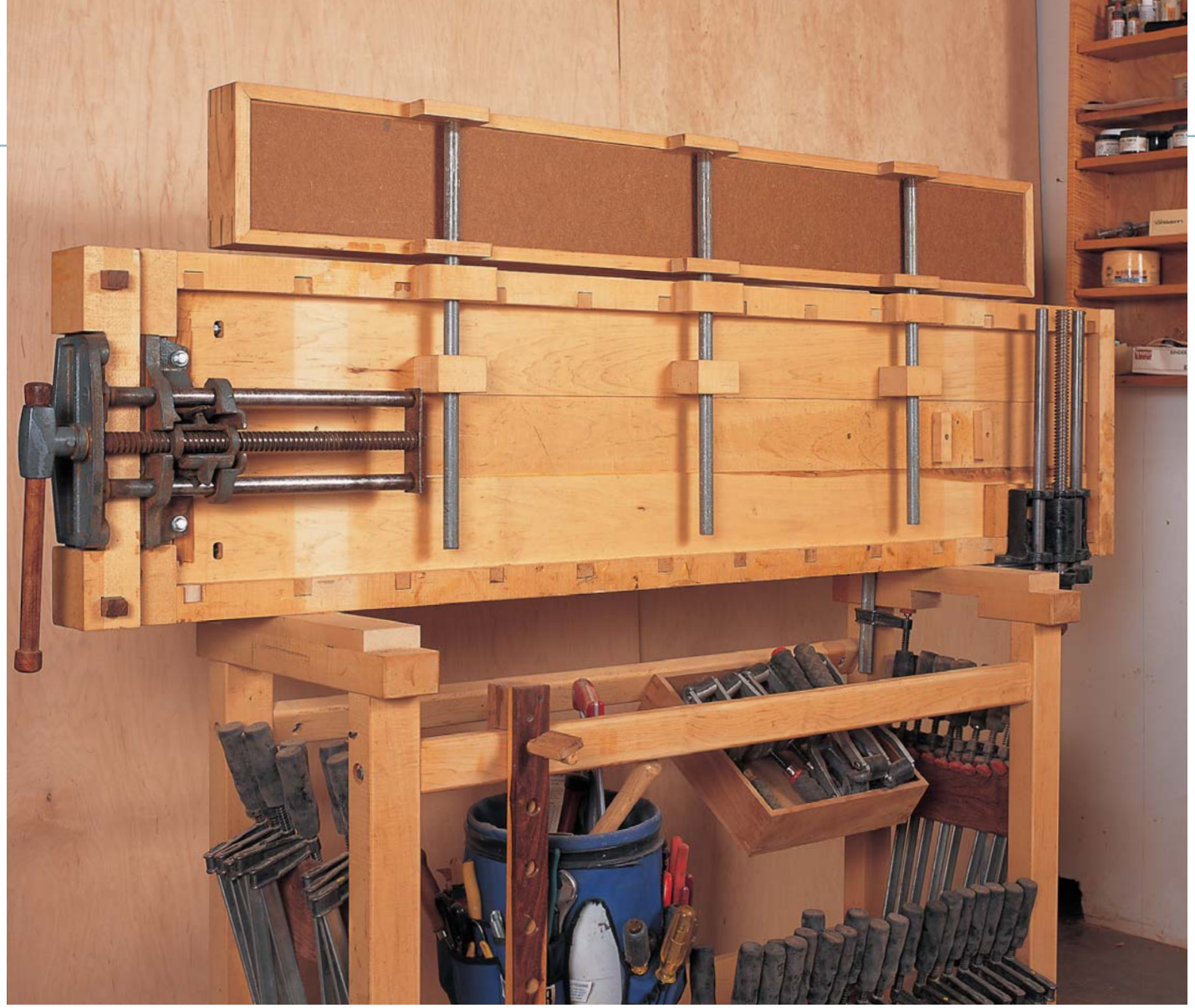
Woodworkers either love tool trays or hate them…or both. The main advantage of a tool tray is that it keeps your tools close at hand. It also gets your tools below the level of work. The alternative is clearing everything off the bench when you need the surface.

Most benches mount the tool tray on the far side of the bench, lengthwise. If it's level with the bench surface, it can extend the effective work area. But some, such as the Lervad, offer a tray that can be switched from side to side and attach to the end of the bench as well. The center tray configuration from Lee Valley Tools is a novel approach that has the benefit of easy reach from both sides.

Unless the tool tray is a permanent part of the benchtop, there are many alternative configurations. It's never too late to add a tool tray. Worth considering is a bench with a portable, removable tool tray.



DAVID WRIGHT RETROFITTED A TOOL TRAY to a completed bench. He built a simple dovetailed box and attached it to the side of the bench.



SEATTLE FURNITURE MAKER HANK HOLZER mounted his tool tray to three pipes that go beneath the benchtop; they support the tray and allow it to be pulled out or pushed in. When the tray is pulled out, the work surface is increased. The tray can also be removed entirely.

If you plan a tray on the far side of the bench, remember that as the width of the bench increases much beyond 30 in., reaching across it becomes pretty awkward.

Unfortunately, tool trays tend to accumulate shavings, bits of sandpaper, screws, and other odd bits of shop trash. Keeping them clean can be a losing battle. Everyone who's worked with a tool tray has spent time poking through wood shavings looking for a missing screw or small tool. You can't really use air pressure to clean out the tray, because you'll blow the tiny part across the shop. Using a vacuum doesn't work either because just about the time you spot the part you were looking for, it disappears, rattling down the vacuum hose into the bag.

Aggravating as this is, where are you going to stow your tools if not in a tray? About the first time your newly honed chisel lands edge first on the concrete floor, you begin to rethink your resistance to tool trays. And there are ways to deal with the tool tray junkyard. Some trays have openings in the bottom so you can easily scoop the waste into a bin below. Others have ramps built into each end, making clean out easier. So far, the most sensible solution is the center tray that's open at the ends, standard on Veritas® benchtops.

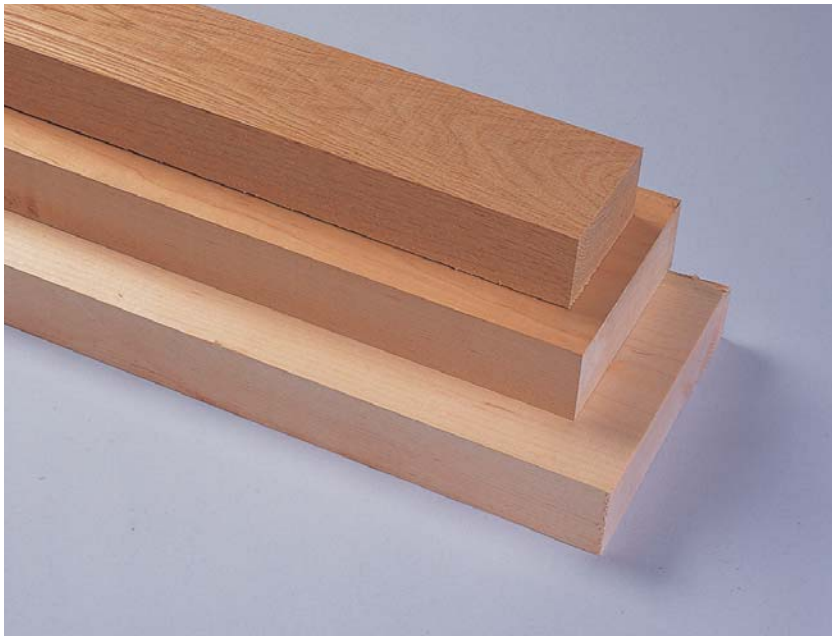
A CENTER TOOL TRAY OPEN AT ONE END is standard on Lee Valley's Veritas® line of benchtops. It allows you to easily sweep out shavings, sawdust, and other waste. The bottom of the tray also ties the two matching slabs together, forming a wide top.

Materials for Tops

The array of materials woodworkers choose for benchtops varies almost as widely as the range of operations that are done at the bench; but materials fall into two general categories: solid lumber and an amazing array of man-made panels.

Tops can be made from solid boards glued together like a length of butcher block or they can be made from a solid slab of wood or layers of solid lumber or plywood. Some are hollow like a torsion box; some are faced with Masonite or plastic laminate. And benches can be found in any combination of the above and more. Like decisions regarding hardware, the choice of materials affects the benchtop construction method, and the construction method affects the choice of materials.

DENSE, SOLID HARDWOODS MAKE GOOD BENCHTOPS. *From top to bottom:* Oak, while not common, makes a handsome and durable choice; beech is the favorite benchtop material for European benches; and maple is hard, close-grained, beautiful, and economical.



BY FAR THE MOST COMMON BENCHTOP is made from planks of solid wood face-glued together. Flatsawn boards turned on edge provide a more stable quartersawn grain configuration. The end cap is optional, but it helps hold the top flat.

Smart Solution

MILLING THICK STOCK

An underpowered table saw will often bog down under the stress of ripping 8/4 hard maple. Saw burns are likely. You'll need at least 3-hp saw with a long outfeed table to do the job. One option would be to mill your stock in the shop of a friend who has an adequately powered saw. Another is to have the stock milled at the dealer where you purchase it.

Laminated Solid Lumber

For most woodworkers solid wood is still the only "proper" benchtop. It just feels right when you pound on it. And no woodworker can dispute the durability and beauty of hard rock maple or European beech. Aesthetics certainly play a role in the choice of top material, but so, too, do dozens of other factors: cost, stability, and durability, to name a few.

Hardwood of some kind is the most common benchtop material. One reason is that high-quality man-made materials are a relatively recent innovation. The classic benchtop made of laminated solid lumber evolved long before plywood, MDF, and torsion boxes.

Hardwoods, like hard maple, oak, and European beech, are at head of the list for benchtop materials. Softwoods, like pine and spruce, are less common for benchtops because they are softer and less durable. On occasion, woodworkers bring in exotic species, such as purpleheart, but rarely for the top working surface itself; they are more likely to use these woods for trim. Using contrasting woods for end caps, vise jaws, or handles adds a decorative touch.

The most popular method of building the actual top is to glue strips of hardwood together to form the length, width, and thickness you decide on. A laminated benchtop usually begins with fully cured 8/4 boards milled to 1¾ in. The thickness of the benchtop determines the width of the boards, which are ripped on the bandsaw or table saw, turned on edge, and face-glued to one another. A flat surface for the setup and good beefy clamping cauls will keep the assembly flat during gluing. The final step is to surface and fatten the top.

There are many alternatives to laminating your own benchtop, including purchasing

HARRY WILLIAMS CREATED A SHOWPIECE BENCH by using contrasting woods. The side rails, end caps, and some of the benchtop planks are purpleheart. He carried the theme into the drawer faces, each a different species of wood.

butcher block slabs already milled and glued. These are often sold in home centers for kitchen countertops. Preglued tops can be had in almost any size you like.

Benchtops can also be purchased from woodworking supply retailers. This is certainly worth considering if you plan to build your own bench. The choices of length and thickness are almost limitless, up to 3 in. thick and as wide and as long as you'd ever want a bench to be.

Commercial benchtops seem expensive only until you do some math on the cost of the raw lumber and add in your time. But there are advantages to gluing the top yourself. Gluing up in the shop facilitates dog hole milling when using square dogs and the installation of a tail vise; plus you can control the grain orientation and better match the color. Many stock slabs have finger joints. Structurally, finger joints make little if any difference, but if you prefer to have full-length pieces, slabs without these joints are readily available at a slightly greater cost.

Single-Plank Solid Wood

As tempting as it is to use that single solid slab of wood you have had sitting in the corner of the shop for the past several years, you might give some thought to its suitability for a workbench. Wood moves as humidity changes. As experienced woodworkers learn, usually the

SANDOR NAGYSZALANCZY BUILT HIS BENCHTOP using a premade slab of maple strips. Slabs sold for kitchen countertops are available through lumberyards, home centers, and catalogs.

hard way, wood moves with enough force to split granite, despite any amount of effort to the contrary.

A single slab is inherently less stable than glued planks for several reasons. First, how the slab is cut out of the tree will greatly affect how much it moves and in which direction. Unless it was indeed a gigantic tree, chances are the growth rings will be roughly horizontal. If this is the case, the slab will tend to cup and grow significantly wider and narrower with weather changes.

If the grain is vertical or nearly so, the movement in width will be less; but if the slab includes the very center of the tree, it's likely to

Moisture Content

If the moisture content of lumber has not stabilized with the surrounding atmosphere, the wood will shrink dramatically, especially when the outer layers of a roughsawn board are milled away, exposing the core of the board. Evaporation of water by either air-drying or kiln drying brings the moisture content down to the 6%–12% range normally considered optimum for furniture making. But even when lumber is completely cured, it will continue to move as the surrounding humidity fluctuates. (For more information, see Bruce Hoadley's book *Understanding Wood*.)

THIS MASSIVE SLAB CUT from a single tree will make an impressive and exceptionally heavy benchtop. The key to using a slab for a benchtop is carefully drying the stock in a controlled environment and monitoring its moisture content.

RUSTIC-FURNITURE MAKER JON BROOKS brought his craft to bench making. A solid-slab top holds a specialized vise, perfect for holding irregularly shaped parts.

cup to an even greater degree and may even split right down the middle. At the very least, a single solid slab will need regular maintenance to stay flat.

Man-Made Materials for Tops

While solid wood may be the material of choice for discerning woodworkers, composite materials are an economical alternative. Composites have the advantage of stability and save many hours of labor spent in laminating a solid-wood top.

Plywood, which is layers of veneer glued together, each layer rotated 90 degrees, is relatively light and stiff. High-quality plywood like Baltic birch has many thin layers of veneer without voids in the core. The more layers there are, the stiffer the panel. Moreover, the veneers are all birch, not just the top and bottom layers. The downside is that plywood is much more springy than solid wood when you pound on it, as you would chopping dovetails, causing the project to bounce around as you work. One solution is to use a solid-wood plank in the section where most of the chopping takes place.

MDF (medium-density fiberboard) is great for building mass into a top. It's much less springy when pounded on than plywood. It is a relatively stable man-made material, very flat and heavy, weighing up to 100 lb. for a ¾-in.

CABINET-GRADE PLYWOODS come in a variety of grades and facing materials. *From top to bottom*: Baltic birch plywood, with many very thin layers of birch veneer, is exceptionally stable; medium-density overlay (MDO) plywood, faced with heavy smooth paper, is good for utility benches; Appleply is high-quality prefinished birch plywood typically used for cabinet drawer boxes.

COMPOSITES AND LAMINATES can make excellent benchtops in conjunction with solid wood or plywood. *From top to bottom*: Tempered Masonite, standard Masonite, melamine-faced fiberboard, MDF, and plastic laminate.

THIS ECONOMICAL BENCH is made from framing lumber and MDF. The removable MDF panels in the benchtop are interchangeable and allow for different clamping distances. The wedged opening in the foreground works in conjunction with the moveable shelf to quickly secure a board on edge.

Is MDF Really Stable?

The widely held belief that MDF doesn't warp is easily debunked if you do nothing more that lay a sheet directly on a concrete floor. In a few days your formerly flat sheet will cup noticeably. Nor is it particularly stiff. Pull a string tight across the middle length of the panel, then lift up one end. The panel will bend enough to lift the tight string off of the middle of the panel with enough clearance to slip your finger between it and the face of the panel. So what does this mean for using MDF in your benchtop? First, a large benchtop will sag unless it's supported in the middle. Second, it may warp if exposed to moisture.

sheet and, unlike plywood, having the distinct advantage of an almost perfectly uniform thickness. The surface of MDF, if left exposed, is very smooth and remarkably durable with light usage, such as assembly. If covered with a layer of solid veneer it's entirely possible to build a very massive and durable benchtop with MDF.

Plastic laminate is the almost perfect choice for many work tables and benches. It's smooth, durable, and available in a rainbow of colors and textures. It's easy to apply with contact cement and in most applications—like outfeed tables and drawing/assembly tables—will last even a professional woodworker a lifetime. Be mindful that if you apply plastic laminate to the top of your panel of plywood or MDF, the bench won't stay flat unless you cover the bottom as well to balance the panel.

Melamine is a form of MDF coated on each side with a colored plastic film. Though not as durable a surface as plastic laminate, it's very useful for some applications like glue tables, assembly tables, and drawing tables. It comes in a wide array of colors and is inexpensive and widely available.

Masonite is available in two forms. The lighter color is softer and less durable. The darker color, or tempered form, is harder and heavier. If you need a utility bench into which you need to drive an occasional screw to hold a jig, this is marvelous material. I've used it for utility benchtops, like outfeed tables, for decades. Under very heavy use, tempered Masonite is almost "self-healing" to use the phrase of my former partner, Jeff Smith. Translation: Small screw holes fill with debris and seem to disappear.

Keeping the Top Flat

Among the many roles of a benchtop is to provide an absolutely flat surface on which to work. This is important in a variety of situations, gluing, for example. Unless you have a flat benchtop, any twist or curvature in it will transmit to the piece you're gluing. Keeping the benchtop flat starts with smart construction.

Orienting Solid Lumber

The bad news is that wood moves. The good news is that its movement is quite predictable. Woodworkers who underestimate the force with

STRUCTURALLY, NO BISCUITS, DOWELS, OR SPLINES are necessary to reinforce the glue joint. As this test shows, the joints are stronger than the wood itself. The break occurred in the wood rather than the joint.

which wood moves may be tempted to use something like flatsawn ¾-in. boards edge-glued onto a panel the size of the benchtop and then, in turn, glued down to two or three of layers of plywood or MDF. This would result in a beautiful, thick, heavy top, but one that would proceed to tear itself apart within a season or two.

The wider the solid panel, the greater the total expansion and contraction. The thicker the panel, the greater force with which it moves. The least movement is along the length of the board. The most movement, at least with flatsawn lumber, is across the width, and the movement in its thickness is marginal.

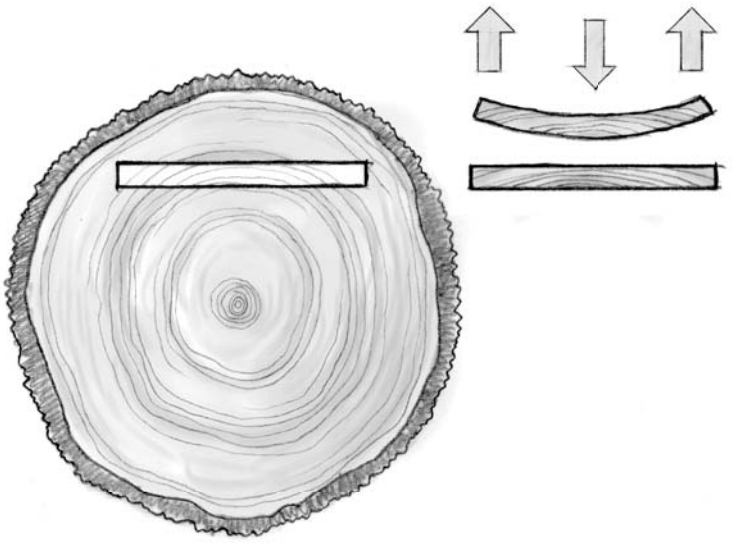
For the most stable solid-wood benchtop, start with flatsawn lumber, the most common cut. Rip it into strips equaling the thickness of the top. Then stand these strips on edge and sandwich them together, forming a glued slab for a benchtop. Yes, there is still some inevitable degree of movement, but by orienting the boards this way, movement is minimized across the *width* of the top. The most movement, in the *thickness* of the top is equally minimized, because the typical top is only 2 in. to 3 in. thick. Enter the end caps.

End Caps

Traditional bench designs often incorporate end caps. They are an integral part of shoulder vises and tail vises, so if these are part of the plan, end caps are a must. In addition, end caps help keep the top flat by capping the end grain, and they usually incorporate a heavy spline for this purpose.

The problem with end caps is that they run perpendicular to the grain of the laminated strips. The inevitable wood movement of the top must be taken into account. By having the top boards on edge, expansion and contraction is greatly reduced, but certainly not eliminated. The end caps must be attached so that the top is free to expand and contract without restriction.

How Boards Tend to Cup



END CAPS CAN ALSO SERVE TO SUPPORT COMPOSITE MATERIALS. In this bench, the surface that will take the most pounding is solid and the remainder is plywood. Plywood's stability means it can be screwed directly into the end cap without concern about wood movement.

Bench Profile

Veneered Top Masquerades as Solid Wood

Dick McDonough likes to build case goods, including entertainment centers and bookcases. To accommodate such large work he needed a super-size benchtop. This bench has a generous 22 sq. ft. of work area.

McDonough constructed the parts of the top that take the most pounding of solid maple. The center, which could easily pass for solid wood, is actually veneered particleboard. To construct the top, he face-glued three pieces of particleboard, a sandwich of ⅝ in. between two pieces of ¾ in. He covered both top and bottom with sturdy 3/16-in. veneer. To cut the veneer, he first resawed it to 5/16 in. on the bandsaw and then ran it through a thickness planer.

Gluing veneer on such a large surface would have taken a forest of clamps, so McDonough made his own from MDF, framing lumber, threaded rods, and nuts—all for under $12. The finishing touch is the inlayed cherry strips that provide a decorative note.

DICK MCDONOUGH MADE THESE SHOPMADE CLAMPING CAULS from lengths of MDF, 2x3s for the top jaw, and 2x4s for the bottom jaw. The lumber is drilled to take a 9-in.-long by ⅜-in. threaded rod fitted on each end with a washer and nut.

WITH THE END CAP REMOVED from this bench, we can see that beneath the beautiful surface, which looks like solid wood, there is a core of particleboard.

CONTRASTING WOOD INLAY adds color and hides imperfections in the veneer joints. After routing a groove to create a uniform recess, McDonough glued in thin strips of cherry.

WINDING STICKS are an old-fashioned but shop-tested means of determining whether a panel is flat. Position them at different points along the top and sight just over the top of the near stick toward the far stick. A variation indicates high spots and twist.

Gluing or otherwise rigidly fastening the caps along the entire width of the top is an invitation to disaster. When the top swells, it could break the joints apart where the end caps are connected to the top. When it shrinks, the top could split right down the middle. In a shop where there is careful and constant climate control, benches are much more stable than those exposed to changes in weather, but the wood will still move.

Flattening a Benchtop

To flatten a benchtop, you remove material from the high areas while avoiding the low spots entirely. The first step is finding the high and low spots. Winding sticks are a low-tech but simple method, and their use probably goes back hundreds of years. In their simplest form, winding sticks are carefully straightened small boards slightly longer than the surface you want to check is wide. By sighting along the top edges of both sticks, you can detect even minute amounts of twist. Carefully mark the high spots.

AFTER MARKING THE HIGH SPOTS from using the winding sticks, use a bench plane to bring them down to level with the rest of the surface. The longer the plane, the flatter the panel overall.

RUNNING A FULL-SIZE BENCH SLAB through a drum sander is a two-person operation; but it saves an enormous amount of time and effort, almost guaranteeing a perfectly flat benchtop.

After you mark the high spots, you can use a handplane to reduce them. Of course, a longer plane is better; a jointer is ideal. Be careful to work with the grain and plane only in the direction that will give you a smooth shaving. Going in the wrong direction may result in a gouge right where you don't want one.

Flattening with Sanders

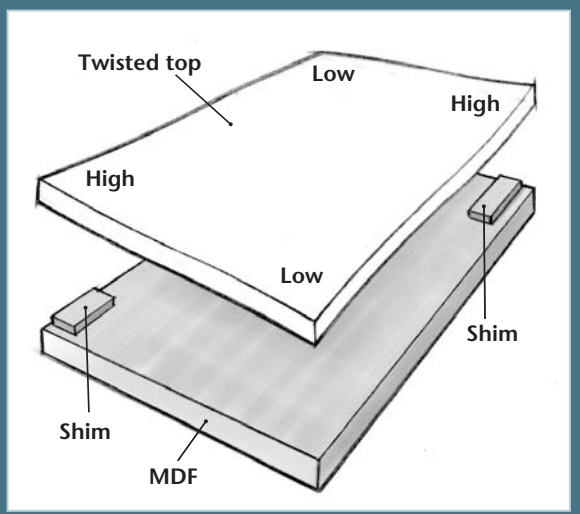
Many woodworkers are sufficiently adept with a large belt sander to flatten a benchtop with one. Again it's a matter of very selectively removing small amounts of material only in previously marked high areas.

Taking flattening by sanding one more step, most woodworking schools and larger cabinet shops have large drum sanding or wide belt sanding machines. Available in most cities for hire by the hour, these machines, some the size of a small car, are able to sand surfaces perfectly flat up to 50 in. in width. The larger sanders have automatic feed, something like a planer, and use several different grits of sandpaper in each pass. The resulting finish is amazingly flat and smooth.

Smart Solution

SHIMMING FOR DRUM SANDING

If your top has twisted a bit, cut a piece of MDF about the size of the top. On a flat surface, with the top surface down on the MDF, shim the high corners so the top does not rock. Use hot-melt glue or carpet tape to stick shims and MDF to the top side of the benchtop before its trip to the sanding shop. Then run the top with the MDF attached, underside up, through the drum sander. The first couple of passes you'll notice the two high corners of the twisted top are all that gets sanded. When you remove enough material that the machine sands the entire surface, you're finished with the underside. Then flip the top over, remove the shims and MDF, and sand the top surface in the same way.



DOWEL PINS CENTERED ON EACH END OF THE BENCH secure the benchtop in use. If you frequently move your bench, you might consider lag bolts instead, which will prevent the top from lifting off.

If you opt for commercial drum or wide belt sanding, be sure to remove any glue squeeze-out from the surface of your new top. When you get the top back to the shop, carefully vacuum the surface removing as much leftover grit as you can. Then if you're still worried about imbedded grit from sanding, take a cabinet scraper to the top, carefully and evenly smoothing it with a very light cut.

Fastening the Top to the Base

The top must be secured to the base. With a very heavy bench, something as simple as dowel pins protruding from the base into matching holes in the underside of the top may do the job. This may seem obvious, but it isn't that simple. The top must be secured in a way that allows it to expand and contract freely.

Intuitively, four dowel pins, one in each corner of the bench seem like an easy choice. But if the dowels have very little clearance, the way most of us like things to fit, the top could literally split in two when it shrinks during times of low humidity. If it's a close fit you want, simply centering two dowel pins in the top, one near each end, will keep it secure and allow the top to expand and contract without restriction.

Though many benchtops are secured with only dowel pins, lag bolts are worth considering if the bench must be moved from time to time. No doubt many a top has hit the floor because the people moving it forgot that the top would simply lift off of the base. If the top is bolted in place, again using two bolts centered in the top, the bench will be much easier to move.

No matter how you fasten the top in place, be sure to allow for movement the same way you would with any tabletop. Either elongate the holes for bolts or dowel pins or fasten the top only in the center.

Finishing the Top

Benches with no finish at all offer the greatest security when anchoring a board with a clamp. But dots of glue will stick to the unfinished surface. Coffee cup rings and dribbles of stain readily soak deep into the top; not that this is necessarily harmful to the bench, but it's certainly unsightly. Most woodworkers opt for some sort of finish, at least a sealer of some kind, on the benchtop.

An easily renewable finish is preferable, given that it's very likely your benchtop will need flattening from time to time. Options for finishing the benchtop include shellac, wax, lacquer sanding sealer, linseed oil, varnish, Danish oil, hardwood floor finishes, and a host of concoctions made up of combinations of these. Whatever you use, take care to coat both the top and underside with the same finish and with the same number of coats. Moisture can more easily penetrate the surface with less finish, causing the top to warp. Coating both top and bottom equally lessens the risk.

LIGHTLY SCRAPING THE SURFACE of the new top removes imbedded grit left by sanding, producing a top that's smooth, flat, and ready for finish. An occasional rescraping will renew the surface very quickly.


Veritas

3

A Solid Foundation

THE BASE OF HARRY WILLIAMS'S BENCH has plenty of eye appeal, giving him the opportunity to use some of the best wood in his collection. Also eminently practical, the base has been outfitted with drawers to keep each tool in its place.

Workbench bases can be as simple as four legs built like a table or as elaborate as an entire chest of drawers. The first job of the base is, of course, to hold the top at the correct height. But that's only part of its role. Not only must the base withstand wracking forces but it must be sturdy enough not to flex. A heavy base can add to the overall weight of the bench. That's good for keeping the bench from walking across the shop when you handplane squirrelly stock. Or it's bad if the bench needs to be moved frequently.

As with everything else regarding workbenches, the ideal base is the one that suits its user for most tasks. One height may be good for cutting hand joinery but not for belt sanding large panels. Besides height, there are other decisions to be made. Materials for bases range from solid lumber to pressed steel to cast iron. Bench joinery can be knock-down or permanent. Drawers or cabinet doors for onboard tool storage require joinery and hardware as well. Making good choices is the first step toward making a base that is both functional and looks good.

A MASSIVE TOP REQUIRES A MASSIVE BASE. Dick McDonough's bench base provides plenty of room for storage in its eight drawers and double-door cabinet. The weight of the base loaded with tools allows plenty of counterbalance for the top, which accommodates no less than four vises.

A CLASSIC EXAMPLE of how the top configuration determines the base is this bench built by Andy Rae. The shoulder vise requires the support of a fifth leg.

Base Configuration

The configuration of the top will dictate, to a certain extent, the configuration of the base. While it's pretty obvious that the size of the top will affect the size of the base, the weight of the top also matters. The last thing you need is to prop up a 400-lb. top on spindly legs. Not only will that make for a top-heavy bench but the top and base will be visually out of proportion.

Minimally, the stance of the base needs to be wide and long enough to make the bench nearly impossible to tip over when applying pressure to the work. It isn't as easy as it might seem to build a freestanding base that resists the exertions of a woodworker making a deep pass with a handplane or a router. But even if your base is on the wobbly side, simply attaching the bench to a wall, or bolting it to the floor, can make a completely rigid bench out of a flimsy one in a matter of minutes.

The placement of hardware and holding devices on the top will designate areas where legs and top rails should and should not go. If, for example, your top will have a shoulder vise, the position of the legs in the base is different from a bench that has a conventional front vise. The same applies to a tail vise as opposed to an end vise. If the vises are to operate without interference from the legs or other supporting structural base members, you can't simply position the legs wherever you like.

If you plan an end vise for your benchtop, you don't want to position a leg right in the path of the vise screw. If you have created a lip for clamping, chances are you'll want to clamp right where the top stretcher traditionally extends out to the front edge of the bench. This same challenge applies to bench dogs. If you'd like access to the dogs from below, to push them up when needed, a top rail or leg positioned in the wrong spot could make this impossible.

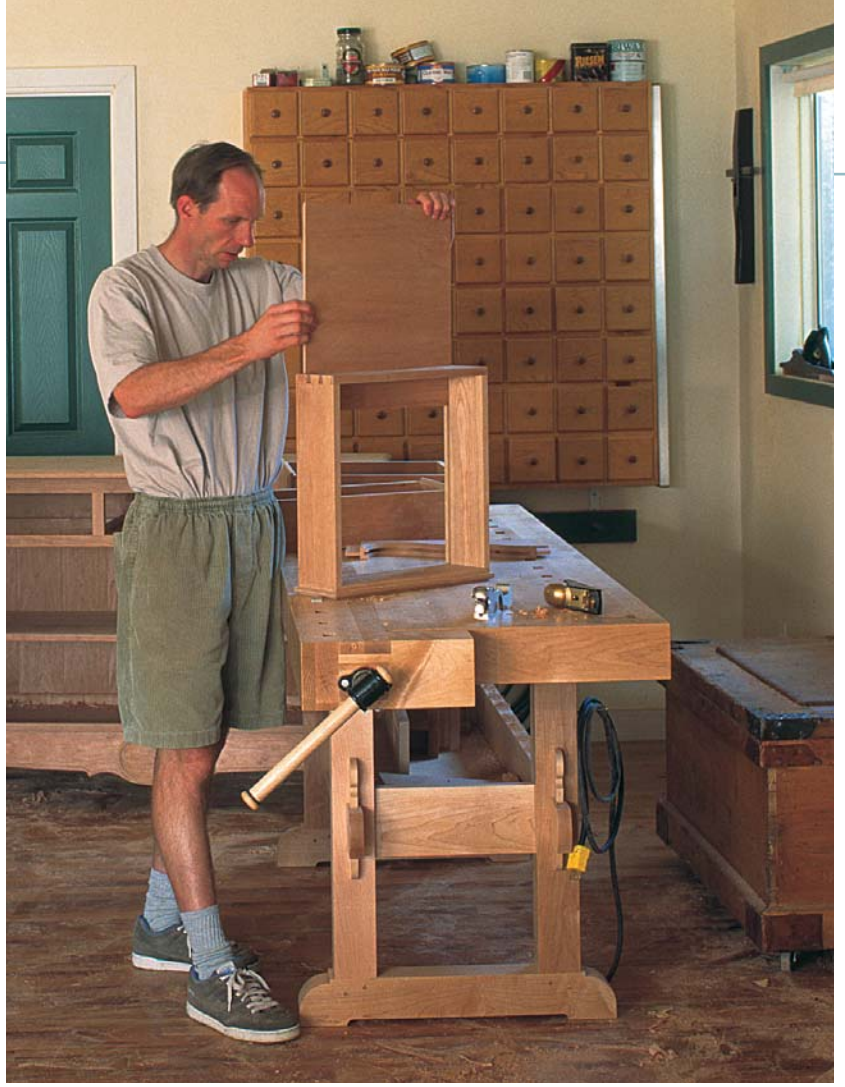
The important point here is to plan ahead. Design your top first and then plan for the clearance for your hardware and holding devices before you build the base.

Frame Bases

Workbench bases generally fall into two classes: frame bases and cabinet-style bases. Just to confuse the issue, some cabinet-style bases are actually built into frame bases and some cabinet-style bases incorporate frameworks. Most commercial benches are built with frame bases, consisting of legs and stretchers connected with bolts. These bases knock down for shipping. Typically, the cabinets and drawers are sold as an accessory that fits into the standard frame.

Frame Styles

A frame base can be as simple as four legs attached together with aprons and some lower stretchers, like Sam Maloof's bench featured in Chapter 7. Maloof's base could equally well hold up a kitchen table. But like a venerable kitchen table, after a mere 45 years of constant



CHRIS GOCHNOUR'S MASSIVE BENCH has sturdy legs, strong stretchers, and sled feet. The stretchers are held to the legs with through-wedged tenons that can be adjusted for seasonal wood movement.

THIS BASE BUILT BY SAM MALOOF could as easily have been a leg-and-apron base for a dining table. By adding a cross brace between the legs, Maloof created a place to hold a useful under-the-bench shelf.

use, Maloof's bench is a bit wobbly. Fortunately, it's nothing some bolt tightening wouldn't cure.

About the only thing Maloof's workbench base has in common with a more typical design like Chris Gochnour's, is that both bases hold up the benchtop. Gochnour's is much more massive and traditional and just *looks* like a proper bench. But there's much more to the story.

The legs on Maloof's bench are slightly tapered, going from about 3¼ sq. in. at the top to about 2¾ sq. in. where they meet the floor. By comparison, Gochnour's are much thicker, almost half again as much lumber in each leg. In addition, Gochnour's bench has massive stretchers mortised into the legs and sled feet attached to the legs spread almost as wide as the top itself.

There's no rule that says that workbenches have to be plain, just because they're meant to be functional. In fact, it often seems that woodworkers can't resist dressing up shop equipment, such as toolboxes and workbenches. Turned legs, for example, can add a nice touch, as long as there are adequate surfaces for joinery.

THIS BEAUTIFUL VARIATION ON BASE DESIGN eliminates the need for a fifth leg to support the shoulder vise by adding a curved stretcher. Note the octagonal section that provides a flat area at just the right angle to connect the stretcher to the turned leg.

The Sled Foot

The sled foot offers several advantages over a simple straight leg. First, a sled foot provides a wider stance for the bench, giving it stability across its width. Second, the sled foot prevents having end grain contact between the leg and the floor. End grain in contact with concrete is an invitation for problems with moisture, especially in an area such as a damp basement. More important, the sled foot offers much greater resistance to wracking across the width of the bench. Because the legs are mortised into the feet, this adds significantly to the cross-bench stiffness.

If you have occasion to slide the bench around in the shop, sled feet offer a great deal more stability, making sliding feasible. Straight legs like those in Maloof's bench will resist sliding because they tend to flex and bounce.

Base Joinery Options

Hand-tool operations like handplaning subject a workbench base to considerable racking stress. Most workbenches can benefit from some means of stiffening the base. Typical is a system of stretchers connecting the legs across the length. Stretchers can be added across the width as well.

Smart Solution

THE VIRTUE OF KNOCKDOWN BENCHES

You never know when you might have to move your bench. A base glued up as a unit will be quite a large and heavy assembly even if the top is removed. Worth considering is the notion of gluing up the two end trestles, then using bolts or wedges to fasten the trestles to the stretchers. The bolts and wedges can be easily removed to dismantle the base, and if the wood in the legs should shrink, the base can be tightened up in a jiffy.

CURT ERPELDING'S BENCH uses three stretchers in all—two on the front and one on the rear. The extra stretcher adds to the rigidity of the frame. The stretchers are attached to the legs with bolts.

KENTUCKY WINDSOR-CHAIR MAKER DAVID WRIGHT added a bottom to the stretchers to make a tool shelf under his bench. It keeps the top of the bench free from clutter and it's high enough so he can easily clean the floor below.

SIMPLE BOLTS AND NUTS hold the stretcher to legs in Harold Greene's bench. A large flat hole is drilled with a Forstner bit to recess the bolt head in the leg and to provide access to the nut in the stretcher.

Butt Joints

The simplest means of connecting stretchers to legs is a butt joint held together with bolts. Bases held together with hardware have the virture of being, at least in theory, knock-down and, therefore, more portable. If you plan to make the base so it knocks down, now is the time to plan how it will come apart.

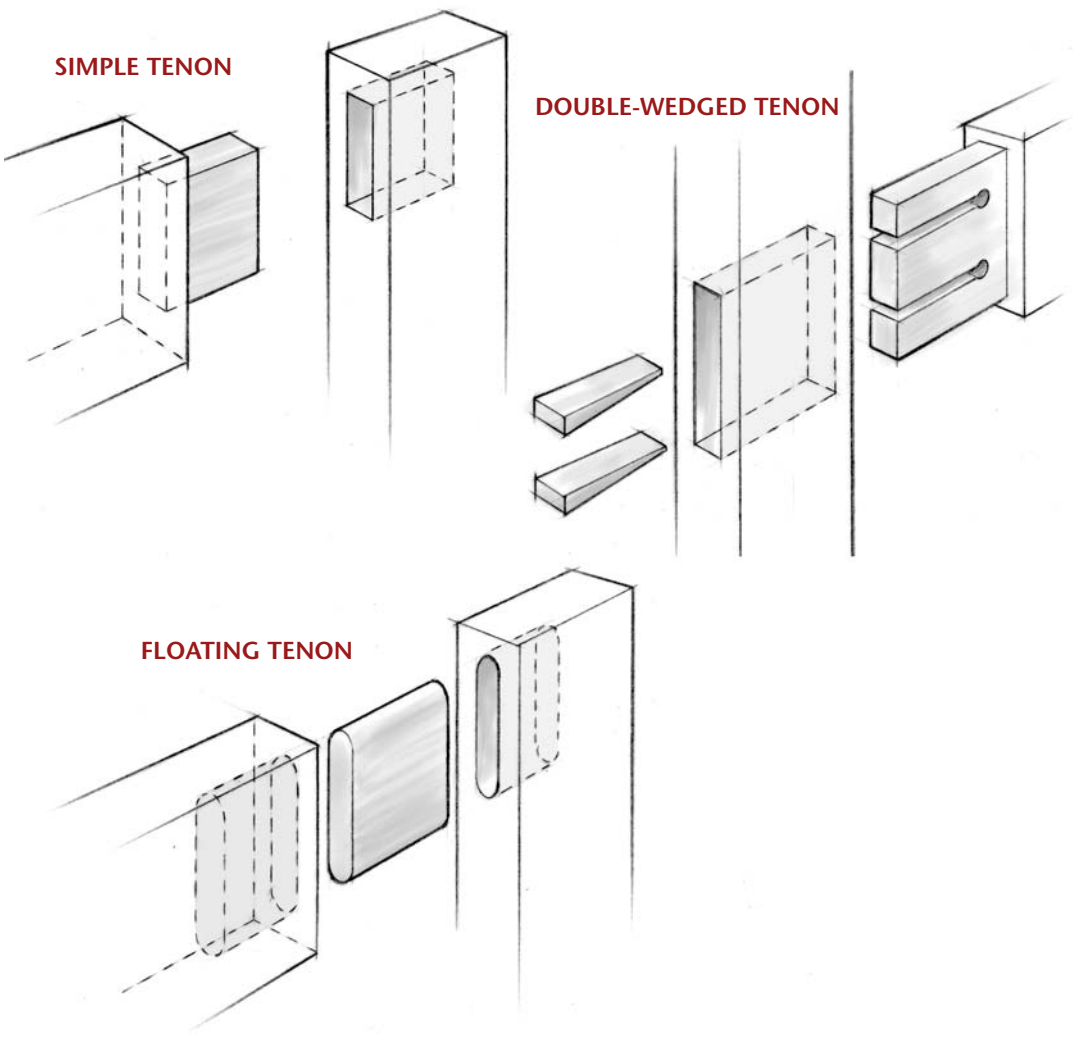
Bolts of some kind hold nearly every commercially made bench base together, at least at the all-important joint between the stretchers and the trestles. Carriage bolts are a bit awkward because you have to somehow twist the nut in a very small hole, but they will certainly do the job adequately. Dowel screw-type bolts, like the bench bolts from Lee Valley Tools shown in the photo below, secure the base and need just a few drilled holes.

Mortise-and-Tenon Joints

Mortise-and-tenon joints are easily the most widely used joints to connect the legs and stretchers for workbench bases. They can be glued, bored and pegged, connected with wedges (glued or not), floating, or one of dozens of other variations. The main purpose of the joint when using sled feet is to form two trestle assemblies for the legs and then to connect the trestles with stretchers to form a base that resists wracking in all directions.

THESE SPECIAL BENCH BOLTS from Lee Valley Tools make base assembly much easier than using carriage bolts. The cylindrical threaded nut fits into a drilled hole. All it takes to tighten the bolts is a twist of a wrench.

Mortise and Tenon Options



Though bench base components may be larger than you'll find in a piece of furniture or cabinet, the process for cutting and fitting them is the same. The mortise is cut with a chisel or hollow chisel mortiser or router. The tenons are cut with a router, table saw, handsaw, or bandsaw, all depending on your preference. As long as the tenon fits the mortise, that's all that counts. Glue will fill voids to some degree, but over time a slack fit will work loose.

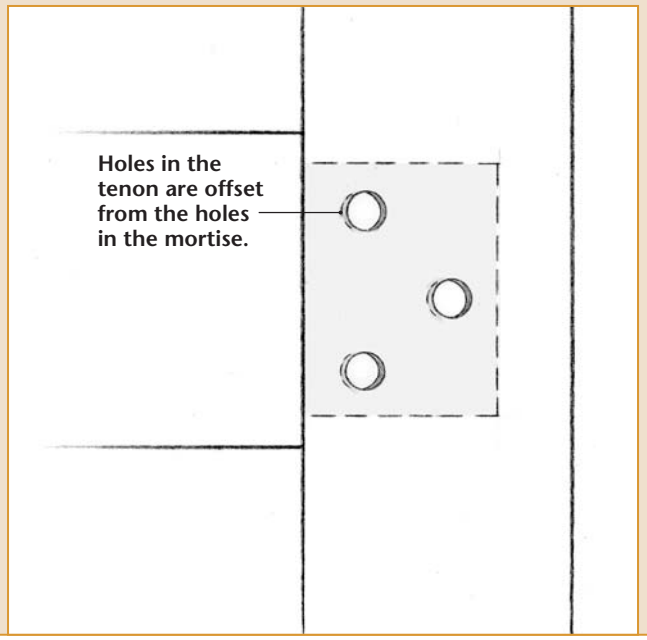
Pinning tenons provides some insurance by providing an extra mechanical connection.

Typically, tenons are pinned with dowels. In a variation of this technique, called draw boring, the joint is pulled together tightly as the pins are driven into the tenon.

Floating tenons work just like conventional mortise and tenons, except you cut a mortise into each of the pieces. Then the tenon material, sized to fit the mortises, is cut to length and glued into mortises in both pieces.

Draw-Bored Tenons

Baltimore woodworker John Alexander studies and practices eighteenth-century woodworking. He and fellow researcher Peter Follansbee examined the way mortise and tenon joints assembled hundreds of years ago have managed to hold so well. The key is the draw-bore mortise and tenon. The holes for pegs are not drilled with the joint assembled in the conventional fashion. First holes are drilled in the face of the piece with the mortise. Next the holes in the tenon are deliberately marked and drilled on an offset. Tapered pegs are then driven into the offset holes, drawing the joint together with such force it's never likely to budge.



Wedged tenon joints are both functional and decorative. Wedges of a contrasting color wood, walnut with maple, for example, adds an interesting touch. Functionally, wedges tighten mortise-and-tenon joints. There are two basic types: those with permanent wedges and those with removable wedges.

Permanent wedges are usually glued in place during assembly. They fit into wedged-shaped slots cut into the end of the tenon and are trimmed flush with the leg once the glue dries. The real benefit of this joint is the mechanical strength of the connection. It ensures a very tight fit between the tenon and the mortise, since the wedge expands the end of the tenon, effectively locking it in the mortise.

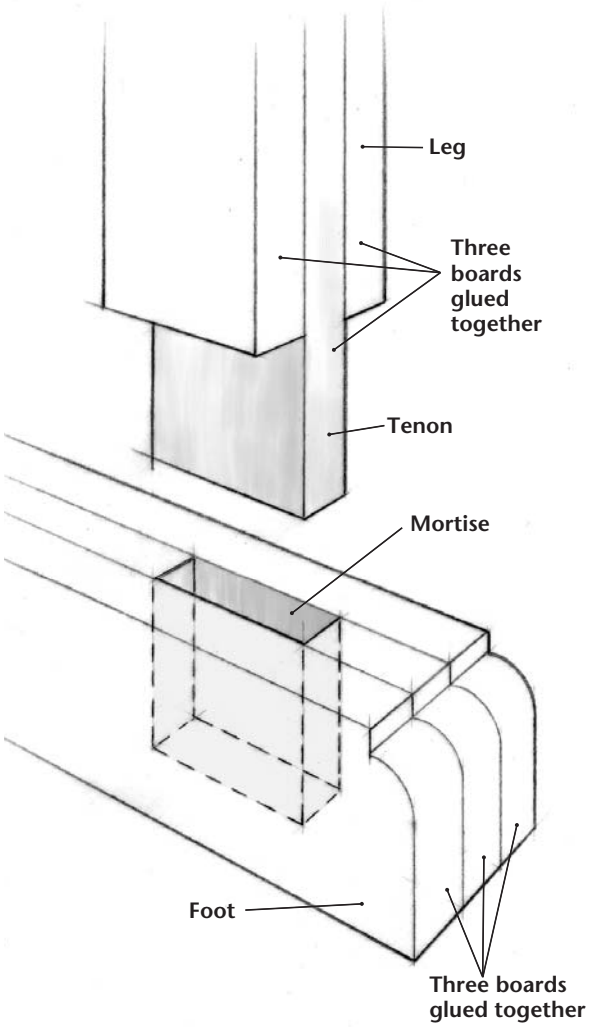
Removable wedges are typically used in a through tenon that protrudes well beyond the surface of the leg. Drilling or chopping a mortise in the tenon for a wedge makes it possible to secure the trestles to the stretchers by simply pounding the wedge in place. Knocking the base down is as simple as reversing the process. The wedges could be glued in place, but typically they're not. Left unglued, they need only a tap to tighten up the joint if it loosens over time.

Three-board mortise and tenons are a very quick way to make a glued mortise-and-tenon joint. The legs and center portion of the sled foot are all the same thickness. Face-gluing boards to the outside portions of the sled feet effectively creates a mortise-and-tenon joint between the foot and the leg. The same principle can be applied to the cleat on which the top sits. You don't have to hollow out any mortises. Everything is simply sawn to length, glued, and clamped together.

BRENT MERKLEY secured the through tenon with a cross-wedge. Pounding it in draws the parts together tightly.

IN JOHN BARBEE'S CLASSIC ACORN BENCH, dowels flattened on one side act like wedges to pull the stretcher tight in the through-tenoned base.

Three-Board Mortise and Tenon



Smart Solution

CUT YOUR OWN

More folks would cut their own threads on steel rod instead of using prethreaded rod if they knew how easy it is. Not only can you make bolts any length you like, but threading just the ends of a solid rod gives the base a much more finished look if the rods are exposed. If you plan to house the bolts in a hole running the length of the stretcher to hide it, threading your own rod is even more advantageous. It will save you the trouble of mortising out a space for the coupling nuts if you can't find the correct length of threaded rod.

Strengthening the Base

Extra insurance against racking can prevent a bench from becoming wobbly after years of use. Cross-braces built into the frame assembly can stiffen the base considerably. Braces can run diagonally across the width of the bench, lengthwise, or both.

Full-length threaded rods bolting the stretchers between the two trestles offer tremendous strength, can be tightened periodically if the bench works loose, and most important, make the base easy to take apart.

It might seem like a daunting task to drill a slender hole the length of a 5-ft. board. But it's easy if you simply rip the board in half and then plow slots in the halves large enough for the steel rod. If you plan to use a coupling nut to connect two or more pieces of threaded rod,

IN MICHAEL DUNBAR'S BENCH, a diagonal brace is dovetailed into the leg. There are cross-braces under the benchtop as well. To prevent the bench from moving, Dunbar screwed cleats to the floor.

THIS STOCK BENCH BASE from Lee Valley Tools uses continuous threaded rods to tie the stretchers to the legs. If the bench begins to wobble, the bolts can be tightened in about 2 minutes.

THIS METAL BASE was bought secondhand. With the addition of a top made from layers of MDF, a vise, and some bench dogs, what began as a secondary bench became the one Clyde Richardson uses most often.

you can place the nut into the slot by enlarging the slots where the nuts go. This is another advantage of threading your own rod. Then glue the two halves of the stretcher back together.

With this method, all you really need to form a strong joint is two or three dowel pins drilled into the ends of the stretchers and into the trestle legs to keep the stretcher located properly. Once you pull it all together with the bolts, the shoulder—where the stretcher contacts the trestles or legs—does the job of keeping the bench base stiff.

Legs Made from Metal

Woodworkers have already voted their choice of material and tend to make as much as they can out of wood, including workbench legs. Using prefabricated bench bases or even cast-iron legs can cut days off of the time it takes to build a workbench base.

Commercial Steel Bases

Available in long lengths and an unbelievable array of shapes, steel is commonly used in industry for workbench bases. A variety of companies offer steel workbench legs, and a quick Web search on the phrase *workbench legs* will produce dozens of leads to on-line sources.

Among them are Production Basics, Ebco Sturdi-Bilt™, and Shop Fox®. Steel bases are sometimes available secondhand through newspaper classified ads or notices of business closings.

Before buying metal workbench legs, make certain that the legs or base will be sturdy enough for your needs. Especially consider how existing bracing or braces you that you add will help stiffen the base to resist racking. Then assemble your base, add a top whether solid wood or composites, and some holding devices, and you're good to go. It may be nothing fancy to be sure, and you may take some ribbing from your purist woodworking friends. But a bench constructed on a metal base can function just fine. At the very least, this practical and relatively inexpensive bench could certainly serve as a secondary bench for grinding and sharpening.

THIS BENCH, ordered from McMaster-Carr Supply Company, has legs that easily adjust in height by loosening a few bolts. John Allison uses it not only for woodworking but for many other jobs around the shop.

Cast-Iron Bases

No discussion of bases would be complete without mentioning the cast-iron base legs from Lee Valley Tools. They have the wonderfully authentic nineteenth-century look, are amazingly heavy and rigid, and assemble with threaded rods and wood stretchers in a matter of minutes.

THESE CAST-IRON BENCH LEGS are reminiscent of the beautiful machines built in the nineteenth century. Not only are they elegant looking and absolutely rigid, they're heavy enough to provide good stability to any bench.

Enclosed Bases

Should a base have built-in drawers or shelves or a cabinet? This is one of those areas in which different woodworkers have very different ideas. The Shakers used benches for storage, building elaborate chests of drawers for their bases. For the more classic cabinetmaker's bench, absent even so much as a shelf, tools were kept in a separate chest adjacent to the bench.

If the bench is on the light side, storing tools below the benchtop in a tool chest or cabinet built into the base can improve the bench by adding stability and mass. And, as another bonus, tools are close at hand.

Configuring an Enclosed Base

Storing tools below the bench in drawers, in cabinets, or on shelving is almost as controversial as the question of tool trays. For every woodworker who thinks it's only logical to install some drawers below the benchtop, there is another who thinks drawers and cabinets interfere with clamping devises. Both are correct.

THE DIEFENBACH WORKBENCH limits the optional cabinetry to the lower part of the base, leaving plenty of clearance for bench dogs and clamping devices between the underside of the top and the upper surface of the cabinet.

HAROLD FOSS EXTENDED THE OVERHANG OF HIS BENCHTOP so that the bench dogs could be fully recessed when not in use. The round bench dogs are accommodated by leaving some space between the benchtop and the drawer bank.

A LARGE, FLAT SURFACE FOR ASSEMBLY AND GLUING was what Ejler Hjorth-Westh had in mind when he built this bench. He also needed large drawers for storage and solved the problem of access by making them so they pull out from either direction.

You need look no further than having bench dogs in the bench to see how quickly drawers become impractical. If the dogs extend below the bench a few inches, they will block access to any drawer above that. If you clamp to the lip of the bench using a bar clamp that sticks down toward the floor, there's little doubt that eventually you'll block the very cabinet door you want to open. But in the end, all you need to do is to plan for your bench dogs, vises, and other clamping devises before you design your drawers and cabinets.

Exaggerating the overhang of the benchtop is one way to avoid interference with dog holes and clamping. Another is to leave space beneath the benchtop and the top of the cabinets. Most stock cabinets use exactly this solution. Because the basic bench usually has a frame base, it's a relatively simple matter to install the cabinet within the frame, leaving clearance for holding devices. As a side benefit, the flat surface below the bench can become another and less intrusive tool tray.

Ejler Hjorth-Westh takes a very common approach to tool storage with his combination assembly bench and storage cabinet. He uses the top for a simple work surface. Very large drawers below house everything from routers to moving blankets. Hjorth-Westh seems to have thought of everything. If one side of the bench is blocked, he can still gain access to the drawers, since they open from either side.

Since workbenches, as beautiful as they can be, are ultimately practical furniture, drawer hardware can be utilitarian. Simple, shop-built slides work well for shallow drawers and keep costs down. Ball-bearing drawer slides offer smooth action, especially in more humid conditions, such as a basement. Full-extension slides allow easy access to even the deepest regions of the drawer but will certainly add to the cost of the tool storage.

Bench Profile

No-Frills Cabinet Base

Furniture maker, author, and tool collector Sandor Nagyszalanczy brings a practical approach to his workbench. Using a salvaged cabinet as a base and a purchased slab of maple from the Grizzly Tool catalog, he fashioned a combination workbench, outfeed table, and tool-storage cabinet. With the addition of vises, drilled dog holes, and a couple of hold-downs, he was up and running.

Organizing Tools

Having tool storage in a cabinet base is certainly no benefit if the tools rattle around loose so that edges dull or, worse, delicate parts break. Without careful planning, a workbench base can quickly become a series of junk drawers. One solution is to decide exactly where each tool will go and build a separate compartment for it.

IN BRENT MERKLEY'S ROUTER BIT DRAWER, a sliding tray holds small plastic bins for storing small supplies and tools and keeps them organized and dust free.

Harold Foss has an amazing collection of carving tools (see bottom photo on p. 59). Numbering in the hundreds, his tools contain at least one of every imaginable shape, size, handle material, and cutting angle. Each tool has it's own special compartment in a bank of drawers built into the base of Foss's carving bench. Where, you might ask, would be a better place to store these tools than close at hand, right there in a drawer, right there at the bench?

Shallow drawers work better for chisels and marking tools, leaving less drawer space wasted. Deeper drawers can be outfitted with holders for storing bits and blades or can even be deep enough for portable power tools. Of course, the ultimate in tidy tool storage is French-fitted drawers, with recesses shaped to the contour of each tool.

George Levin has a place for everything. And, yes, most of the time everything is indeed in its place. Levin's banks of drawers below his bench have compartments made for each tool. If a compartment is empty, it's quite apparent what's missing. Sitting at his bench, he's able to access just about everything he needs.

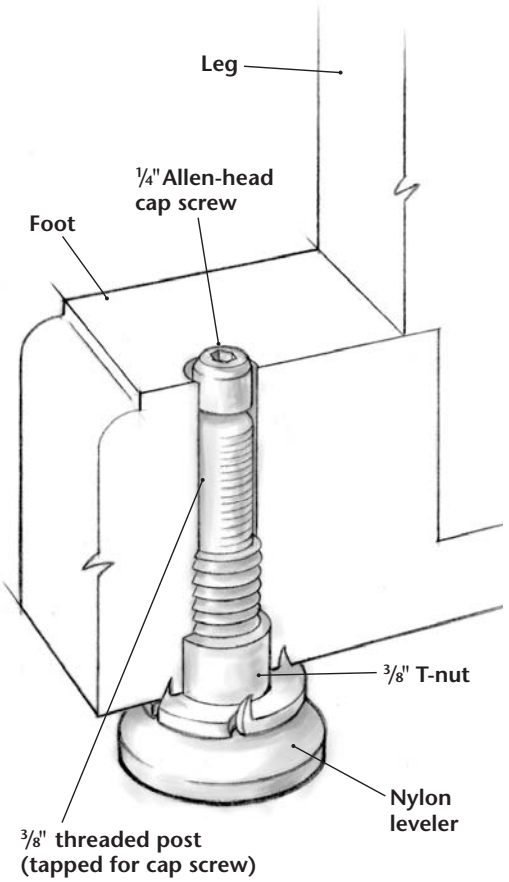
A bench attached to a wall has even more options for storage. A long bench can accommodate a whole run of cabinets, open shelving, cubby holes for power tools, and drawers. A configuration like this is where bench needs meet storage needs. Even if you use a free-standing bench for most of your work, consider installing storage at a comfortable bench height along a wall. Add a top of butcher block, MDF, or plywood and a vise or two. The extra bench space is invaluable for gluing up subassemblies or other process that need to happen "off-line."

YEUNG CHAN MADE HIS CHISELS, KNIVES, AND WOODEN PLANES HIMSELF. So it's only fitting that he would make special compartments to house his one-of-a-kind tools.

GEORGE LEVIN HAS TAKEN TOOL STORAGE TO A HIGHER LEVEL. His drawer for hammers and pliers has a plywood insert cut out to careful fit around each tool with enough room around the handles to easily grasp them.

A LONG RUN OF OPEN SHELVING OR CUBBIES, covered with a sturdy top, makes an excellent first or second bench. The base can be enclosed with doors or drawers can be added.

Adjustable Leveler



Leveling the Bench

If you build or buy a base and make it perfectly true, chances are the bench will wobble because the the shop floor is uneven. Concrete floors are rarely so flat that a bench won't rock just a bit. Wood floors aren't much better.

You could always bolt the bench to the floor, but most woodworkers are reluctant to do so, even if the bench won't move from its intended spot for years. And if you pull the bench down to an uneven floor, you will likely introduce distortion in the bench. It's quite easy to bend even a heavy cast-iron table saw by bolting it to an uneven floor.

If there really is a single spot for the bench, one where it will stay, on at least a semipermanent basis, you can level the floor quite easily

BY FITTING A POWER STRIP designed to handle heavy electrical loads to your bench, you make portable power tools more accessible and cut down on the hazard of extension cords threaded through the shop.

by creating pads for the bench right where the feet contact the floor. If the floor is concrete, a bit of grinding with a cone-shaped grinding wheel, though messy, will quickly lower the two highest corners. A large disk or belt sander will work the same way on a wood floor. Take off a little at a time, and periodically slide the bench in position to check your progress. When you finish, mark the floor where the feet go.

Adjustable levelers, an idea developed by Michael Fortune, among others, operate like the levelers on washing machines. You simply screw the leveler out until the bench doesn't rock any more. Fortune figured out a way to adjust them from the top with an Allen wrench to make it easy to level the bench.

Electrical Power

With the possible exception of the Colonial Williamsburg cabinet shop, virtually every woodworker, no matter how traditional, uses electricity. Portable power tools need a handy electrical outlet. Some woodworkers like a reel-type outlet hanging from the ceiling, but a power strip with multiple outlets is very handy, especially if you plug in more than one tool at a time.

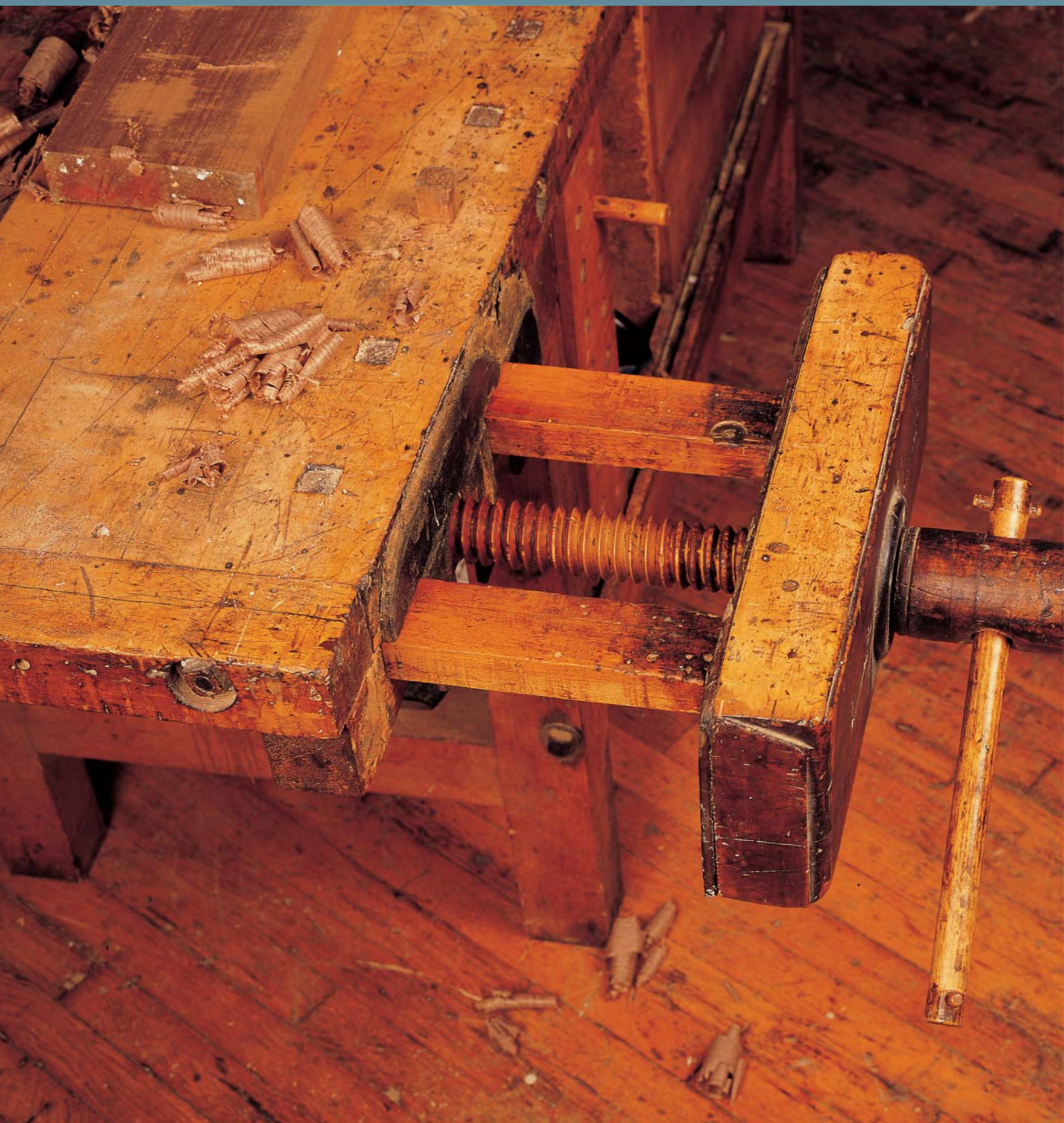
Home centers offer power strips that can be either wired directly in the shop electrical system or powered with an extension cord. Make sure your circuit is grounded. There is a small inexpensive electrical tester you can purchase to test the outlet you plan to plug into. It confirms a good ground and proper wire hookup. Be mindful of the power requirements for the largest power tool you'll be using at the bench. Plastic power strips commonly used in home offices rarely have the capacity to provide sufficient current for a large router, so check this out with your supplier before purchase.

Bench Profile

A Single-Stretcher Base

Only his third woodworking project, Michigan woodworker Brandon Pierce gave this bench a number of distinctive features. The cross-legged single stretcher base is held together by large tusked tenons. A few taps of the hammer, and the stretcher is pulled tighter into the mortises. The massive stretcher provides plenty of rigidity for the base.

The bench also features two chain-driven twin-screw vises, one the full width of the end and one on the face. Four rows or round bench dog holes provide easy clamping with either vise. But the most remarkable thing about this bench is the material that Pierce used. The bench is built entirely of purpleheart.



WHEN KELLY MEHLER BOUGHT HIS BENCH at auction in 1980, it had already seen a lifetime of service in a very busy commercial woodworking shop. The original wooden vise screws still work perfectly.

4

Getting a Grip

I built my first workbench from salvaged driftwood. I built the vise out of a discarded oak shipping pallet and a metal jack screw I bought for $1 at a garage sale. I couldn't apply much pressure without having the thing creak and groan as if it were going to break, although it never did. I did a lot of woodworking with that cobbled-up vise, but ever since I've had a very genuine appreciation for a "real" vise.

Workbench vises are available in an incredible range of configurations, sizes, materials, and price ranges. There are front vises, shoulder vises, leg vises, tail vises, single-screw vises, twin-screw vises, chain-driven twin-screw vises, clamp-on portable vises, quick-action vises, patternmaker's vises, machinist's vises, vises with wood screws, vises with steel screws . . . and this is a partial list at best. We'll take a look at vises old and new, across the spectrum of design and installation.

Locating Vises

The traditional configuration is to put the tail or end vise on the right end, with a front vise on the left as you face the bench (see drawing on p. 30).This convention stems from the practice of moving a handplane from right to left, pushing with the right hand and guiding with the left. Obviously, it favors woodworkers who are right handed. Many left-handed woodworkers who live in a predominately right-handed world have learned to compensate. But it makes sense, when building a bench for a left-hander, to consider reversing these vise locations.

DOUG BETTS BUILT TAIL VISES on each corner of his bench. This way, depending on his inclination, he can use either hand or either side of the bench.

Left or right, there is no rule that says the front vise must be mounted at the corner of the bench. Some woodworkers prefer to mount it closer to center. You might even decide you want more than one. If so, be sure to locate them so they don't interfere with planing operations or compromise the action of end or tail vises.

Types of Vises

As we saw in the last chapter, the type of vise you choose may affect the placement of legs or other structural parts as well as the location of the vise itself. You should try to decide on the types of vises you will need as early as possible in the planning process. As with every other decision you make when building a new bench, the types of vises you choose depend on the kind of woodworking you do and how you like to work.

End Vises

If there is a single characteristic differentiating a real bench from a simple work platform, it's an end vise with bench dogs. The end vise can be as simple as a quick-action vise mounted at the end of the top. A relatively new innovation in the end vise world uses two screws that rotate simultaneously using a chain and sprockets. But the traditional end vise is a tail vise (see "The Innovative Nyquist's Vise" on p. 86).

Tail Vises

Tail vises look very simple from the outside, but they're quite elaborate mechanisms. Guide bars pilot the assembly as a screw applies pressure. Bench dogs in the movable vise jaw apply pressure, holding the workpiece against stationary dogs on the benchtop.

LARK KING'S BENCH HAS TWO FRONT VISES, both mounted well away from the corners. With this configuration, he has lots of clamping options, including using both vises at once.

NOT ONLY DOES A TAIL VISE ACT LIKE ANY OTHER end vise in setting the distance between the bench dogs, it excels at tasks like securely holding stock for sawing.

A TAIL VISE TUCKS NEATLY into the profile of the benchtop, so it must be planned while configuring the top and the base.

Front Vises

Front vises, as the name implies, mount to the front edge of the bench, usually on the left corner. They are the workhorses of the bench. Frequently, front vises are called on to support one end of a long board. They commonly work in conjunction with a board jack (see Chapter 5) for this purpose.

Shoulder Vises

Shoulder vises have no tendency to wrack, as do other front vises, making them ideal for cutting dovetails or clamping angled pieces; plus they offer a clamping area that's unobstructed by guide bars or screws. A board of just about any width can easily be clamped, with its edge just above the level of the bench. This makes it comfortable to work on the edge of the board using a board jack to support the other end. Both the bench and base must be built to accommodate the shoulder vise, as the assembly forms a peninsula extending out from the benchtop.

THE ABSENCE OF GUIDE BARS or a vise screw between jaw surfaces makes the shoulder vise especially handy when a board must be clamped vertically. For a right-hander, the vise is generally located on the left side of the bench.

THIS REPLICA OF A BENCH found at the Hancock Shaker Village typifies the sort of bench the Shakers built and used to fashion their elegantly simple furniture. The cherry leg vise is beautiful, functional, inexpensive, and relatively simple to build.

Leg Vises

One of the oldest and simplest mechanisms for a front vise, the leg vise derives its name from the tall front jaw, usually extending down from the benchtop to just above the floor. The front jaw pivots at the bottom, commonly using the benchtop as the rear jaw. Leg vises are tremendously powerful for two reasons. There are no guide bars to introduce friction in the mech-anism. And since the screw is widely separated from the pivot point, nearly the entire force of the screw is applied to the jaws, giving it tremendous leverage.

Popularized by the Shakers, leg vises are rare on new benches, except among fans of historical woodworking. But their simplicity, strength, and durability makes you wonder why they're not more popular for modern woodworkers, especially those who wish to make everything from scratch.

TEACHER AND WINDSOR CHAIR SPECIALIST MIKE DUNBAR chose wooden screws for the twin-screw front vise on his reproduction eighteenth-century workbench.

Screw Mechanisms

All vises use some type of screw to adjust the opening between the jaws and apply pressure. For centuries, these screws were made of wood; of course, metal screws are more common these days. Wooden screws are usually used in all-wood vises, but metal screws can be used in either shopmade wooden vises or in commercial vises.

Wooden Vise Screws

Wooden vise screws have a unique appearance and feel. Woodworkers who will use nothing else never seem to pass up the opportunity to tell you that wooden screws are unmatched by anything made of metal. Among the many advantages of wooden screws is the coarseness of threads compared to those made from steel. This means that a single turn on the vise handle moves the vise jaws farther (and faster). The finer threads of a steel screw move the jaws only a short distance with each turn of the handle.

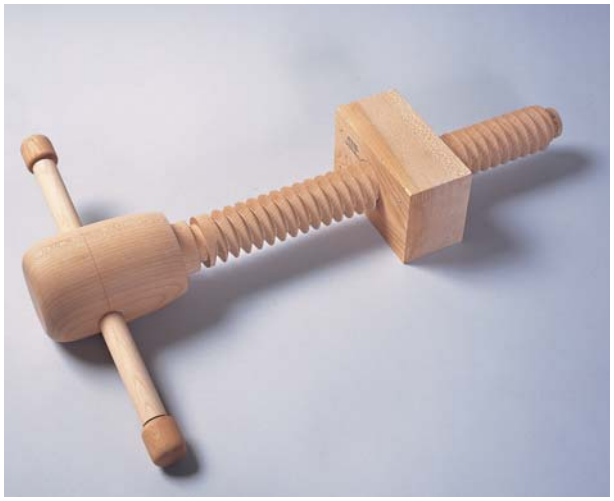
Considerations regarding wooden screws include seasonal expansion, lubrication, and protecting the screw while using the vise. Wood screws are much more vulnerable to damage than are steel screws. When designing a front vise with guide bars, the bars should be slightly higher than the screw. This will protect the screw itself by limiting the depth of the vise so that a piece clamped in it will touch the guide bars, not the screw.

Tempting as it is to have the screw fit very precisely into the nut, a bit of clearance is advisable because of seasonal changes in both the nut and screw. That perfect fit in the dryness of winter may turn to a frustratingly tight fit when the humidity rises in summer. Some screw manufacturers advise applying a pinch of ground pumice to the threads of a tight screw

Smart Solution

CUTTING YOUR OWN SCREWS

If you'd like a whittling project, try cutting screw threads with a carving knife like the Romans probably did. J. R. Beall in his book *The Nuts and Bolts of Woodworking* does a good job of showing how it's done. First, wrap a thread around a dowel, carefully spacing the wraps to match the threads per inch; then cut away all but the crest of the screw thread. After this is done, try the tricky part: cutting the internal threads in the nut. If this isn't your cup of tea, try a thread box or a router. Better yet, order a nut and screw from a wooden thread-cutting wizard like Howard Card of Crystal Creek, New York.



A COMMERCIALLY AVAILABLE WOODEN SCREW makes the feel and action of a traditional vise accessible to any woodworker.

TWO TYPES OF TAIL VISE SCREWS. The top one has a steel housing. The lower screw is the type used with shop-built guides.

and slowly working the mechanism. The pumice acts as a grinding compound to loosen the threads.

Paraffin is the most commonly recommended lubricant for wood screws, but virtually any dry lubricant will do. Be careful not to overlubricate, though, so the screw won't loosen on its own through use.

Millions of wooden screws were produced for centuries by using thread boxes to guide the stationary cutter while the thread box rotated around the dowel rod. Thread boxes, both new and antique are commonly available. A more recent innovation in cutting threads on dowels uses a pointed bit in a router, with either a metal-working lathe or a router jig to guide the cut. As the dowel rod slowly rotates, the router bit cuts the threads.

Wooden screws are readily available through a variety of sources (see Resources on p.196), made to order or off the shelf, in a range of styles, lengths, and diameters.

Steel Vise Screws

Woodworkers who are less devoted to tradition than practicality may find steel vise screws a better choice. They tend to wear less and are not affected by seasonal changes in humidity. Available from woodworking retailers, these screws make the task of a building a vise fairly straightforward.

Screws are manufactured specifically for shoulder vises, tail vises, and front vises. It is important to study the manufacturer's specifications before purchasing the screw. Even more important is to purchase the screw before making the final plans for the vise design.

Twin-Screw Vises

Vises with two screws have been around for centuries. Since there are no guide bars, the vise is not subject to wracking. Furthermore, it is much more straightforward to make the vise from scratch absent the guide bar mechanism. Woodworkers trying to cut dovetails on the end of a board could easily clamp the board upright between the screws. The only limitations are the distance between the screws and the height of the vise off of the floor.

Though they work very well to hold even angular pieces, double screw vises require three hands to operate. You basically have to hold the workpiece with one hand while you tighten both of the vise screws with the other two hands. This is easy enough to get used to, of course, and since having two screws solves so many of the challenges of single-screw vises, it's worth the effort.

Chain-driven twin-screw vises have the unique ability to almost entirely prevent the normal wracking common to single-screw vises, which rely on guide bars to resist wracking. Instead of having to turn each screw independently, you need to turn just one, which drives the other screw using sprockets and a chain.

Whether for use with an end vise or a front vise, the chain-driven mechanism makes clamping operations possible that could break an ordinary vise. Installed on the front of the bench, the vise performs like a shoulder vise. Used as an end vise, it allows a wide range of options for locating bench dogs.

A DOVETAILER'S DREAM, this long double-screw face vise has plenty of room for clamping fairly large panels and holds pieces without racking.

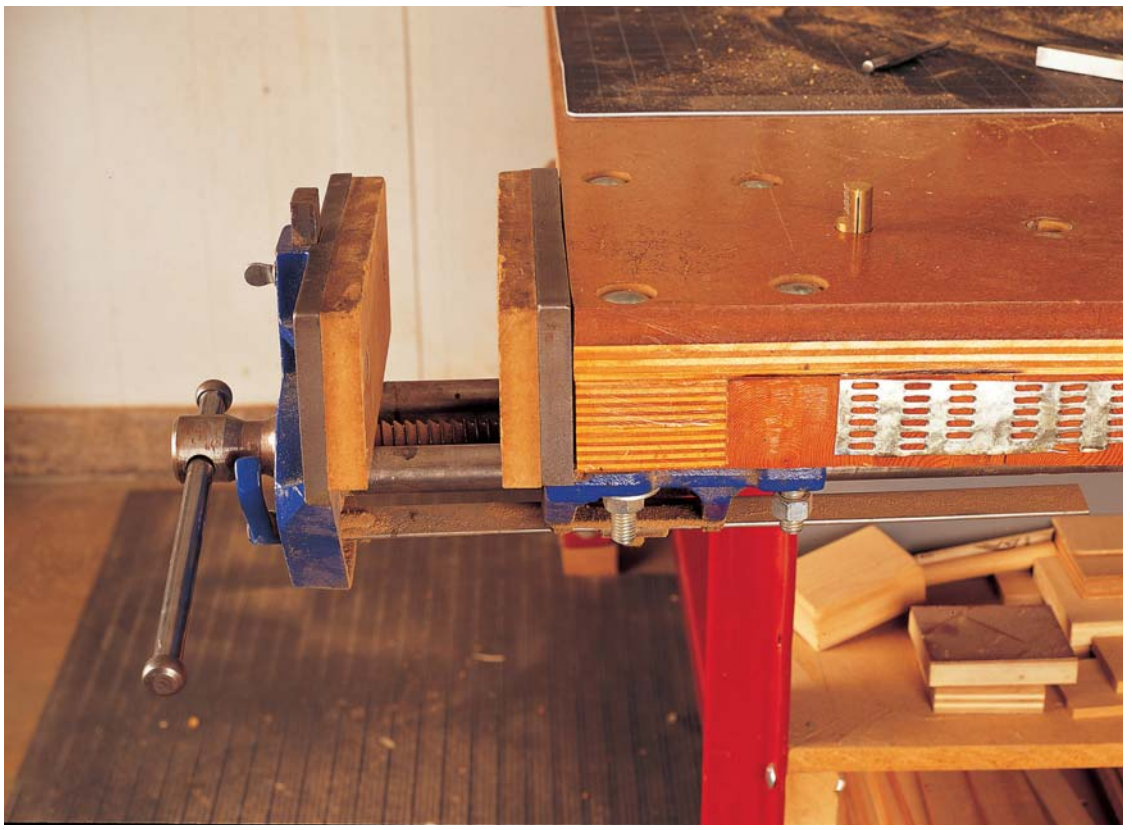
THE VERITAS® TWIN-SCREW VISE (shown with one handle and the chain guard removed) features a chain mechanism that drives both screws simultaneously and thus prevents wracking.

THE CAST-IRON JORGENSEN® VISE features quick-release convenience and pop-up bench dog. The quick-release mechanism uses a gravity-actuated half nut. Half a turn counterclockwise releases the jaw so you can slide it open or shut.

Manufactured Vises

The long-standing tradition is to build vises from wood, but it certainly is faster and easier to mount a commercial vise wherever a vise is needed. Manufactured vises are usually mounted as front vises. Mounting them as end vises is a bit trickier, depending on the overhang of the benchtop and the configuration of the base. As with other bench hardware decisions, it pays to choose your end vise before building the top or base.

If you decide to have only one vise, consider mounting it on the left front part of the bench, because that is where you will most likely be working. Many manufactured vises have a pop-up bench dog. When the vise is used in conjunction with dogs along the front of the bench, or across its width, the dogs securely hold the work for handplaning or other operations on the benchtop.



THE EASIEST VISE INSTALLATION is on a bench with a top that is just exactly thick enough to hold the jaws at the right height. With a thinner benchtop you'll have to add blocks below it. This vise is mounted proud, with the rear jaw beyond the front edge of the bench.

THIS OLD RECORD® VISE was installed with the rear jaw mortised in behind the front rail during top construction. The rail is installed after the vise is in place. Note the use of a block on the side opposite the workpiece to keep the vise from wracking.

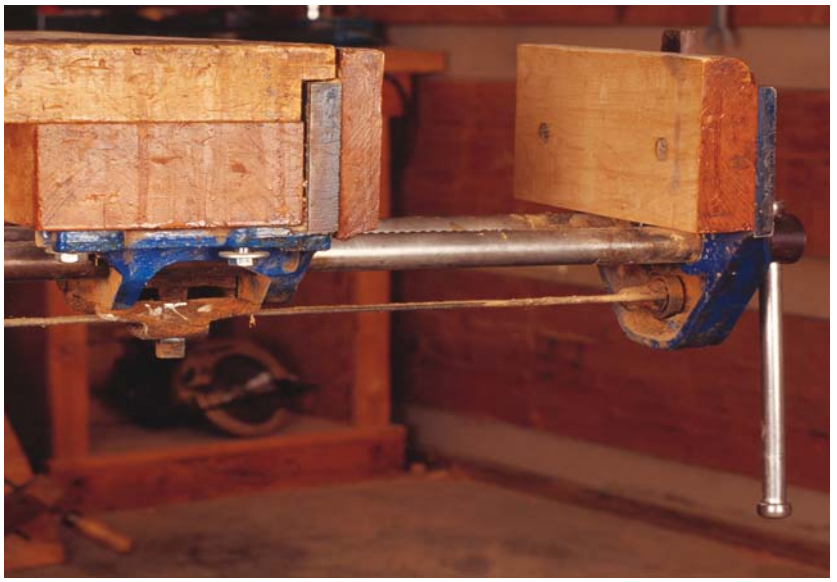
Quick-Action Vises

Self-contained quick-action vises are a real time saver. Instead of endlessly rotating the vise handle, they can be opened or closed in one quick motion. They also cut down bench building time dramatically because they can be mounted with just a few bolts. After adding some pads for the metal jaws, you can be working with them in nothing flat.

Quick-action vises work in one of two ways. Either a spring lever on the front of the vise releases the screw or a gravity-actuated half nut releases the screw when the handle is rotated counterclockwise.

This type of vise can be mounted in several ways: with the rear jaw out proud of the front of the bench, with the rear jaw flush with the front of the bench, or with the rear jaw recessed behind the front rail of the bench. Mounting the vise with its rear jaw proud of the bench is the most common installation and is certainly the easiest. All it takes is four screws and some pads on the metal jaws—and you're done.

Mortising the rear jaw into the edge or front rail of the bench is straightforward as long as you add the pad to the rear jaw first. The thickness of the pad determines the depth of the mortise.



Installing the rear jaw behind the front rail is most easily accomplished in the course of building the bench. Mortise out the edge of the top before installing front rail. Otherwise you can mortise into a rail or pad so that the rear jaw is completely enclosed and add a pad as an addition to the existing rail. Then add a wooden pad to the outside jaw as well.

IN THIS INSTALLATION the rear jaw is mortised in to be flush with the edge of the benchtop. A wooden pad added to the rear jaw brings it out beyond the edge.

The Record Quick-Action Vise

Found bolted to woodshop benches across the globe, the Record quick-action vise has set the standard in bench vises for generations. Based in the United Kingdom, Record Marples, Ltd., has been a victim of a corporate takeover. The future availability of the vise and, indeed, the continued existence of Record Marples itself is in doubt. There are still Record vises on the market, thanks to the forethought of woodworking retailers who bought out the remaining inventory. And it's likely someone will continue limited production of the vise. But if you want one of these classics, don't wait too long. Otherwise there are perfectly good substitutes from other manufacturers, including Jorgensen® and workable replicas from Asian manufacturers.

Patternmaker's Vises

Cast-iron machines built in the nineteenth and early twentieth centuries were not only functional but beautiful as well. In each machine, there were hundreds and sometimes thousands of separate parts. At the time, factories employed thousands of patternmakers. Large plants were cranking out parts for machines of every imaginable description, from sewing machines to locomotives. Using two-dimensional drawings, the patternmaker's art was to sculpt very precisely shaped full-scale wooden patterns for casting each of the metal parts. The patternmaker's vise is unique in its ability to firmly hold a workpiece of just about any shape and change its position, even to the point of laying it flat on the benchtop, all without releasing the part from its grip.

THOUGH PATTERNMAKING for castings is mostly computerized these days, these vises, like this Emmert Turtle Back, have found homes on the benches of furniture makers like Sam Maloof.

The Emmert patternmaker's vise was, and for many woodworkers still is, the ultimate woodworking vise. It set the standard for a multipurpose vise for decades and, in a lot of ways, still does today. First patented by Joseph Emmert in 1891, the vise was the breakthrough woodworkers had sought for centuries.

The vise jaws rotate 360 degrees and can be locked at any point. The entire vise tilts 90 degrees and can be set anywhere in between; and this vise also allows the workpiece to lie flat on the benchtop. The jaws can even be angled to hold tapered work. If you rotate the vise 180 degrees, in just a couple of seconds, you can bring up a set of small metalworking jaws for small parts. Four retractable dogs, two in each main jaw, grip the workpiece like steel fingers. If that weren't enough, the dogs on the outside jaw, like those in any end vise, can be used in conjunction with dogs on the benchtop to hold larger pieces.

Emmert produced about a dozen different models in two styles, generally known as the Turtle Back and the Universal. Both models were available in two sizes. The larger Number 1 weighs in at around 85 lb., opens to 14 in. and is over 18 in. wide. The smaller Number 2 has jaws 14 in. wide and opens to 12 in. The Turtle Back, the oldest version, is identifiable by looking at the front cover, which is how it got its nickname. The later model, the Universal or K1, is characterized by a round casting on the front of the vise with a lever off to one side used to angle the jaws.

Though rare these days, Emmerts still show up at estate sales and classified ads from time to time. A search on an auction web site like

eBay will commonly yield an Emmert or two for sale. Used tool dealers often have one on hand also. Their value to collectors has driven prices up to the point that a 50-year-old Emmert in good shape can fetch many times the cost of a new patternmaker's vise.

Emmert copies are manufactured overseas and are available for a fraction of the cost of the genuine article. The imported vise sold by several different distributors is manufactured by the Yeon Chuan Machinery Company in Tiawan. The size, function, and mechanism are nearly identical to the smaller Number 2 Emmert. Though the quality of the machine work and smoothness of its operation aren't as good as the original, if it's a patternmakers' vise you need, you'll get a lot of vise for a minimal investment. The one I mounted on my bench works just fine.

THE EMMERT NUMBER 1 UNIVERSAL is the larger of the two vises in this class. Its jaw capacity is 14 in. without pads. It's just about the perfect vise for working irregularly shaped parts.

ROTATED VERTICALLY, this Emmert patternmaker's vise brings the workpiece above the level of the benchtop for detail work. Note that with the wooden pads installed, the small metalworking jaws won't close completely.

THIS REPLICA of the smaller Emmert, is one of two patternmaker's vises still being manufactured.

NOW COLLECTOR'S ITEMS, OLIVER PATTERNMAKER'S VISES were produced for only a short time. Arron Latt finds his perfect for holding components for the intricate articulating sculptures he builds.

THIS VISE COULD BE CALLED "Emmert meets the twenty-first century." Made of a special alloy, the Veritas® patternmaker's vise from Lee Valley Tools incorporates all the versatility of the Emmert plus extra features, such as quick action.

Other patternmaker's vises are available, both new and used. Emmert had a lot of competition. Companies like Oliver, Colombian, and others manufactured vises of equal quality and almost identical operation.

The newest version of a patternmaker's vise is the Tucker from Vertitas®. It looks and operates much like the small Emmert. But that's where the similarity ends. The Emmert's cast iron has been replaced by a special cast alloy. In a farewell to patternmakers, the vise parts are cast using permanent graphite molds rather than the sand casting for which patterns were made.

No doubt the feature woodworkers like most is its quick action. Not only does it open without endlessly rotating the vise handle, the opening is spring loaded so the vise opens automatically. This operation can even be done with a foot pedal, which leaves both hands free to position the workpiece. The four round dogs rotate to capture carvings and irregular shapes.

Unlike the Emmert, the vise mounts to the face of the bench, not to the top. Purchased separately, additional mounting plates installed at different locations or even on different benches make the vise portable as well. By contrast, the mounting plate is permanently attached to the imported Emmert clone, so the entire vise would have to be unbolted.

Mounting a Patternmaker's Vise

What all patternmaker's vises have in common is the mechanism below the benchtop. The vises have a cylindrical hub and rotating square beam, which are located below and behind the vise, hidden from view for the most part. These assemblies have to clear the underside of the bench no matter what thickness the top is. If it's over about 2 in. thick, you have to mortise for the hub. If the top is thicker than that, you may also have to mortise for the rotating beam. Doing all this chopping and sawing will certainly be easier with the bench upside down and supported solidly at—you guessed it—workbench height.

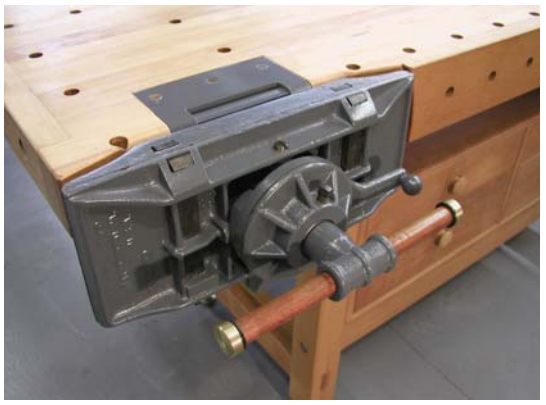
THE IMPORT VERSION OF THE EMMERT, sold by numerous retailers, may not operate quite as smoothly as the original, but it's readily available at a fraction of the cost.

There are two ways to mount an Emmert-style patternmaker's vise. The typical installation on modern benches positions the vise an inch or two out from the front rail of the bench. This is logical, because the hinged mounting plate appears to be designed to fit along the front edge of the bench. But actually, the inventor of the vise had something slightly different in mind.

Instead of having the rear jaw project out from the front of the bench, Emmert intended it to be flush or nearly so. The original installation instructions say this rear jaw is supposed to be let into the front rail of the bench so that the gripping surface of the rear jaw projects only ⅛ in. This makes perfect sense given how many benches are built, with the rear jaws of normal front vises flush with the front rail.

ORIGINAL INSTALLATION INSTRUCTIONS from Emmert suggest mounting the vise so that the rear jaw sets flush with the front edge of the benchtop. The benchtop shown here is inverted to display the cutout for the vise installation.

WITH THE VISE PARTIALLY INSTALLED, you can see why material has to be removed to clear the center hub. This is the hub that allows the vise to rotate 360 degrees. The flange to the right is the tilt mechanism.



VIEWED FROM THE TOP, the vise looks right at home set in with the rear jaw flush with the front of the bench. No one would guess that a bushel of material was removed to fit the vise in place.

LEATHER IS AN IDEAL COVERING MATERIAL for vise jaws. It's easiest to glue on a large piece and then trim it to size. A sharp knife makes easy work of it, but old timers would gently tap the edges with the round part of a ball-peen hammer, cutting the leather on the sharp edges of the vise.

UNTEMPERED MASONITE HAS A SMOOTH SIDE and a corrugated side. Gluing the smooth side to the vise jaws leaves the rougher side to provide a great gripping surface that's padded just enough to protect the workpiece.

Since you'll want to fit the vise to the mortises several times before you're satisfied, dismantling the vise for mounting purposes makes the job far easier. Hefting the entire 85-lb. assembly on and off of its intended spot will get old very quickly. Once the mortises are cut, the vise mount simply bolts in place, and the rest of the vise can be reassembled more easily.

New patternmaker's vises come with very specific instructions, which if followed carefully, make the job pretty straightforward woodworking. Just like the old Emmert-type vises, decide on the location first and then follow the instructions. If you're installing an Emmert clone, it comes with templates for the mortises. Be mindful the templates are only a starting point, don't do any actual cutting without first making sure the layout works in your situation.

Protecting the Work

As convenient as it is to purchase an off-the-shelf vise, the cast-iron jaws of most commercial vises are just not suitable for woodworking. Their slick surfaces provide little traction for a workpiece, and some cushioning must be added to keep the jaws from damaging whatever they're gripping.

The long-standing tradition is to add wooden pads to the inside surfaces of the jaws. Most vises have predrilled countersunk holes in the jaw faces to allow the wooden pads to be screwed on. Pads need not be very thick, as thick jaws cut down on the open capacity of the vice. They do need to be thick enough to provide good purchase for the screws.

Wood is not the only option for cushioning the jaws. Plastic, while not very traditional, does provide adequate protection. It is used by some manufacturers of portable vises. Other cushioning options include leather and composite materials (hardboard, plywood).

LIKE ITS COUSIN THE SWISS ARMY KNIFE, this is a tool you'd want to have on a desert island. The vise is lightweight, portable, and amazingly versatile.

Specialty Vises

Clamp-on vises, like Z-vise from Zyliss®, are great for outdoor work or anytime you need a portable vise. If you were heading out on an extended sea voyage, this lightweight vise would be the one to take along. The Z-vise is the clamping tool equivalent of the Swiss Army Knife and shares a pedigree. Constructed of a strong, but lightweight aluminum alloy, this amazingly versatile vise was originally designed for the Swiss Army. Other clamp-on vises are available from a variety of manufacturers, including Record and Veritas, which offers an in-line style.

Plastic composites are now tough enough to use for power-tool housings, and a logical step was to manufacture lightweight vises from these materials. Although not as quick to install as the clamp-on portables, the Record Quick Vise fastens to any benchtop or wood surface with a few screws. It is able to exert over 500 lbs. of clamping pressure, impressive for such an economical and lightweight tool.

Machinist's vises are not usually found on new cabinetmaker's benches, simply because they have few woodworking applications. But the jaws meant for metal working come in very handy any time metal has to be worked, such as when you shape a scraper blade. Most machinist's vises also have a very useful anvil area behind the jaws, a feature I use frequently.

The multipurpose vise is more versatile than the conventional configuration. Most regular machinist's vises rotate on a vertical axis, but the multipurpose rotates on a horizontal axis as

A GREAT WAY TO TEMPORARILY MOUNT a machinist's vise is to bolt it to a square of plywood. Add a cleat below the plywood, and grip it in a bench vise. To contain metal shavings, install a frame around the base.

well. Just like an Emmert, it offers two different pairs of jaws and the ability to angle them any way you wish. Unless you have a dedicated metal-working bench, permanent mounting is not usually an option. But there are plenty of ways to mount the vise temporarily.

Shop-Built Vises

Woodworkers are tinkerers by nature. For centuries, they figured out ways to make their own vises. You could, of course, make a vise completely from scratch. There are plenty of ways to make even the vise screw itself from wood, as we've seen. But it's entirely more practical to start with a manufactured screw mechanism and use it as the basis of your vise design.

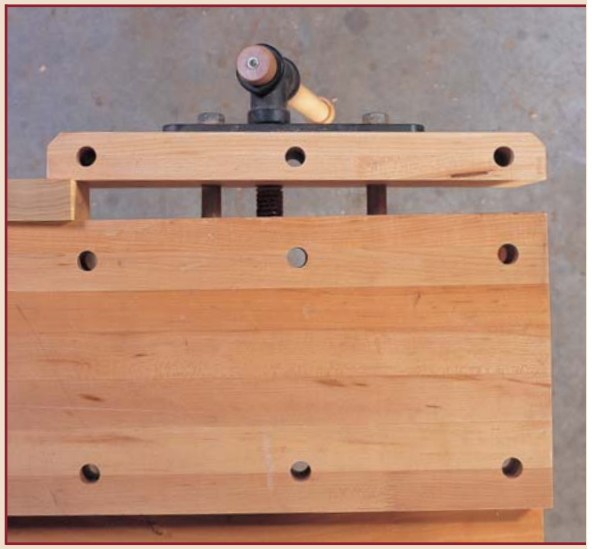
Bench Options

Avoiding Wracking

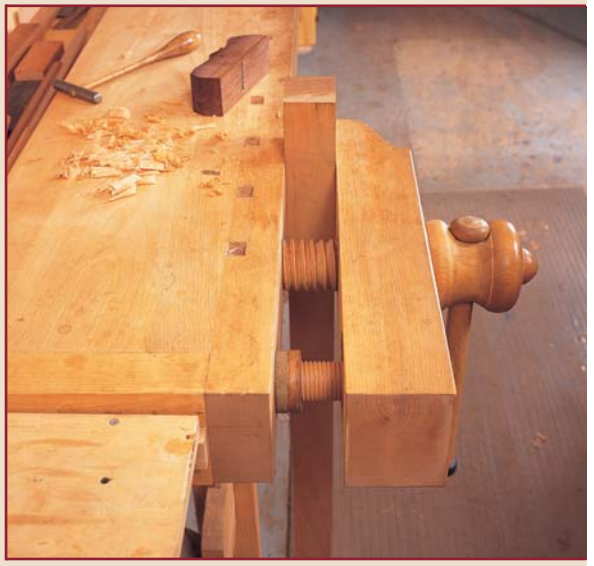
The wracking problem with single-screw vises has plagued woodworkers from the day these vises were invented. The simplest method of keeping a front vise from wracking is to place a block the same size as the work piece at the opposite end of the jaw. This way, the screw is more or less centered between two blocks the same size: one at each end of the jaw opening. But there is a much more elegant solution, one that requires only two hands and does not mean plowing through the scrap pile looking for just the right size block.

Ejler Hjorth-Westh's bench came from a small manufacturer in Scandinavia, where Hjorth-Westh was born. It's a very old concept, and executed beautifully in this fairly new bench. The wooden vise jaw is fitted with a secondary screw, which you see on the left side of the jaw. The brass knurled ring on the wooden nut spins easily and rests against the rear jaw of the vise. The screw itself is attached to the front jaw. A hole drilled through the rear jaw allows the screw to pass through the rear jaw unimpeded.

To clamp a board in one side of the vise, tighten the vise just snug enough to hold the part, spin the nut down toward the rear jaw until it bottoms out, then apply as much pressure with the main screw as you like. To close down the vise for thinner pieces, the nut can be spun into a recess in the front jaw.



SINGLE-SCREW VISES, which use guide bars to keep the jaws parallel, will bind and wrack when pressure is applied to only one side of the vise. A block of wood the same thickness as the work equalizes the pressure and prevents wracking.



EJLER HJORTH-WESTH'S FRONT VISE has an adjustable screw to keep the jaws parallel. The smaller screw is attached to the outer jaw. Hjorth-Westh spins the knurled brass nut against the inner jaw to keep the jaws parallel.

Front and End Vises

The most realistic way to build a conventional front or end vise is to use a self-contained metal vise screw mechanism. Many are available that even incorporate a quick-action option. These assemblies are very straightforward to install, come with complete instructions, and work beautifully. You can then build front and rear jaws any size and configuration you wish. All of the vise mechanisms come with instructions. But there are several things to consider when installing them.

When making the wooden outside jaw, be sure to leave extra material on its top edge. It's nearly impossible to install hardware so that these two top surfaces match exactly. When the vise installation is complete, close the vise jaws, and then plane down this extra material. This will ensure that the top of the outer vise jaw is in exactly the same plane as the benchtop.

Adjustments may be necessary if one side hits first when the vise is closed. This is the result of mounting the vise with the mechanism at a slight angle. To correct for this, first check to see if it's possible to adjust the mechanism. There may be enough clearance in the bolt holes to be able to loosen them just a bit, make an adjustment, and retighten. If this doesn't correct the problem, try shimming the outer jaw at one side of the connection, between the steel and the wood. Since wood tends to compress over time, use aluminum cut from beverage cans or try thin plastic.

If the jaws still don't fit properly, mark the area where you need to remove material. Then shave off just a bit from the outer jaw Use a straightedge to make sure the jaw remains flat.

Once the jaws close parallel, check to make sure they apply pressure evenly when they are closed. Place a business card in each of the

four corners of the vise and tighten the vise to normal pressure. If any of the cards is loose, the pressure is uneven. Try adding more shims to slightly tilt the outside jaw. If this doesn't work, it's back to the handplane.

Shoulder Vises

Though possible to build onto an existing bench, shoulder vises are better designed into a bench built from scratch. A successful shoulder vise design depends entirely on building a substantial cantilevered arm to support the pressure from the vise. The arm itself should be a very stiff wood, like oak or maple, and as large a member as possible, something on the order of a minimum of 3½ sq. in. Even so, shoulder vises have to be used with some care, since too much pressure applied with the vise screw can tear the bench apart.

There are many configurations for handling vise screw pressure. The most common installations depend on a threaded steel rod positioned as close as possible to the jaw opening. Typically, this rod extends all the way across the bench, forming a bolt to reinforce the wooden joinery and absorb most of the pressure.

Tail Vises

For a large proportion of woodworkers, a proper workbench must include a tail vise. Most woodworkers use a tail vise for two different operations. First, they use it in conjunction with bench dogs to clamp a workpiece flat on the benchtop. This clamping method leaves the entire surface of the piece accessible. Second, they clamp pieces in the jaws of the tail vise.

The challenge in building a tail vise is to conquer the natural tendency of all single-screw vises to wrack. The root of the problem is having the pressure point offset from the vise screw. This means that as you apply pressure with the screw in one direction, the workpiece being secured by the bench dogs is applying pressure in the other, twisting the vise guides. The greater the distance from the row of dogs to the centerline of the screw, the greater the leverage, compounding this wracking force.

For centuries, bench builders have sought to overcome this problem using a variety of means to keep the vise square to the bench. Early tail vises are made entirely of wood, including the screws. Later variations use steel screws. Some modern production benches use a self-contained steel mechanism to both guide and close the vise. Others have a separate screw and steel guide system. All these are designed to minimize wracking.

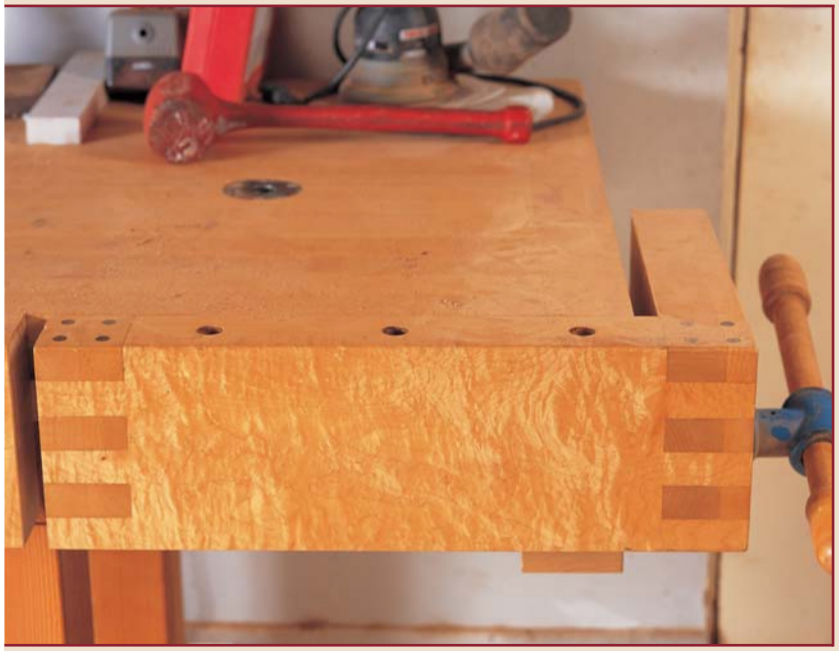
Traditional shopmade vises certainly have their building challenges, but woodworkers are an innovative lot. John Nyquist's tail vise design is an example of how creative thinking not only solved the wracking problem but made the vise more versatile. And there is real satisfaction in using a vise as beautiful and well-crafted as his.

Bench Options

Vises with a Decorative Touch

Who says that vises need to be strictly functional? A little imagination can turn the humble and practical vise into a work of art. From the very beginnings of the craft, woodworkers have added decorative touches to their tools. For generations, the workbench, like the toolbox, was proof of a woodworker's competency. The prospective client could get a preview of the furniture maker's level of design and joinery by seeing firsthand the craftsmanship lavished on the bench. The same applies today. A first-time visitor to your shop almost always notices the bench before anything else.

For all woodworkers, building a workbench is as much a labor of love as it is a simple matter of filling a need. It's also an opportunity to add artistic details to something that will actually stay in the shop, unlike a lot of the projects that we build. Vises, being compact parts of the bench, are a perfect place to express creativity.



THE BEAUTIFULLY FIGURED MAPLE of Jim Robbins's tail vise is cut from the same board used for the front rail. Not only does it provide an attractive detail but the continuity of the grain pleases the eye.

PURPLEHEART IS AN ACCENT COLOR in the front rail and end vise of Harry Williams's bench. Strips of the same stock glued into the top slab of the benchtop continue the theme.

WHY SETTLE FOR ORDINARY ROUND KNOBS at the ends of the vise handle? Judith Ames wanted something more distinctive, so her husband, Hank Holzer, obliged by carving the end knobs.

Bench Profile

The Innovative Nyquist's Vise

A typical tail vise, when completely closed, leaves a gap of 2-3 in. between the end cap and the outside jaw. So most woodworkers clamp only in the inside jaws. John Nyquist's design allows clamping in both the inside and the outside jaws. Nyquist's vise closes both jaws simultaneously and completely, providing an additional clamping option other tail vises lack.

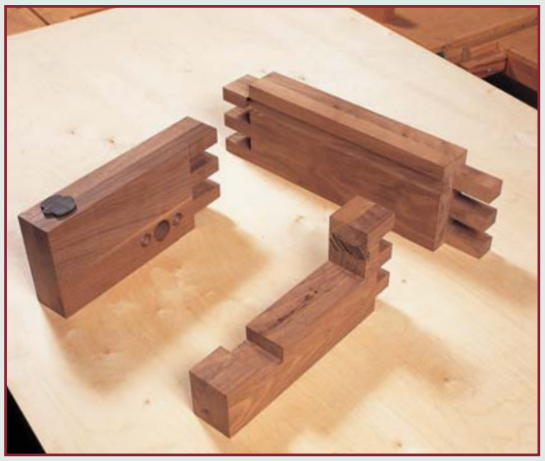
In most tail vises, the vise screw is on the outside encased in what looks like a solid block, but is actually a hollow box. On the long jaw, there is a relatively thin cover over the screw mechanism, which forms the lid of the box, the part that's flush with the benchtop. Nyquist locates the screw on the inside of the slide so that the movable jaws are solid.

Under the bench, there are two teak guide bars, one stationary guide attached to the underside of the benchtop, and one movable guide screwed to the vise jaws. The guide bars ride in notches milled into the mating pieces.

The movable part of the vise is a U-shaped structure with large finger joints at the corners. The bottom of the U-assembly is the long jaw, which contains the dog holes and runs along the front of the bench. A cold-rolled steel guide bar slotted and screwed into the long jaw runs in a matching groove milled into the front edge of the bench.The part to which the screw is mounted is the outside jaw. The part mostly hidden under the benchtop is the stationary inside jaw, which is attached to the front rail of the bench. The inside jaw contains a notch that rides on the stationary teak guide bar.

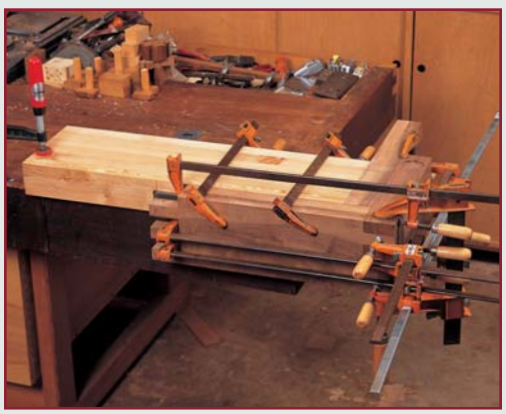
THE UNDERSIDE of this Nyquist-style vise shows the darker teak stationary and movable guide bars. The movable guide bar connects the U-shaped jaw assembly. The stationary guide bar below it is screwed to the underside of the benchtop.

THIS TAIL VISE is an amalgam of carefully chosen materials, Steel is used for the screw and for the front guide bar, which keeps the vise flush with the benchtop. Teak's natural lubricant works well for the sliding members. Walnut machines and glues well, making it an excellent choice for the jaws.



THE THREE COMPONENTS of the U-assembly are joined by finger joints. The slot cut out of the inner jaw in the foreground rides on the stationary teak guide bar.

NYQUIST ROUTED matching grooves in the bench and the long jaw of the vise. A guide bar of cold-rolled steel milled to precise standards is key to the smooth operation of this vise. He screws the steel guide bar to the movable long jaw.



HERE NYQUIST uses a mock-up of the end of the bench for gluing, but he typically uses the bench itself for a gluing armature. It's critical for the jaw to mate with the bench precisely, since with his design, both inner and outer jaws close simultaneously.

A wooden guide bar is notched and screwed into the lower side of this movable assembly, fastening the inside and outside jaws to one another. This movable guide runs through a notch cut into the end cap and held in place by a notched block.

What keeps Nyquist's vise from tearing itself apart, especially when clamping something between the end cap and the outside jaw of the tail vise, is the carefully cut finger joints he uses to join the corners of the three jaws.

Nyquist routes a slot to accept the front guide, a bar of cold-rolled steel. The guide is screwed to the vise assembly and slides in the groove in the benchtop. Cold-rolled steel is produced to precise tolerances so it's ideal for this critical part of the vise. He routes a matching slot in the front edge of the benchtop.

It's essential to carefully fit the tail vise assembly to the bench. If the vise is not clamped to a jig or the bench itself, chances are it will not mate properly with the end cap/benchtop corner. Nyquist glues the assembly in two stages. First he glues the finger joint at the outside corner where the long jaw meets the outside jaw. Once this cures, he glues the finger joint joining the long jaw to the inside jaw. Then the assembly is ready for the installation of the steel outside and teak inside guide bars.

To operate smoothly, the vise screw flange must be exactly aligned with the screw. When it is bolted to the end cap, the sand-cast surface where the flange mounts to the bench does not provide enough precision. Nyquist chucks the assembly into a metal-working lathe and cuts the mounting face of the flange exactly square to the screw.

CLYDE RICHARDSON MADE THE SPRINGS for these wooden bench dogs from a discarded bandsaw blade. He routed a groove in each dog to house the spring and secured it with a screw.

5

Holding Your Work

Bench dogs, holdfasts, hold-downs,

and other bench accessories have long been a feature of workbenches—and for a good reason: They work. A vise in conjunction with bench dogs is twice as versatile as a vise on its own. Hold-downs and holdfasts act like a third hand, holding irregularly shaped work. Bench dogs allow the entire bench to become a powerful clamp to hold the work. In addition to traditional holding devices, there is an wide range of devices that work in conjunction with the bench. Board jacks support long boards for handplaning, stops and bench hooks hold the work for sawing or handplaning, and dedicated fixtures hold work for specialized woodworking crafts like chairmaking.

This chapter is devoted to workbench accessories. Some need to be fitted into the bench from the start, so it's wise to plan for them in advance. Square dog holes, for example, are much easier to cut when making the benchtop than afterward. Other accessories, such as metal stops, can be added later. Because woodworkers recognize the value of such devices, manufacturers offer an interesting variety of options. And for woodworkers who love to build things for the shop, there is an endless array of useful projects to make.

Bench Dogs

If there's a single feature identifying a woodworking bench, it's the bench dog. Bench dogs extend up from the surface of the benchtop like fingers to grip the edges of a board so that the board's entire surface is unobstructed. Used in conjunction with an end vise, it's almost like having an extra pair of hands to hold the board while you work on it. Bench dogs come round or square and made of brass, steel plastic, or wood. Some even incorporate clamps of their own.

Square or Round?

The shape of the dog depends on how the bench is made in the first place. The most feasible way to create the square mortises is to dado them into the planks when building the benchtop. Square bench dog holes can certainly be chopped into an existing solid bench, but it's a pretty daunting task to get them right. Round dogs greatly simplify the process of retrofitting dogs, since all you need to do is drill ¾-in. holes.

ON A TRADITIONAL BENCH, the work is held between two dogs: one in the tail vise and one placed in a dog hole along the bench. Closing the vise squeezes the workpiece between the two dogs.

Square dogs are usually slightly rectangular in shape, with some sort of spring device to keep them either retracted or pulled up to the desired height. A larger head, either applied or cut into the shaft of the dog, actually applies the pressure to the workpiece. The holes mortised into the benchtop are normally set at a slight angle, 3 degrees to 4 degrees, tilting toward the vise that is used to apply the pressure. A notch mortised into the top of the dog hole provides space for the head when the dog is pushed all the way down.

Round dogs have a lot going for them. The holes bored for dogs have many uses beyond simply gripping a workpiece with bench dogs. The ¾-in. shaft size is standard not only for dogs but for hold-downs, holdfasts, and a variety of other bench accessories as well.

The face of the round dog, the actual pressure point, is cut at an angle that tilts toward the vise, providing a clamping angle similar to that of square dogs. As with square dogs, this aids in keeping the workpiece down tight to the benchtop.

Because round dogs rotate, holding a piece like a chair seat, round tabletop, or other odd shape is very straightforward. The face of the dog naturally revolves until it's flat on the edge of the piece, regardless of its shape.

High-quality brass dogs have carefully knurled faces to provide friction to hold the workpiece securely. These dogs incorporate a wire spring to keep them in place. Plastic pads are available to cushion the workpiece when the job reaches the final stages. Some round dogs have a plastic coating over the entire surface. These incorporate small bullet catches to position them vertically.

Just about any face vise will accommodate round dogs to hold boards flat on the benchtop. If your vise has an adjustable dog, as many do, a single row of dogs across the top of the bench

A SELECTION OF BENCH DOGS from Lee Valley Tools: Traditional metal square dogs, round dogs with cushioning sleeves (aptly called *muzzles*), a shorter version of the round dog called the Bench Pup®, the Veritas Wonder Dog®, and the smaller Wonder Pup®.

in line with the dog on the vise will work just fine. Drill ¾-in. holes about every 6 in. across the bench to house the round dogs.

If you would like two rows of dogs or if your face vise does not have a built-in dog, simply add a hardwood block to the outside jaw of the vise. Drill two dog holes centered on the vise screw in the new jaw. Drill ¾-in. dog holes across the benchtop in line with those in the vise jaw and—presto!—you'll be able to use dogs. Do the same with an end vise, and you can clamp a workpiece on the benchtop that's as long as the bench itself.

Materials for Bench Dogs

The proper material for dogs is about as controversial as their shape. Wood, metal, and more recently plastic dogs all have advocates. Metal dogs are difficult for the average woodworker to fabricate, but wooden dogs, now that's something else entirely.

ROTATING ROUND DOGS ARE ESPECIALLY USEFUL for carvers, like Clyde Richardson, making it easy to hold irregularly shaped work.

WOODEN DOGS DON'T NEED TO BE ELABORATE. Straight-grained hardwoods, such as oak or ash, are good materials for wooden bench dogs. A wooden spring set in a notch holds the dog in place.

Wooden dogs, made by woodworkers for centuries, are certainly the logical choice of material from a rational point of view, not to mention how aesthetically pleasing they are. One advantage of wooden dogs is that hitting them with an edge tool will not damage the blade.

You can easily modify your basic dogs for special purposes, adding pins or V-grooves for thin or mitered stock. Best of all, when they wear out you can make a new batch of them from material you find in the scrap bin. Since they cost virtually nothing except your time, you can make one for each dog hole in the bench so you don't have to constantly move them around to different holes.

Choose straight-grained hardwoods for your bench dogs. Since dogs will be under tension in use, avoid squirrely grain or defects. Some people like to taper their bench dogs, but a simple square shape and some sort of spring to hold it up works just fine as well.

There are many methods for making springs to hold the dogs in place. A saw kerf cut into the dog at an angle will hold a wooden spring. Metal springs made of old bandsaw blades are also easy to fabricate. Grind off the teeth from a section of the blade, bend it into a slightly rounded shape and secure it with a screw (see the photo on p. 88).

Round dogs can also be made of wood. California-based woodworker Sandor Nagyszalanczy takes a very different approach when it comes to getting the job done. His bench, built from discarded cabinets and a mail-order butcher block, is nothing fancy;

SEATTLE STUDIO FURNITURE MAKER Hank Holzer made enough wooden dogs to fill each of the dog holes along the front of his bench. He can raise and lower them easily and quickly, never having to shift them around to different holes.

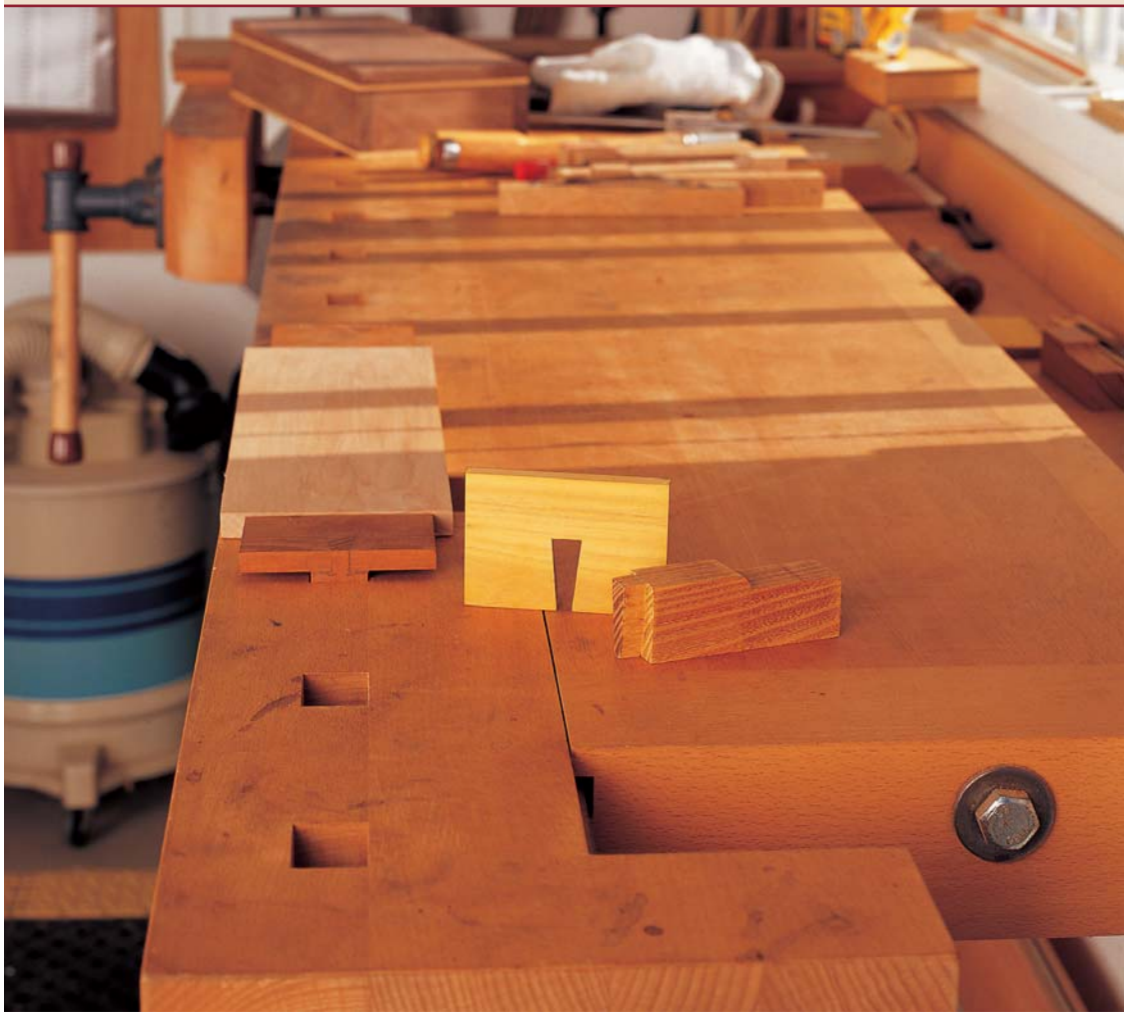
Bench Options

Dogs for Thin Parts

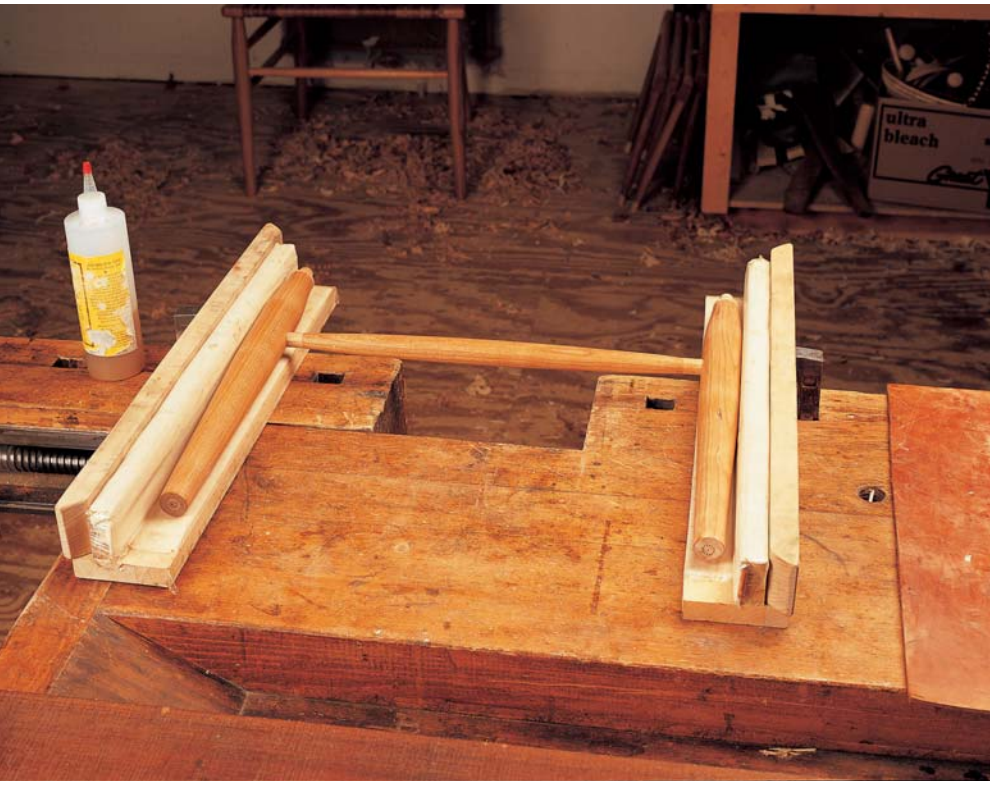
Clyde Richardson loves to make small wooden boxes in his converted barn in Kentucky. For working on the very thin parts, he makes bench dogs shaped like mushrooms, with the shaft dovetailed into the thin square heads.

Richardson uses a hard local wood for the shaft and softer wood like pine for the head. He notches the shaft to fit into the square dog holes in the benchtop. Then he makes the head whatever height he needs to accommodate the thickness of the material he's working on. He cuts a dovetail pin on the top of the shaft and a corresponding tail in the head.

This type of wooden dog could easily be modified for round dog holes by using a dowel for the shaft and drilling a hole in the head to the size of the dowel.



STEEL DOGS ARE STRONGER and more durable than those made of wood, but having to worry about hitting one with an edge tool is their chief drawback.



BRIAN BOGGS ASSEMBLES PARTS OF HIS CHAIRS with this jig. He uses the tail vise as a clamp to press the parts home very gradually. Boggs prefers the steel dogs because they have to be quite high to allow pressure to be applied in just the right spots.

neither are the dogs he makes for it. He buys ¾-in. maple dowels, cuts off pieces, and just like that, he has dogs.

Metal bench dogs are obviously stronger than wood. But many woodworkers worry about using steel dogs. If you accidentally hit a steel dog with a nice edge tool, chances are you'll knock a chip out of the edge. But advocates of steel dogs, like chairmaker Brian Boggs, say this isn't really a problem if the dog is at the correct height. For planing or other edge-tool work, the dog would be just high enough off the benchtop to hold the stock securely.

Boggs has used steel dogs for as long as he can remember and has never hit one with a tool. He prefers steel dogs because they offer such a positive grip. He can apply a good deal of pressure without having the dog distort, slip, or wear out, especially when clamping irregular shapes, as he frequently does.

When building chairs, Boggs uses the tail vise with the dogs like a press during assembly. He uses a specialty built fixture to both cushion the work and hold it in the right position. The dogs are raised well above the benchtop to exert pressure evenly. Because he often has to use significant pressure to make the parts seat, he works his vise and dogs hard. The steel holds up far longer than wood.

As noted earlier, brass is also used for bench dogs, particularly the round variety. Brass is softer than steel and less likely injure precious edge tools during unintended contact. For that reason, it's used on the knurled face of some steel dogs. It's hard enough to leave compression marks, however; so it's a good idea to provide a cushion of wood or plastic when you reach the finish stages of a project.

Plastic-coated dogs were once associated with lower-end stock benches, but recent developments in plastic coatings have produced material some woodworkers find entirely suit-

able for bench dogs. These dogs have a heavy knurling on the heads so they won't slip on the edge of the workpiece, and since they're softer than metal, they won't damage edge tools.

Locating Dog Holes

Traditionally, workbenches, particularly those from central Europe and Scandinavia, had one row of bench holes in line with the dog holes in the tail vise. That makes perfect sense if the woodworker uses mostly solid wood cut into long, relatively narrow pieces.

For wide stock or panels, several rows of dog holes in combination with a twin-screw end vise is an option that offers much more versatility (see Chapter 9 for an example). The wider the end vise, the wider the possible spacing. As we saw in the last chapter, the farther the dog is from the centerline of the vise screw, the greater the wracking potential. But as long as the workpiece is wide enough to span two pairs of dogs, one row on each side of the screw, the pressure is even. A full-width end vise with chain-driven screws will allow at least four rows of dog holes and won't wrack.

Stops

Simple stops are found on some of the earliest workbenches. They do what they say, stop the wood from moving when forward pressure is applied with a handplane or other tool. Some classically trained cabinetmakers swear by them because they're fast, simple, and need no complex vise and bench dog arrangement to work. The end of the board being planed simply rests against the stop, which prevents the board from moving when pressure is applied. This technique, which does not clamp the piece in any way, takes some getting used to; but like most acquired skills, it eventually becomes second nature.

Smart Solution

SPACING DOG HOLES

How far apart should the dog holes be from one another? It is tempting to make as many holes as possible to provide the greatest number of clamping positions. But all those holes in the bench can potentially weaken the structure. If you're mortising for square dogs, cutting dog holes is hard enough work. Somewhere between 5 in. and 8 in. is a good compromise. And for aestethics, the distance should work out more or less evenly at the ends.

LEE VALLEY TOOLS' CHAIN-DRIVEN double-screw vise with its four bench dog positions can be used as a clamp for edge-gluing as well as for an end vise.

THIS ADJUSTABLE STOP IS NOTHING MORE than a piece of stock projecting through a mortise in the benchtop. When not needed it can be unclamped and stowed flush with the benchtop surface.

POP-UP STOPS CAN BE LOCATED ANYWHERE on the benchtop by drilling a hole and cutting a shallow mortise. In the background are steel bench dogs with brass faces, which are somewhat kinder to stock than all-steel dogs.

Pop-Up Stops

A pop-up stop can be as simple as a mortise in the bench through which a board can be raised or lowered. The board can be clamped to a bench leg, as shown in the photo above. Many woodworkers who use these devices put a slot in the stop to hold a screw and wing nut, making adjustment easier than using a clamp. Another choice, available from woodworking retailers, is the aluminum stop. These stops are mortised into the benchtop. They sit flush when not in use and, when needed, provide handy little teeth to hold the work.

Bird's-Mouth Stop

Wedged stops quickly capture the edge of a board and hold it upright. Wedges are a natural clamping devise predating any sort of vise with a screw. A simple wedge cut into the end of a

piece of scrap yields a very quick and useful jig for holding a workpiece on edge; this is commonly known as a bird's mouth.

Using the jig couldn't be easier. Clamp the bird's mouth to the bench, jam the workpiece into the opening on edge, and tap the wedge in place. You might find this setup works just as well even without the wedge. Using thicker stock for the stop provides height, which keeps the workpiece more stable.

Holdfasts and Hold-Downs

Both holdfasts and hold-downs share the same advantages and shortcomings. They are quick and easy to apply and equally quick to release. They offer a way to clamp something far from the edge of the bench and can provide a great deal of downward force. The more you pound a holdfast, the tighter it gets—at least up to a point. Likewise, the more pressure you apply with the screw of a hold-down, the more pressure. Both devises clamp in a radius around the hole or holes drilled for them.

On the down side, they are prone to slip when you apply sideways pressure to the workpiece and thus should normally be used only in conjunction with a stop or dog. And if you try to clamp two pieces together on the benchtop in a precise location, holdfasts and hold-downs tend to push the pieces laterally as you apply pressure. An example of this is when you clamp a guide block to aid in chopping dovetails. It is very difficult to keep the guide block positioned correctly as you apply pressure with a hold-down or holdfast.

GARRETT HACK USES A BIRD'S-MOUTH STOP when planing a board on edge. The cutout created when making the stop is the perfect wedge for securing the work.

COMMERCIALLY MADE HOLD-DOWNS offer a reliable way to clamp boards to the surface of the bench. Benches with ¾-in. holes drilled for round bench dogs will usually accommodate a hold-down almost anywhere on the surface of the top.

NOTHING MORE COMPLEX than a piece of angled metal, holdfasts have been used at least since the times of ancient Rome. To anchor them in place, simply tap the top with a mallet. Releasing them is as easy as tapping the back.

Holdfasts

A holdfast is a device with no moving parts: It's a simple L-shaped piece of iron that, when jammed into a hole in the benchtop with a hammer, clamps the part down to the bench. Simply tapping the top with a mallet anchors them in place; the more taps, the more pressure. To release, tap on the back of the holdfast and out it comes. Hold-downs, on the other hand, are like clamps. They operate on the same principal of having a shaft lodged into a hole or flange in the benchtop, but they use screw threads instead of hammer blows to apply and release pressure.

Most commercially made holdfasts are all cast iron and are prone to cracking if you try to apply too much pressure. Others have steel shanks with cast-iron tongues and are much more durable. The key is flexibility. Steel is both stronger and more flexible than cast iron, and steel won't shatter when pounded with a hammer.

Hold-Downs

Screw-type hold-downs work like vertical clamps. Instead of being tapped into place, they grab on to the hole bored in the benchtop as pressure is applied to the screw. Most screw-type hold-downs have serrations on the bar to increase gripping power in the hole.

Virtually any benchtop made from solid wood of sufficient thickness can be drilled for a holdfast or hold-down. The thicker the top, the better the holdfast will grab. Thin tops don't offer enough hole length for them to seat properly. If the benchtop is made of a softer material, such as pine or plywood, or if it is thinner than

THIS HOLD-DOWN IS AN ACCESSORY for Sjöberg workbenches and is designed to fit into a drilled hole protected by a steel sleeve.

WASHINGTON FURNITURE MAKER Curtis Erpelding uses forged hold-downs made by a local blacksmith. Made of steel rather than cast iron, they have much more flexibility and holding power.

TWO POLES OF AIR-DRIED OAK shaped to an octagon provide Curt Erpelding with a versatile clamping system anywhere on his benchtop. The shape isn't as important as the diameter and the length. The poles need to be slender enough to flex slightly.

about 1½ in., it's probably not suitable for holdfasts. In either case, the hole drilled for the holdfast will wear much more quickly than if the benchtop is thicker or made from some very hard and dense wood. When locating the holes for holdfasts or hold-downs make sure they will not interfere with other bench operations.

Go-Bars

The term *go-bar* might imply that this useful device is a modern invention, but in fact go-bars have been in use for centuries. They are nothing more than fairly slender boards sprung between the bench and the ceiling. Tension holds the work in place. A smaller version of these go-bars is widely used by instrument makers, because they are ideal for holding delicate parts during glue-ups. Inexpensive to make, they can be used anywhere on the bench and require nothing but a flat piece of sheet goods mounted to the ceiling.

Using Clamps for Hold-Downs

Clamps used for assembly can also make effective hold-downs. In Sam Maloof's shop, there is not a conventional hold-down to be found. Maloof and his co-workers normally use clamps for holding pieces to the bench. One of the reasons Maloof built his workbench as an unadorned solid slab with a generous overhang was to create a surface for clamping, something he does constantly.

Holding some of the sculpted parts from one of Maloof's signature chairs takes some ingenuity. Around Maloof's shop are specially designed workbench extensions that look like ironing boards covered with carpet for padding. Parts can be worked directly on the extension without damage. Triangular blocks, some wood covered with carpet, some rigid foam, both protect and support chairs for detailing.

CLAMPS IN CONJUNCTION WITH SPECIALLY designed pads are ideal for securing chair parts. Sam Maloof places a pad below to cushion a chair seat. Mike Johnson uses two carpet covered blocks to hold a chairback to the "ironing board" bench extension.

THIS SHAKER-STYLE BENCH built by Jon Leppo features a sliding board jack. The holes accommodate pegs to allow for a variety of board widths. the entire assembly slides back and forth to accommodate boards of different lengths.

Board Jacks

If you work on the edge of a board longer than 2 ft. or 3 ft., you'll be capturing one end of it in your front vice and supporting the other end with a board jack of some kind.

A board jack is a device to keep the board level and just the right height above the bench-top. A board jack might be as simple as propping one end of the board on a stool or as elaborate as a pegboard system specially designed to accommodate different widths of lumber.

A simple way to support stock is to drill a series of holes in the front rail at the same elevation as the guide bars in the front vise. Round pegs inserted into the holes can be used to support the long end of the board very easily. Obviously, if the board is much wider than 6 in. to 8 in., its edge is will be too high to work on if its lower edge sits on the vise's guide bars. Then it's time to bring in the board jack.

Sliding Board Jacks

A traditional Shaker bench incorporates one of the most functional and beautiful board jacks. Its curved shape and simple design is anything but simple to build, but it works beautifully. The Shakers used the space below the bench for storage. To allow workers to open the drawers, the jack had to move out of the way. The close spacing of the peg holes provides adjustment for boards of different widths.

Curtis Erpelding uses a sliding board jack that is adjustable for both length and width. It slides along the upper stretcher on his bench, has a series of holes for different width boards,

CURTIS ERPELDING'S BOARD JACK slides back and forth while suspended in a slot on the underside of the bench. He sets the height by inserting the round support in one of the holes; to fine-tune the height, he rotates the support.

LARS MIKKELSEN MADE A BOARD JACK with a bracket at the top that locks into place with the bench dogs he makes from 1-in. dowels. The outer face of the leg is in the same plane as the inner jaw of the vise.

and incorporates a unique cam feature for fine-tuning. A cylinder, about 3 in. in diameter, has an offset hole drilled in it for a dowel pin. The pin fits in one of the holes for a rough adjustment for width, then by rotating the cylinder, Erpelding can tweak the position of the board until it's parallel with the benchtop.

Dog Hole Jack

A sliding T-slot board jack allows full adjustment of height. Lars Mikkelsen's board jack is a model of woodworking ingenuity and economy. The support can be tightened at any point in the slot. Unlike most board jacks, which slide back and forth in a groove, this device was designed to fit into the dog holes. It has a brace near the top that slides under the benchtop and rests on a ledge. The bench dog goes through the brace and holds the assembly tight.

Building this style jack requires no special hardware. A toilet bolt, such as the one Mikkelsen uses, works fine to adjust the block in the slot. But special T-slot bolts are available. Even Mikkelsen's bench dogs are shopmade: 1-in.-diameter dowels set into dog holes drilled so they're tilted 5 degrees toward the end vise. Under load, the dogs straighten up.

Somewhat less versatile, but no less handy, is a pullout support built right into the bench. It's not adjustable for board width or length so its best used for narrow stock that's on the long side, but it's always there when you need it and never gets in the way.

THIS HANDY PULL-OUT SUPPORT in Andy Rae's workbench is always available to hold a long workpiece for hand-planing. When not in use, the support disappears into a slot under the bench.

AT AROUND 18 IN. LONG, Phil Lowe's bench hook extends out over his bench farther than most. Reaching across the bench gives him good posture and balance but also allows him to site along the bench hook to visually line up the saw cut so the cut is square.

THE DESIGN FOR ANDY RAE'S BENCH HOOKS goes back to at least the eighteenth century. The hooks are used in pairs to hold longer boards on the benchtop.

ANDY RAE WORKED IN FRANK KLAUSZ'S SHOP for many years and built his bench very much like his mentor's—right down to the flip-up stop. Made to accommodate either a push or pull sawcut, the stop is perfect for a quick cut. When not in use, it folds out of the way.

Bench Hooks

One of the oldest and simplest devises in woodworking, a bench hook provides a stop to hold a workpiece. One part of the hook extends down the front edge of the benchtop to keep the hook from sliding across the bench. The other part of the hook is the stop or fence. Hand pressure against the board keeps it in place. The bench hook excels at holding smaller workpieces for hand sawing. Some woodworkers saw a 90-degree or 45-degree kerf into the back fence and use it to guide their sawcuts, like a miter box.

When cutting longer lengths, the typical bench hook is too short. Andy Rae uses two separate bench hooks, which he calls *cut-off hooks*. They can be placed as far apart as necessary, offering full support even for a long, heavy board.

A bench hook can also be used as a portable bench protector, as a place to make chisel cuts on small parts, or as a cutting board for knife cuts.

Because a bench hook relies on forward pressure to keep it in place, it works well with Western-style push saws. The push stroke of the saw forces the workpiece against the bench hook. At the same time, the downward hook grabs the front of the workbench. Obviously, this arrangement is less than ideal for those who prefer Japanese pull saws.

Andy Rae, who uses both types of saws, has modified a flip-up stop design used by his mentor Frank Klausz. This one pops up from front or back. Whether pushing with a conventional saw or pulling with a Japanese saw, there is always a convenient stop on the end of the bench.

Fixtures and Auxiliary Tables

Retrofitting your workbench for round dog holes opens a range of possibilities. Not only can you take advantage of the many commercial dog variations based on the round dog idea but you can make fixtures using the round dog holes. A pattern of ¾-in. dog holes will hold a variety of fixtures in place. Used in conjunction with the vise jaws, a flip of the vise handle holds the fixture as securely as if it were a permanent part of the bench.

A Versatile Platform

A ¾-in. piece of plywood, about 30 sq. in., will provide a base for a number of special-function tables, including the metal-working station shown on p. 82. Drill ¾-in. holes in the plywood to coincide with the pattern of dog holes to position the base. Drop the plywood in place on the bench. Then cut a thick block about 6 in. wide by 12 in. long and clamp it into the front vise so the top edge is up flush with the underside of the plywood. Glue and bolt this block to the plywood.

Sharpening Station

Use the platform just described or make another one to create a sharpening station. The perimeter dam confines water from sharpening stones. It's easy to attach small holders for stones, a pond for water, guides, and other sharpening gear. The nice thing about having this attached to the bench only temporarily is you can work at your main bench where you have good light and a measure of comfort, handling a somewhat messy process without cluttering up your woodworking area or tying up an entire bench. When everything is sharp as a razor, the intact station can rest on a shelf out of the way.

T-Track Fixtures

T-track hardware is now available from woodworking retailers and is second only to dog systems for adding practical clamping features to benches and jigs of all types. T-track hardware is usually made from aluminum, which makes it easy to cut and machine. Some hardware is predrilled for screws. Simply rout a ¾-in. groove deep enough for the T-track to sit flush or slightly below the bench surface, then screw it into the routed recess. Make certain that at least one end is open so that the T-bolt can be removed. Then add a tightening knob or cam lever, and you have an efficient clamping system or hold-down.

GEORGE LEVIN'S T-SLOT SYSTEM gives him the flexibility to clamp most any project flat to the benchtop. He can lock the T-slot dog anywhere he likes; then using the dog on the vise, he clamps the workpiece in place.

A PORTABLE SHARPENING STATION with pegs that fit right into the round dog holes holds everything you need, including a piece of glass for flattening with wet/dry sandpaper and a place for stones. And the entire station has a frame to contain the mess.

6

Bench in a Box

A HIGH-QUALITY WORKBENCH by any standard, this Ultimate American model from Diefenbach would be a welcome addition to any shop large enough to accommodate its nearly 8-ft. length.

Woodworkers are do-it-yourselfers by nature. As a group, we're somewhat on the thrifty side as well. We often presume that building a bench is more economical than buying one. But when you add up the cost of lumber, hardware, and other materials, prefabricated benches don't look so expensive after all. And if you make a realistic estimate of the time involved, even figuring minimum wage as an hourly rate, chances are you're money ahead buying a bench and paying the hefty freight for having it delivered.

The desire to build a workbench is never entirely rational. But most of us opt to purchase rather than build components. There may be some portion of the building process that suits you more than others. Perhaps building the benchtop challenges your time or resources enough for you to contemplate alternatives to building from scratch.

Once you begin purchasing components, it's a short leap to purchasing the entire bench. Among the offerings of workbench manufacturers, you might find exactly the right bench.

Bench Components

Only 20 years ago woodworkers had many fewer options in commercially available bench parts. The choice was among building the bench from scratch, using only manufactured hardware, or buying a finished bench. Today a bench builder can choose from a wide array of parts, essentially putting together a custom kit. Some of these components are from bench manufacturers and sold through woodworking tool retailers. Others come from an unsuspected source—the local home center.

Manufactured Benchtops

One of the most difficult parts of building a workbench is laminating the top and getting it flat. So it's no surprise that benchtops are a popular commercial item. Butcher block sold for countertops is now available in lumberyards, home centers, and just about any outlet that sells kitchen cabinets. Depending on the source and the manufacturer, the quality may vary. Lower-priced countertop butcher block is usually 1 in. to 1½ in. thick. You can special order just about any size or thickness, but expect to pay a premium for thicker slabs.

Butcher block that is a minimum of 1½ in. thick can make a decent benchtop, provided it gets adequate support from a rigid structure. California woodworker Sandor Nagyszalanczy used butcher block over some scavenged kitchen base cabinets. He wanted a wider

A BUTCHER BLOCK can be ordered in just about any thickness, width, or length you would need for a workbench. By the time you add the raw materials and labor to mill and glue up a workbench slab, the cost of a manufactured top is quite reasonable.

THE MAIN TOP OF SANDOR NAGYSZALANCZY'S WORKBENCH is prefabricated butcher block. Laminate countertop makes a solid, smooth, and flat workbench, which doubles as an outfeed table.

benchtop than is usually traditional and a bench that would be easy to build. The commercial butcher block he ordered provided a fast and economical solution. To build the bench, he simply bolted the countertop to the cabinets. And the height allows the bench to serve as an effective outfeed table for his table saw.

Bench slabs are usually thicker than the typical countertop butcher block, generally 2 in. to 3 in., and are more than adequate for a workbench. If you price the amount of wood you'll need and figure in waste and the amount of time and energy you'll spend milling, gluing, etc., the cost of a slab compares very favorably to a top you would glue up yourself.

Bench slabs are usually solid maple laminate and are available in just about any length or width you would want. The downside of these slabs is that it is quite difficult to add square bench dog holes and, unless you specify otherwise, they usually contain finger-jointed segments. But a butcher block works just fine if you intend to drill round dog holes.

Complete benchtops manufactured by such companies as Swedish workbench manufacturer Sjöberg offer a way to get a more traditional configuration without having to build it yourself. These benchtops also offer a quick means of getting a great bench that's somewhat cheaper than buying the entire bench outright. Just build a base, and you have a bench.

SJÖBERG BENCHTOPS feature red beech construction, predrilled dog holes, and already installed vises. Add some sort of base, and you have a workbench.

Manufactured Bases

Just as kitchen countertops makes a good benchtop, kitchen cabinets can make good bases. Since aesthetics is less a factor in a workbench than in a kitchen, you may be able to find great bargains for slightly damaged base cabinets. Ask at your local kitchen cabinet dealer or check your home center for special sales. If you decide to go this route, make sure the cabinets are substantial and not just particleboard boxes.

As we saw in Chapter 3, a variety of manufacturers sell steel legs for workbenches. Combined with a commercial benchtop, industrial-style legs offer one of the shortest routes to a sturdy workbench. Lee Valley Tools' cast-iron bench legs provide a rigid bench base and come with two truss rod assemblies for stiffening the stretcher. The bench builder provides the wood. There is also a version that can be used to make space-saving wall-mounted benches.

The cast-iron leg assemblies are reminiscent of machines made in the Industrial Revolution. Nineteenth- and early-twentieth-century machines are characterized by castings that are not only functional but also beautifully decorative. The incredible weight of these legs give the bench excellent stability. Bolting the legs to two maple stretchers makes the base extremely stiff as well. The bolts are full length and ½ in. in diameter.

FOR A FAST, BEAUTIFUL, AND SOLID BASE, use these cast iron legs, which are also reasonably priced. Full-length truss rods tie the pair of legs together for a base that's rigid and, at nearly 120 lb., heavy as well.

WITH THIS WORKBENCH KIT FROM LEE VALLEY, just about everything you need, except vises and base materials, is included. It comes with two predrilled slabs, instructions, and all the hardware.

Kits

With the products that we have looked at so far, and some readily available hardware, you can essentially make your own bench kit. The idea of commercial workbench kits goes back to the famous Acorn bench kit first introduced about 20 years ago. Peter Shapiro's company, which manufactured Acorn benches and kits by the hundreds, eventually went out of business, so the benches themselves are no longer available. The good news is you can still buy the plans for the bench from Grizzly and build it yourself.

Few companies offer kits in the normal sense. Though most commercial benches come disassembled to some degree, they can't exactly be called kits. Many manufacturers offer benchtops all assembled and include plans and hardware for the base.

But the idea of a workbench kit is a good one. Kits allow you to take advantage of the manufacturer's merchandising: You get a deal for buying more items all at once. Kits also save you the trouble of researching and assembling all the hardware and dimensioning the stock. Lee Valley Tools offers kits at two different levels: hardware only and hardware plus prelaminated bench slabs.

Smart Solution

INSTANT TOOL STORAGE

It's worth noting that manufacturers that sell complete benches often sell base accessories, such as cabinets and drawers, separately. If you are willing to make your benchtop and base frame to a specific size, you can buy manufactured tool storage drawers or cabinets and simply install them. As with hardware, if you plan to do this, it's best to buy the components first and build around their actual dimensions.

26 CHAS. A. STRELINGER & CO., DETROIT, MICH., U. S. A.

WORK BENCHES.

We present here a line of Work Benches suitable for carpenters, cabinet-makers, carvers, amateurs, etc. These Benches are all made in first-class style, glued-up hard maple tops, and maple legs. They are put together with joint bolts, and can be easily taken apart and crated for removal or shipment. The Benches, Figs. 1810 and 1810a, are designed for use in manual training schools, and for gentlemens' and youths' home use. The width is 20 inches, with 13 inch glued-up maple top; length 4½ feet. The drawers and cupboard in Fig. 1810 are a superior substitute for the tool chest.

Price of Fig. 1810a, $8.00; Fig 1810, $12.00.

FIG. 1810a.

FIG. 1810.

CHAS. A. STRELINGER & CO., DETROIT, MICH., U. S. A. 27

Fig. 1807 is what is known as a Cabinet Maker's Bench. No. 1 is the size most commonly used.

No. 1, $12.00; 25 inches wide, with 14 inch maple top, 6½ ft. long, 34 inches high.

No. 2, $13.00; 6½ ft. long, by 30 inches wide, 16 inch maple top.

No. 3, $14.00; same as No. 2, but 7 ft. long.

The Carvers' Bench (Fig. 1809) is quite similar to the Cabinet Makers' (Fig. 1807), but is 5½ ft. long and has no side vise. Price $11.00.

We also have the Cabinet Makers' Double Bench (not illustrated), designed for use in places where space is limited. It is also well adapted for special or large work. It is 7 ft. long, 37 inches wide, with 11 inch pine center in top. It is practically the same as two No. 3 benches placed back to back.

Price $20.00.

FIG. 1807.

FIG. 1809.

THE STRELINGER CATALOG, printed over 100 years ago, shows that some things have changed but not others. The configuration of the upper right bench is quite familiar and is still being manufactured by a number of companies. What's changed just a bit is the $12.00 price tag.

Manufactured Benches of the Past

Contrary to what many woodworkers think, woodworkers of earlier times did not always build their own benches. The idea that a woodworker made his bench to prove his worth to his teachers and later to his potential customers is only partially true. The fact is that someone needing to make a living often made the prudent business decision to buy a bench. Larger shops and trade schools usually had no choice but to purchase commercial benches.

Early catalogs attest the health of the bench-making industry of the late nineteenth and early twentieth century. Some of the company names are still familiar, but for very different reasons. In business for almost 150 years, gadget manufacturer Hammacher Schlemmer was once known for its workbenches and workbench accessories, including bench dogs and hold-downs; but these days they are better known for innovative consumer products, like their upside-down tomato planter.

Some bench makers of the past have long since gone out of business, but their products remain a testament to their workmanship. Woodworkers who discover these treasures will find themselves with much the same choice as when they discover a vintage handplane. The first question is whether it works well enough for active use in the shop. The next decision is whether to preserve the bench as a precious artifact of the past or put it back into service.

IN 1980, KELLY MEHLER bought two of these benches at auction for $250. They were sold when an Indiana chairmaking shop closed its doors. Even though the benches saw long service in their previous location, the wooden vises and vise screws still work flawlessly.

ROBERT ABRAMS'S BENCH came from a St. Louis trade school's pattern-making program. He paid less for the entire bench than the Emmert vise alone would now fetch on the Internet. Note that the vise is installed so the rear jaw is flush with the front of the bench.

Many of these benches are fully functional, as useful to their new owners as they were to the tradesmen or students of yesteryear. Some of them offer unique configurations or rare patternmaker's vises. Antique benches occasionally come up for sale at auctions of workshops that have gone out of business or when schools are refurbished. Considering both the practical and historic value of old workbenches, it is surprising that there is not more active trade of them on Internet auction sites.

Contemporary Bench Makers

Like other manufacturers, bench-building companies come and go with unsettling regularity. Brands of benches once common in woodworking shops and schools are no longer available, and new brands have taken their place. Just as suddenly, old brands thought lost reappear. Despite all these fluctuations, there will, we hope, be continued demand for high-quality manufactured benches.

Almost all production benches come from Europe. Well-established name brands like Sjöberg, Ulmia, and Diefenbach dominate the market, or at least they do today. Some newcomers include Lee Valley Tools, Laguna Tools, and benches from imported from eastern Europe. Rather than list each company's entire line, since several of them manufacture dozens of different models, I'll try to highlight the benches that are unique in some way and those that are at the high end of the price scale. It's fair to say in the case of stock benches, the heavier they are the more expensive they'll be (and the higher the freight for delivery).

Ulmia

The Ulmia brand is almost synonymous with workbenches. Of course the company also makes a variety of woodworking tools, from bowsaws to spring clamps. But most woodworkers would say at the very least, an Ulmia is a "real" workbench, with its classic tail vise,

A Changing Industry

Workbench manufacture was once a thriving business in the United States. Today there is not a single company building workbenches on a production scale. Almost all commercial benches come from Europe, but even there, the market has shrunk considerably. In Germany, for example, much of the market for benches was large trade schools, generously funded by the German government. With the unification of Germany, much of this funding has apparently been shifted to other priorities.

The adoption of the Euro in the Czech Republic and other eastern European countries affects the price of everything imported from that area of the world, including benches. But currency exchange rates are only part of the saga. Political strife in southern Africa has threatened the supply and manufacture of Garrett Wade's unique Rhodesian teak benches.

The moral of the story is: If you have your eye on a specific manufacturer's workbench, don't wait too long to buy it. Global economic forces may soon put it out of reach.

THE ONLY WORKBENCH BRIAN BOGGS has ever had in his shop is this classic Ulmia. Though Boggs has worked the bench hard for decades, having used it to assemble some 1,700 chairs and counting, the bench is holding up just fine.

THE THOUSANDS WHO'VE EVER TAKEN A WOODWORKING CLASS will be familiar with this Sjöberg bench. Though smaller than the classic bench, its handy size gives students two vises, storage, and a dedicated work area.

THE ULMIA COMPANY HAS HAD ROCKY TIMES but seems here to stay—using the old name under new ownership. Though lacking the familiar tool tray, the Improved Professional model is reminiscent of the Classic Ulmia.

front vise, tool tray, massive square steel dogs, and high-quality German hardware. Ulmia benches grace thousands of shops, studios, and schools on both sides of the Atlantic.

Once a mainstay of the bench-building industry, the Ulmia Company has had its ups and downs in recent years. The Ulmia Company was sold in 2000 only to return two years later, retaining its old name and much of its product line, but under new ownership. The company is back on its feet producing workbenches, and it is hoped that importer Garrett Wade can count on a continuing supply.

The Improved Ulmia Professional Bench differs a bit from the classic model one finds in many shops around the world. Some of the changes stem from the difficult equation of quality and price. The good news is that the changes don't seem to affect the performance of the bench.

Like its predecessors, the new Ulmia bench is solidly constructed of red beech and weighs a hefty 325 lb. The massive 24-in. by 78½-in. top is over 2½ in. thick in the center and 4 in. thick at the edge. Instead of the traditional square bench dogs, Ulmia chose to update to round dogs for this model. A second row of dog holes for use with the front vise facilitates clamping panels. To gain more bench surface, the traditional rear tool tray has been replaced by a shelf below the bench surface.

Sjöberg

Swedish-made Sjöberg benches are widely distributed by a number of woodworking retailers. The Sjöberg model 1200 makes a good first bench for woodworkers on a budget. Many newcomers first experience a Sjöberg in a woodworking class, since the price point makes this bench attractive to schools, both here and abroad. Most benches shipped into North America have front vises and end vises, but the company also makes benchtops with European-style tail vises.

Sjöberg offers a complete line of bench accessories. All benches come with a hold-down mortise and protective metal sleeve as well as plastic or plastic-coated bench dogs. Square dogs are still available on some of the traditional benches, but like other bench manufacturers, Sjöberg is now offering round bench dogs on many models, along with an additional row of dog holes for panels. Mortises in the leg under the end vise can hold a Sjöberg hold-down, turning the leg of the bench into a board jack. An especially nice feature of these benches is the option to mix and match base components, including drawers and cabinets.

American woodworkers familiar with the Sjöberg small benches are often surprised to learn that the company offers a large variety of benches, from a bench only 3 ft. long to their top-of-the-line 8-ft. cabinetmaker's bench, weighing almost 400 lb. They also have a carver's bench, whose top tilts up to 90 degrees. The carver's bench also has a built-in ballast compartment, which if filled with sand increases the mass and stability of the bench.

Their Ultimate Woodworking Bench should satisfy detractors of tool trays, because this model doesn't have one. The width of the

THIS FULL-SIZE BENCH FROM SJÖBERG may come as a surprise to those who think the company makes only small beginner's benches. The Ultimate model is as heavy and well made as any top-of-the-line bench.

DIEFENBACH RECENTLY CELEBRATED 125 YEARS IN BUSINESS. Their benches exemplify quality and attention to detail. The square bench dog mortises, for example, are cut into the front rail rather than being milled into the edge.

bench is almost 2 ft., even without having its width augmented by a tray. The base accepts optional storage cabinets, available with drawers and enclosed shelves. With a minimum top thickness of 3 in. and nearly an 8-ft. total length, this is a bench for serious woodworkers.

Diefenbach

If it's the top of the line you must have, Diefenbach occupies an almost unmatched position among workbench fans. Diefenbach is a family-run woodworking business with three factories in Germany and one in France.

In the end, it's the seemingly small things that make the difference. For example, the square dog holes are actually mortised into the dog hole strip in the bench rather than being cut into the edge of the board like most other benches. The front vise has an adjustable spacer to keep the jaws parallel when clamping a board in one side of the vise.

THE DIEFENBACH FRONT VISE has a devise to keep the jaws parallel when clamping on one side of the vise. When the knurled nut is spun against the rear jaw, it doesn't matter how much pressure you apply, the vise will not wrack.

Diefenbach offers numerous models, each having its own configuration. They will also make custom benches to order, if you want a wider or longer bench. They even offer left-handed models with the tail vise on the left and front vise on the right.

At 413 lb., the 8-ft.-long Ultimate American bench is aptly named. It has drawers and a cabinet below the benchtop, a tail vise and front vise, and even an available insert to fill the tool tray if you want a larger work surface.

If the traditional European bench suits your needs, there's a model called the German that has the characteristic long and relatively narrow (24 in. wide, including the tool tray) top with tail vise on the right and shoulder vise on the left. The twin bench is designed for two woodworkers. Each side of the 36-in.-wide bench has a front vise on the left and tail vise on the right. A center tool tray divides the bench down the middle.

A specialty bench designed for woodworkers confined to wheelchairs has a very high front clearance to provide plenty of room to wheel right up close to the bench. It also has dog holes along the front edge to hold pieces securely within easy reach. The left-side drawer holds tools to keep them handy.

THE ENORMOUS DIEFENBACH TAIL VISE is in keeping with the proportions of the rest of the bench, one of the heaviest on the market. The narrow fingers connecting the jaws give the all-important joint plenty of gluing surface area.

THE VERTITAS BENCH FROM LEE VALLEY TOOLS is certainly unconventional, with it's optional cast-iron leg assembly, center tool tray, four rows of round dogs, and twin-screw end vise. Assembling the bench is easily accomplished in less than an hour.

Lee Valley Tools

Canadian tool company Lee Valley Tools has taken a unique approach to its workbench products. Like many other tool dealers, the company sells a wide variety of workbench accessories and components. But when it comes to a bench for general woodworking, Lee Valley offers one very well designed model. The only options are cast-iron legs or hardwood legs.

The designers of the Vertitas Workbench System were not afraid to reinvent the bench. It doesn't matter that it doesn't look exactly like traditional benches. In fact, the only feature of this workbench that's conventional by European standards is the front vise.

The deciding factor in the Vertitas design is practicality. Most tool trays fill up with workshop trash. No problem for the Vertitas bench; its center tray is open on one end so debris is easily removed. Two slabs on each side of the tray provide more even support for wide work than a traditionally located back tray. A full-width twin-screw end vise prevents racking, and the four rows of bench dog holes make clamping anything from a single board to wide panels easy. And, yes, the inventors of Bench Pups offer round bench dogs. Truss rods come with both the cast iron and the hardwood base for keeping the assembly tight and rigid.

Laguna Tools

Laguna Tools president Torben Helshoj understands what woodworkers need in a bench because he is a woodworker himself. His line of workbenches are made to his design and are imported from Europe. Laguna benches are on the traditional side. They feature thick tops of European beech with conventional front and tail vises. But, like nearly every modern bench manufacturer, Laguna offers round bench dogs. They are angled both to capture the work and to hold it down on the benchtop.

The classic workbench is available in two sizes—5 ft. and 7 ft.—to suit most workshops. Laguna's Signature Series bench is a beautiful full-size, heavy bench with lots of drawer space below and a massive top. Tool tray fans will like the ramps at each end of Laguna tool trays,

IRONICALLY, WOODWORKING IS A RATHER UNCOMMON ACTIVITY for someone in the woodworking tool business. Laguna Tools president Torben Helshoj knows benches because he's a woodworker himself, and designed a line of benches accordingly.

Bench Options

Custom Bench Builders

For woodworkers who are not equipped or inclined to build their own benches, there at least two alternatives to buying a stock bench. Some manufacturers, Diefenbach, for example, will make custom benches to order. But commissioning another woodworker to build a bench may be the way to get a final product tailored to your exact specifications.

Lief Carlsson makes benches in the classic Scandinavian configuration with a tail vise and shoulder vise using wooden vise screws cut from birch roots. While Sweden may seem like a long way to go for a custom bench, California woodworker Ejiler Hjorth-Westh did just that. Hjorth-Westh finds Carlsson's vises, with their hand-cut screws, give the vises just the right feel.

LEIF CARLSSON AND EJLER HJORTH-WESTH live about 7,000 miles apart, but that didn't stop Californian Hjorth-Westh from ordering one of Carlsson's benches. The bench was custom-made for a left hander.

David Charlesworth, an English furniture maker, builds custom benches with a top configuration originated by his teacher, Ted Baley. What initially looks like a tool tray near the center of the bench is actually a removable well made up of individual segments. When the sections are removed, it's simple to clamp to the solid bench surface with ordinary bar clamps. While the front portion of the bench is just 16 in., the effective total width combining front and back sections is twice that.

Charlesworth's handsome base configuration offers solid construction and a visual appeal reminiscent of the best Arts and Crafts furniture. The rear set of legs tilts outward, effectively widening the stance of the bench to make it more stable. The stretchers and upper cross members are joined to the legs with wedged through tenons.

Rob Cosman, a woodworking teacher, furniture maker, and custom bench builder in New Brunswick, Canada, has some strong views about bench design. For him, a bench without a shoulder vise is at best an overcomplicated compromise and at worst entirely useless. Cosman builds benches on commission only, and only for a select few. He'll build any configuration you want, including one set up for a left hander, as long as it coincides with his notions of the "proper" bench.

DAVID CHARLESWORTH'S BENCHES include a unique twist on center tool trays. Removing sections of what seems to be the floor of the tool tray provides clamping access, allowing you to use clamps instead of holdfasts.

THE CONFIGURATION OF THE CHARLESWORTH BENCH gives it all the advantages of both a narrow and a wide bench. The two separate slabs, one wider than the other, can be used independently by simply removing the floor sections of the tool tray.

THIS BENCH IMPORTED FROM THE CZECH REPUBLIC is every inch the classic European workbench, built with red beech throughout. The bench comes complete with square dogs, tail vise, and built-in storage cabinet.

which make sweeping out the debris much less of a chore. The signature series also features dog holes drilled along the front rail and down the leg under the tail vise. Add a holdfast sized to the dog hole, and you have a board jack.

Garrett Wade

New York tool merchant, Garrett Wade has been an Ulmia distributor for many years. Recently, the company has started carrying several workbenches from other parts of the world. For a time, the company was importing a modern configured bench from Africa made of deep red Rhodesian teak, which has stability comparable to the beech used in European benches. Unfortunately, world conditions have limited the availability of this handsome bench.

The Cabinetmaker's Storage, Traditional-style Workbench is a good value in a traditional workbench. Imported from eastern Europe, the bench is constructed of red beech. The top surface area is comparable to the Ulmia bench that Garrett Wade also sells. Any woodworker seeking to purchase the classic European-style bench would be pleased with this acquisition, especially considering the cost of comparable benches. It features a solid tail vise, traditional square dogs and dog holes, and a 20-in. front vise. The base includes a lockable tool cabinet and storage shelves.

BUILT IN THE 1960s, Sam Maloof's bench is perfect for the way he likes to work. To hold his furniture parts, he uses either the antique Emmert vise or simply clamps parts to the overhanging lip of the bench.

7

No-Frills Benches

Woodworkers often build or buy a series of benches, each one different, before they achieve the ultimate bench design. So before you stress yourself trying to come up with the perfect bench the first time, why not make a simple and functional bench and take it out for a test drive? That way you can decide firsthand what works and what doesn't. See if you really need all the fancy gizmos. At the end of the day, you'll have a nice bench you can always use for sharpening or assembly and, in the process, be better prepared to tackle the "real" one.

This chapter features some workbenches that demonstrate the virtue of functional simplicity. The workbench Sam Maloof has used for decades is, by furniture maker's standards, unusual. Basically, a heavy maple top supported by a minimal base built like a table, this bench makes a good project for a new woodworker. Niall Barrett's bench, inspired by an Ian Kirby design, is equally straightforward. While these benches are simple, they perform all the tasks necessary to general woodworking. They are versatile and sturdy enough to serve you for years to come. In fact, you may decide, as did Maloof, that your first bench *is* the perfect bench.

Getting Down to Basics

To build a workbench, you'll first need a workbench. This classic predicament in woodworking is inescapable. So, while you're gearing up for perfection, practice by building something more down to earth, something very basic.

What do you really need in a workbench? For the moment, set aside the images of gleaming beauties you've seen in the catalogs and be honest with yourself. Do you really need a bench that weighs 300 lb.? Must it have classic wooden vises and square bench dogs? As we've seen in earlier chapters, the essentials of a functional workbench are a flat top, a sturdy base, and a means to secure your work to the bench. Other features may make your workbench more versatile or make some operations easier, but these are enhancements, not essentials.

While laminating and flattening a solid-wood top is the most arduous part of building a bench, the most technically difficult chores are building and installing shopmade vises. That's why most bare-bones benches use a stock vise. In fact, a vise is not an essential, as long as there is sufficient clamping surface along the edge of the benchtop, but adding a vise to a bench does immensely improve its versatility. Faced with the choice of only one vise, some woodworkers would attach the vise to the left front area of the bench. Others would install the vise on the right end to enable clamping with bench dogs. But if one vise is good, two vises are even handier. Why not install both?

DENNIS TREFFRY'S CONSTRUCTION-SITE BENCH is as simple as it gets. He built the whole thing in less than a day. It's entirely held together with drywall screws and knocks down for transport in about 15 minutes.

SANDOR NAGYSZALANCZY GATHERED THE PARTS OF THIS BENCH from a variety of sources. The assembly was a simple matter of bolting on a vise, drilling some dog holes, and screwing the top to the base cabinets.

The widest variation among simple benches is in the base construction. The base needs to be sturdy enough to withstand the forces of hand and power tool use. Accomplishing that can be as quick as screwing on plywood aprons or as elegant as legs and stretchers with wedged mortise-and-tenon joints. Simple benches usually use metal hardware, such as bed bolts, carriage bolts, and continuous threaded rod to make the connections.

Many woodworkers elect to make a plain frame-style base and then build storage into it. This could be as simple as the shelf under Sam Maloof's bench or as complex as a bank of cabinets and drawers. The added weight is certainly desirable and will keep the bench from walking across the room. In most cases, the storage components can be added later, but if you plan to add storage you should consider building a sturdy cabinet that can act as the base structure itself.

Remember, the main purpose in constructing a simple bench is to have a bench to work on *now.* But it doesn't hurt to plan ahead. If you want storage below the benchtop, you can easily modify the designs that follow. You can also change the top dimension to suit your workspace. Similarly, you can adjust the height to suit your size and working preferences. As tempting as it is to do otherwise, for now, keep it simple.

THE JAWS OF MALOOF'S ANCIENT EMMERT VISE are designed to go out of parallel to grasp irregularly shaped parts securely. Then without releasing the part, the vise can rotate and tilt to almost any angle.

Sam Maloof's Bench

Sam Maloof's bench sits in the center of a fairly large room in his shop, one crowded by burl slabs, a table saw, drill press, chairs in various stages of assembly, boxes of parts, patterns, clamps, and odd planks of walnut and maple. In this room, on this very simple bench, Maloof has produced hundreds of pieces of incredible furniture, including work that now has found a home in national museums.

A Uniquely Personal Design

By European standards, Maloof's workbench is unconventional to say the least. The bench is quite low, much wider and longer than usual, and built more like a table than a workbench. The base is painted a flat bluish green and the top has no finish on it whatsoever. The single vise, a massive old Emmert, is mounted to one end of the top instead of in the more common front left position. There isn't a single hold-down. Instead Maloof uses the versatility of the patternmaker's vise to hold the irregularly shaped parts so distinctive of his chair designs. The benchtop is solid wood and has a wide overhang so that he can clamp parts using conventional clamps.

There is a simple elegance to the bench. Even on close examination, it is not immediately apparent the legs are tapered. It would have saved Maloof precious hours to simply leave them straight, but that's what makes him Sam Maloof—a willingness to spend extra time to add beauty to an otherwise functional object. He not only tapered the legs but rounded the corners as well and, in the process, transformed

IF YOU CAN BUILD A TABLE, you can build a bench like Sam Maloof's. The base doesn't get any simpler, and the top is nothing more than a glued-up and through-bolted slab with a patternmaker's vise at one end.

NOT AN EXACT REPLICA OF SAM MALOOF'S BENCH BY ANY MEANS, the one I built for myself incorporates my own notions of joinery and construction preferences. To help keep it stiff, I beefed up the legs and aprons and ran full-length bolts to connect aprons and legs.

EVERY MARK ON MALOOF'S BENCH represents yet another project he's produced in his prolific career as a furniture maker. The square nuts he used when he built the bench in the 1960s are still available, but much less common these days.

the look and feel of the whole project. His genius is in being so subtle in these refinements that at first you may not even notice them.

Straightforward Construction

Maloof's benchtop is 84 in. long by 38½ in. wide. Even though he is of average height, his bench is relatively low, at just 31¼ in. The maple slab is 2½ in. thick and through-bolted using 1¾-in. boards glued up butcher-block fashion. The base is built with tapered legs 3¼ sq. in. at the top and attached to 3¼-in. aprons, 1 in. thick, with a single stretcher well above floor level.

The base joinery in the original is mortise and tenons. Under the top, Maloof fit two connecting braces the same size as the aprons, equally spaced. He used diagonal corner blocks with hanger bolts to stiffen the joint between the aprons and legs. To further stiffen the legs, he bolted a single stretcher to braces on either end of the base.

No woodworker can resist the temptation to redesign something someone else has built, and I'm no exception. Using Maloof's bench as inspiration, I designed my replica based on readily available tools, parts, and materials and added a few modifications to suit my own woodworking preferences.

Smart Solution

DESIGNING TAPERS

Tapers are tricky because you are working with only a few degrees of angle. Too little taper, and you may have well left the workpiece square. Too much taper and the foot of your leg will be too small. For a workbench, you need a reasonably good size footprint for stability. Let your eye be the guide. Draw the taper lightly on the leg blank with pencil. Try slightly different angles. When it looks right, mark a line. That's all there is to it.

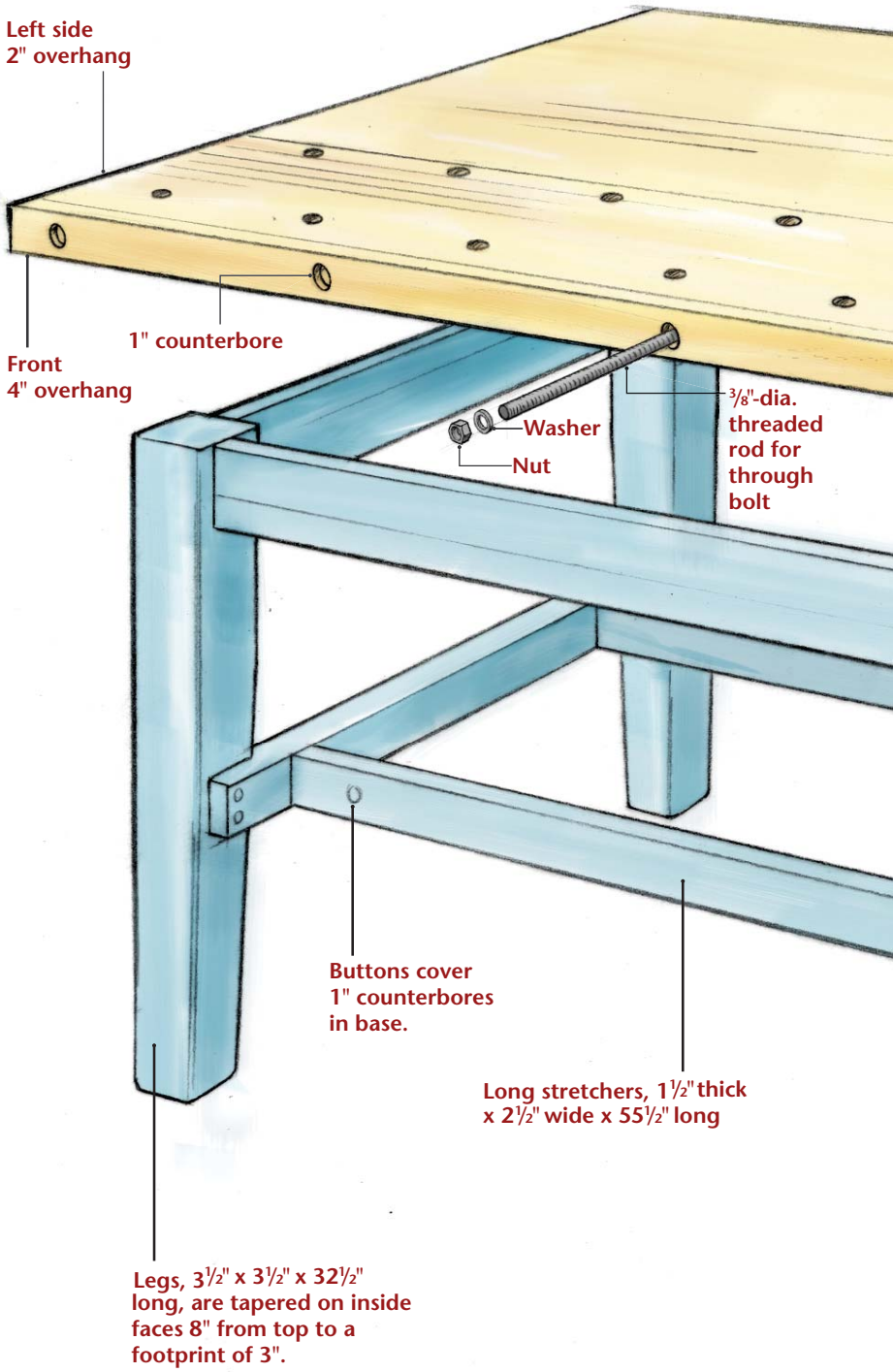
Maloof-Style Bench

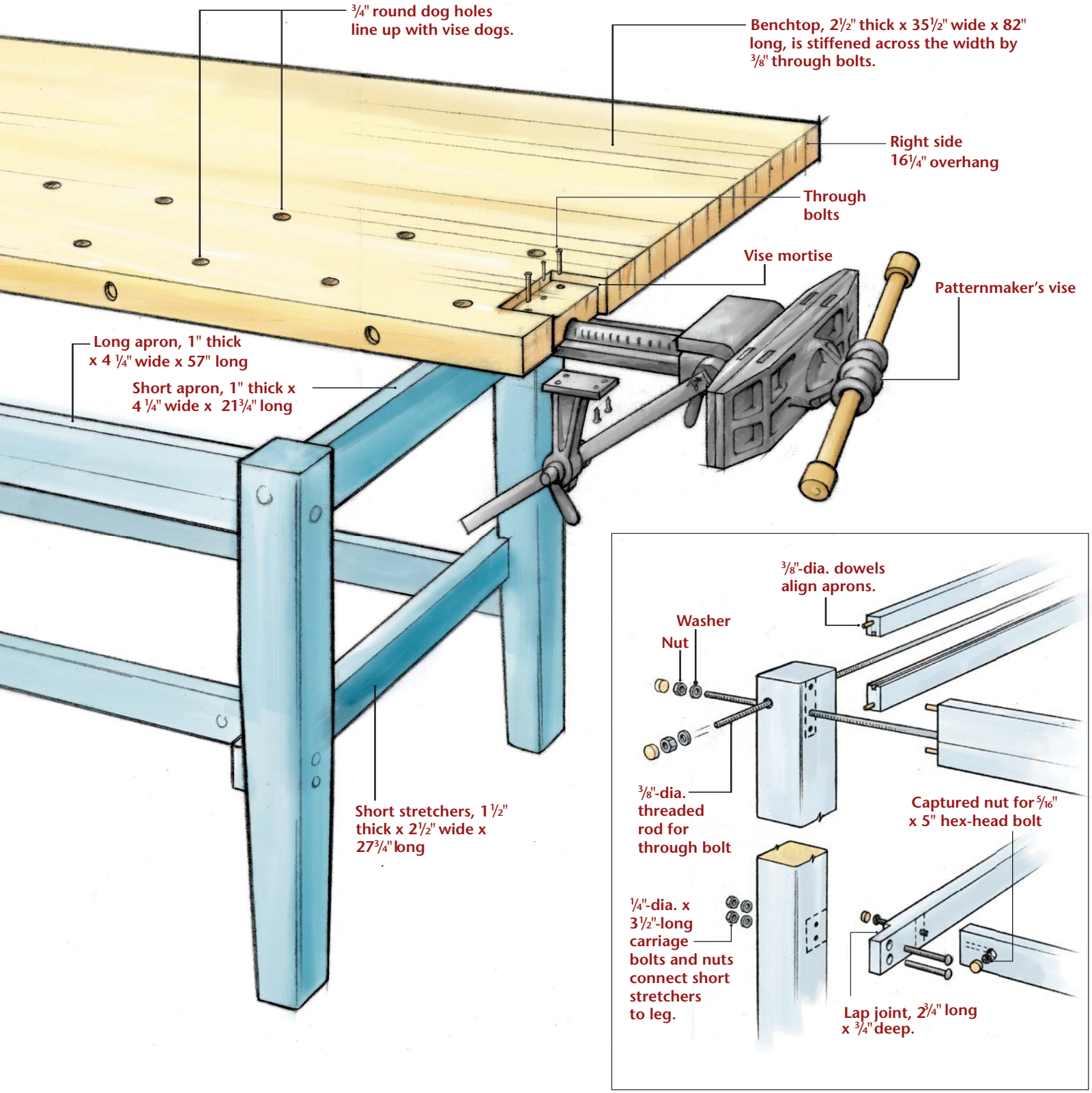
I designed the bench to look like Sam Maloof's, but with a couple of differences. I decided the top should be 2½ in. thick like Maloof's, 36 in. wide, and 82 in. long, built in three separate slabs and through-bolted. I built the base 35 in. high, up several inches from Maloof's, and plan to raise the height even more if I need to by using blocks under the feet. The legs of the original bench are 3¼ in. tapering to 2¾ in. at the foot. To increase the sturdiness of the base, I used a 3½-in. blank and tapered down to 3 in.

I chose to install an imported clone of Maloof's antique Emmert, and mounted it in the same place, the end of the bench on the left side. I drilled ¾-in. round dog holes every six in. along the length of the bench. The two rows of holes line up with the two dogs on the outside jaw of the vise, so it serves as an end vise when I need one.

A workbench is subject to much more wracking forces than a typical kitchen table. As a result, Maloof's bench has become a bit wobbly after a mere 40 years of constant use. So I decided to through bolt the aprons to the legs to stiffen them. Continuous threaded rods are hidden in slots cut into the aprons. By removing plugs hiding the nuts and washers, I can easily tighten or even dismantle the bench base entirely, if need be. I also made the aprons slightly wider (4½ in.), to further stiffen the bench, and added a second lower stretcher on the base to hold a shelf.

Like Maloof, I decided not to finish the top of the bench. Leaving the surface bare gives the top a bit of tooth, or slight roughness, making clamping operations more positive. I painted the base a similar blue green, despite an initial reluctance about covering up all that beautiful maple.




¾" round dog holes line up with vise dogs.
Benchtop, 2½" thick x 35½" wide x 82" long, is stiffened across the width by ⅜" through bolts.
Right side 16¼" overhang
Through bolts
Vise mortise
Patternmaker's vise
Long apron, 1" thick x 4 ¼" wide x 57" long
Short apron, 1" thick x 4 ¼" wide x 21¾" long
Short stretchers, 1½" thick x 2½" wide x 27¾" long
⅜"-dia. dowels align aprons.
Washer
Nut
⅜"-dia. threaded rod for through bolt
Captured nut for 5/16" x 5" hex-head bolt
¼"-dia. x 3½"-long carriage bolts and nuts connect short stretchers to leg.
Lap joint, 2¾" long x ¾" deep.

FOR RIPPING 8/4 MAPLE, use a saw with at least 3 hp and a sharp, clean blade designed for ripping. Next, and very important, are two safety items: a splitter guard and an outfeed table capable of supporting the long end of a heavy board.

THE KEY TO GETTING A FLAT BENCHTOP is aligning the pieces with clamping cauls. First clamp the cauls in place, then squeeze the glue joints together. Remove the clamps in an hour or so, and scrape off the excess glue while it's still soft.

Building the Bench

I decided to build this bench entirely from soft maple. It's readily available in lumberyards, great to work with, and paints beautifully. The soft maple is lighter and less expensive than hard rock maple, but harder and heavier than pine or poplar. I like the idea that the top is slightly softer than most of the wood I work with, cushioning the work just slightly. Like Maloof, I painted the base and left the top unfinished.

I used 1¾-in.-thick boards (8/4 rough dimension). I normally buy my lumber already kiln dried, surfaced, and jointed on one edge so I am able to get right to work ripping the boards to width. I chose boards with end grain as horizontal as possible. When turned on edge, the planks have grain that's very nearly vertical. Most of the expansion and contraction will be in the thickness rather than the width of the bench, making the top more stable.

Building the Top

The top itself is simple to build but will certainly give you lots of exercise. The process consists of four major steps. First, cutting the boards to rough length and width; second, gluing up the boards into manageable segments; third, drilling holes in the segments for the through bolts; and fourth, planing the boards to finish thickness in a portable surface planer. The final assembly uses the top's through bolts for clamps.

Cutting the planks to rough length and width makes them easier to handle and releases the tension in the wide planks. The finished top was to be 82 in. long, so I cut the planks to 85 in. I planed each board just a bit to both renew the surface for gluing and to reduce the thickness so that seven of the boards glued together was just under 12 in. in width. Ripping

the boards to rough width is the next step, in this case to 2⅞ in., ⅜ in. wider than the final thickness of the top. Once they're ripped, I set the boards aside for a couple of days, joint them straight, then rip them again to 2⅝ in., leaving them ⅛ in. oversize.

Gluing the slab with its length of 85 in. and weight of 150 lb. is a daunting task in a small shop. To make it more manageable, I decided to break the construction into three segments, each weighing around 50 lb. I glued-up three slabs, each just less than 12 in. wide, the maximum width my small portable surface planer will handle. When the slabs are each planed down to net thickness, in this case, 2½ in., and cut to length, then the three slabs can be bolted together to form the 36-in.-wide top.

To keep the slab flat and the boards aligned, I use clamping cauls instead of dowels or biscuits. A piece of laminate slightly notched on the bandsaw, like a notched trowel, makes a great glue spreader. I applied clamps wherever it looked like I needed them, judging by the amount of squeeze-out. With yellow glue, each slab needs to stay clamped up for only an hour or so. I took one slab out of clamps, scraped the excess glue while it was still soft, and then clamped up the next slab reusing the same clamps. Using this system I was able to glue up all three slabs the same day.

Planing the slabs to thickness is easier with shop-built infeed and outfeed tables to help support the heavy slabs. I ran each of the three slab segments through the planer, smoothing them on both top and bottom and planing them each to the same 2½-in. thickness.

Preparing for the hardware is best done while the top slab still in its three component sections. The first step is to select the slab that will go on the front of the bench. Then locate and mark the dog holes. The holes must line up with the dogs on the vise and must not be blocked by the legs and aprons. I drilled the ¾-in. holes in the drill press, with shop-rigged support.

THOUGH IT'S HEAVY ENOUGH TO NEED SUPPORTS, drilling the dog holes in a single segment of the benchtop with the drill press is much easier than trying to do so after the benchtop is assembled.

Smart Solution

CLAMPING CAULS

By clamping the pieces between sets of cauls above and below the slab every foot or so along the length of the glue-up, the individual boards stay in very close alignment. I apply as much clamp pressure to the caul clamps as I need to flatten the slab and only then apply cross pressure to the glue joints. Scraps of the 8/4 maple, 1¾ in. by 1¾ in. by 12 in. long make strong cauls. On the side of the caul against the glue joints, I applied slick cellophane tape, which allows the boards to slide together easily and keeps the cauls from sticking to the slab.

THIS SIMPLE JIG, clamped in place, guides the drill bit so it starts straight. The block was drilled in the drill press and milled to the same thickness as the benchtop. Lay out the holes carefully, and drill from each side to meet in the middle.

AFTER MARKING OUT THE TAPER, I cut it freehand on the bandsaw. I left the top 6 in. straight so the aprons would butt to the legs. I smoothed the bandsaw cuts with a belt sander.

I RIPPED THE APRON MATERIAL IN TWO, ½-in. from the center. Then, to create a dado, I milled a ½-in.-wide by ¼-in.-deep slot. I glued the two pieces back together, forming a ½-in. square hole the length of the apron to house the full-length bolt.

On the outside edges, I drilled 1-in. counterbored holes for the nuts and washers. Positioning my first through bolt 4 in. from the end of the top to allow for the vise mortise, I drilled the holes from the edge in toward the middle on each slab, meeting in the center. Drilling the bolt holes ½ in. in diameter allows plenty of clearance for the ⅜-in. thread rod.

Assembling the top is straightforward using the gluing cauls to align the three segments, and the through bolts to do the actual clamping. I used only four small dots of glue between each segment, just to keep the slabs aligned. If I want to resurface the bench, I can easily separate the three slabs and plane them in my portable planer. I used winding sticks and a straightedge to make sure the top was dead flat with no twist. An hour spent detailing the top with a belt sander finished the job for me, but you might be more comfortable using a handplane instead.

Building the Base

The leg blanks are two layers of 8/4 face-glued soft maple milled into a 3½-in. square by 32½ in. long. I laid out the tapers, then used a bandsaw to make the actual cuts. Only the inside faces of the legs are tapered. I left the upper 8 in. straight and tapered from there down to 3 in. at the foot. A belt sander quickly smoothes the faces, but a sharp handplane or hand scraper will work as well. I finished up the edges by routing with a ½-in.-radius bit.

The aprons connect to the legs and serve as points of attachment for the top. I rough cut the apron material to 4½ in. wide and planed it to 1 in. thick to match Maloof's bench. Then I ripped the aprons into two pieces, ½ in. off the

center, to facilitate cutting the slots for the bolts. The bolts in the side and end aprons have to be offset because they both go through the legs. By orienting the end and side aprons differently, the bolts have clearance to bypass one another as they extend through the legs.

Using a dado cutter, I cut slots ½ in. wide by ¼ in. deep in the edge of each of the two halves of the apron, creating a hollow slot ½ in. square down the length of the apron. Then I glued the two halves of the apron back together, using cauls just like I did with the top. I carefully sanded the aprons once the glue cured.

Two dowels on each end of the aprons keep them aligned. It was a simple matter to drill holes in the legs and aprons to accept the dowel pins. I glued the dowels only into the aprons and drilled the holes in the legs slightly oversize.

Final Assembly When the bolts were tightened with a ratchet, the base was very solid. I plugged the holes with wooden buttons. Maloof used ¼-in. carriage bolts to attach the lower stretcher to the legs, so I did the same.

I attached the base to the benchtop with only two ⅝-in. lag bolts, one at each end running up through blocks bolted to the inside of the end aprons. Because the bolts attach the top only at the center, any expansion or contraction of the top throughout the seasons is unrestricted.

Installing the Vise

Mounting the vise is pretty straightforward, as long as you follow the instructions that come with it. There's a fair amount of material to remove from the benchtop to accommodate the vise mechanism. There's a sizable cylindrical hub and square beam below the top and a mounting plate that attaches the vise to the upper surface of the bench. The vise comes with patterns to assist with marking out the locations of the various mortises.

LIKE MALOOF, I used ¼-in. carriage bolts to attach the stretchers to the legs. I wanted a slightly cleaner look so, I counterbored holes for button plugs to hide the nuts. It's awfully nice to have a bench to build the bench on. My rolling shop cart fills in for the role of bench.

WHEN INSTALLING THE PATTERNMAKER'S VISE, there is a lot of material to remove to make room for the mechanism on the underside of the benchtop. I did as much as I could with saws and routers first; then removed the rest with chisels and scrapers.

Niall Barrett's Bench

Like many woodworkers, Niall Barrett put off building his perfect bench until he could decide exactly what it should be. For 29 years, the tantalizing image of the "traditional cabinetmaker's bench" danced in his head. Finally, he decided that the dream, however alluring, did not really fit his needs. For one thing, he simply didn't have the time to build a traditional bench with shopmade vises. As a professional woodworker, he needed to devote his valuable shop time to making custom furniture. But even more important was coming to terms with the size of his shop and the way he does woodworking.

Both power tools and hand tools have a place in Barrett's woodworking, without any real preference for one set of methods or the other. He does his layout and portions of the joinery and assembly of every project at the bench. He likes to work on all sides of the bench, so it needed to be freestanding and an appropriate size for his shop.

A Tradition of Simplicity

Barrett's bench is a perfect example of how the bench that a woodworker uses while learning influences his or her notion of the "perfect" bench. While looking for inspiration for this bench, Barrett remembered a bench design by Ian Kirby, who had trained in England. As it happened, Barrett first learned woodworking while growing up in Ireland. The large, double-sided benches of Barrett's student days had much in common with Kirby's bench design, for example, the pop-up bench stop and no end vise.

Trained to work without bench dogs or an end vise, Barrett decided he didn't need them. Although the Record vise he recycled from his previous bench has a bench dog accessory,

BEAUTIFUL, FUNCTIONAL, AND SIMPLE TO BUILD, the Niall Barrett bench is the result of 20 years of contemplation. Not only does it fit Barrett's shop and the way he likes to work, but it used up a pile of 8/4 cherry for a project he actually gets to keep and use.

Barrett didn't cut corresponding dog holes. Instead, he built some traditional accessories to hold the work, like a pop-up stop and a bench hook. The pop-up bench stop stows away when not in use but can be raised to any height required by the thickness of the stock being planed. A panel stop butted against the end stop and clamped in the front vise holds wider work for planing. For crosscutting stock, Barrett uses a traditional bench hook. When they're not needed, the accessories conveniently slip over the base stretchers of the bench, out of the way but close at hand.

Hardware Speeds Construction

The base relies on sturdy legs, wide aprons, and 1¼-in.-thick rails for rigidity. Speeding the building process was Barrett's main reason for using hardware instead of traditional joinery to join the base components. But this method provides several additional benefits. The base can be completely dissembled for moving or storage. The single-bolt construction minimizes potential problems with wood movement. If seasonal humidity changes cause the base to loosen, a few quick turns of a wrench can tighten it.

The top is connected to the base with ⅜-in. by 4-in. lag bolts installed through oversize holes, to allow for wood movement. By loosening the bolts, Barrett can easily remove the top for resurfacing when necessary.

THE ADJUSTABLE POP-UP STOP is all Barrett needs to hold a board for handplaning. He can flip the board around quickly to reposition it or change direction without having to fumble with clamps or hold-downs.

WHEN PLANING A WIDE PANEL Barrett uses his bench stop. One of the reasons he positioned his vise where he did was to facilitate using this simple device. With the stop in place, he can plane anywhere across the width of the board.

Niall Barrett's Bench

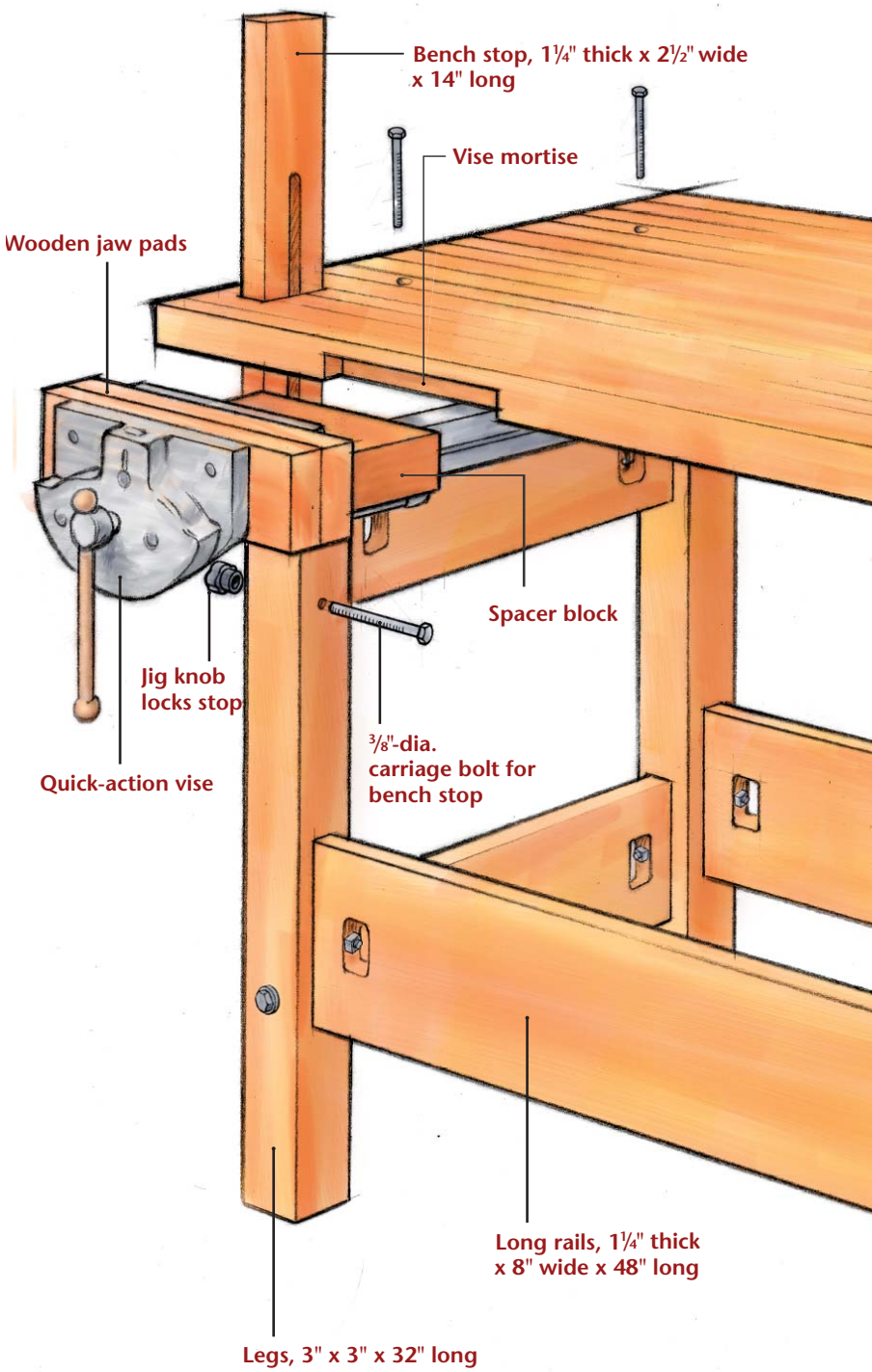
The design of this bench demonstrates how professional woodworkers use smart strategies to save time. Standardizing the size of parts and using the same tools and technique to cut all the bolt-access holes means fewer setups. The result is a very sturdy bench that's very efficient and quick to build.

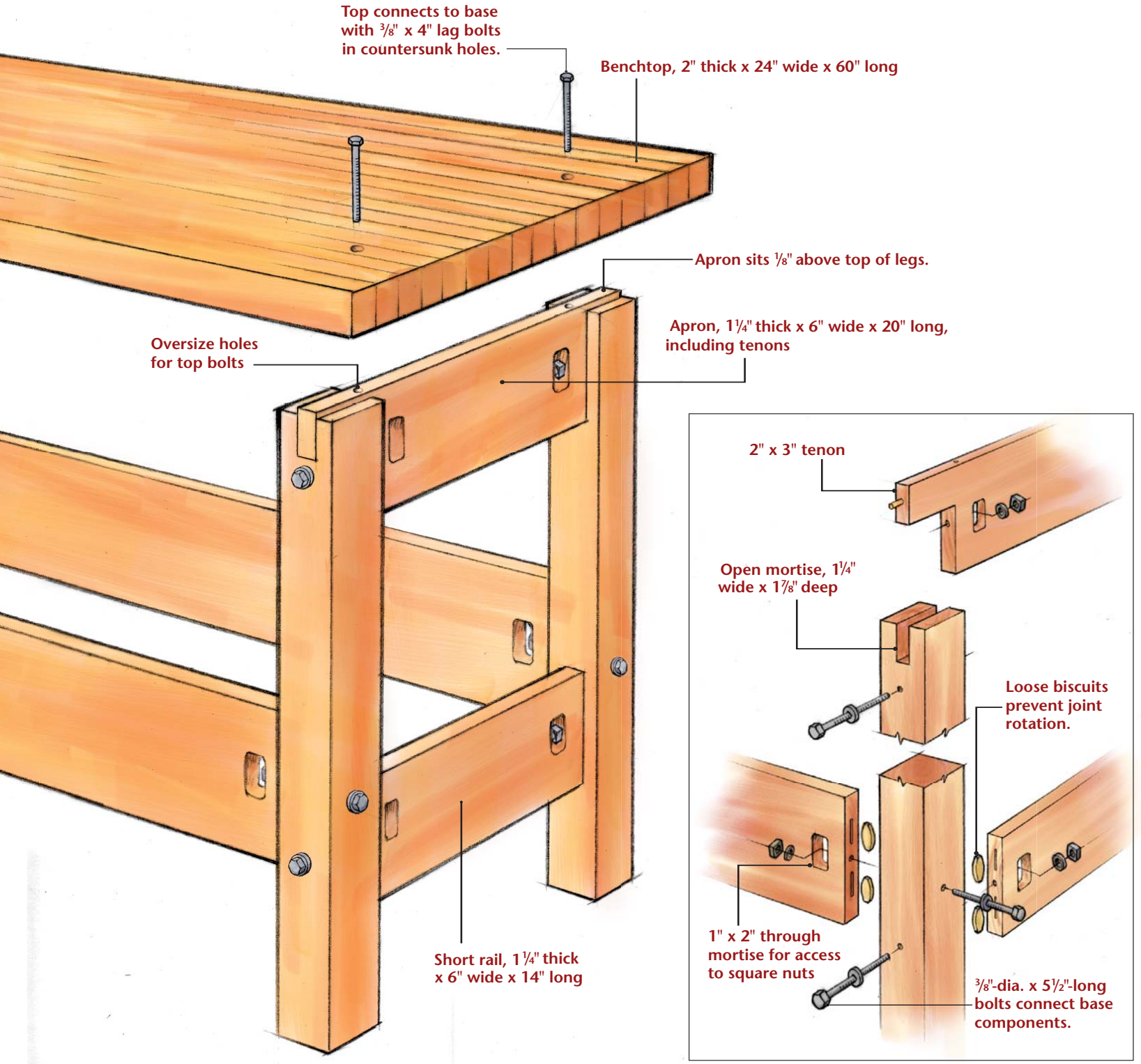
Barrett originally thought he wanted a large benchtop, but ended up with a relatively compact one. The top is just 60 in. long by 24½ in. wide, large enough to hold most workpieces for layout, joinery, and assembly and small enough to fit neatly in his shop. The standard bench height of 34 in. is comfortable for him.

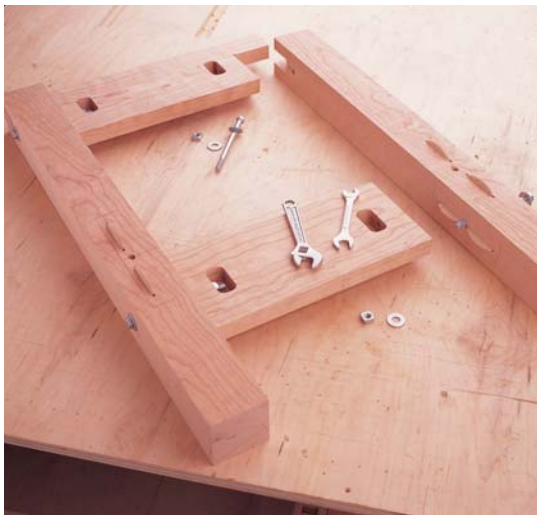
Barrett used readily available materials, including a scavenged vise. All of the structural components are solid wood. When he decided to build the bench, the only 8/4 stock Barrett had on hand was prime cherry, an extravagance that yielded handsome results. The top is built from 8/4 flatsawn stock ripped into strips and turned on edge to achieve a more stable quartersawn grain orientation in the slab.

Barrett wanted a sturdier base than in the original Ian Kirby design, so he used wider aprons and rails. To speed construction, he used butt joints reinforced with through bolts and loose biscuits instead of traditional wedged tenons.

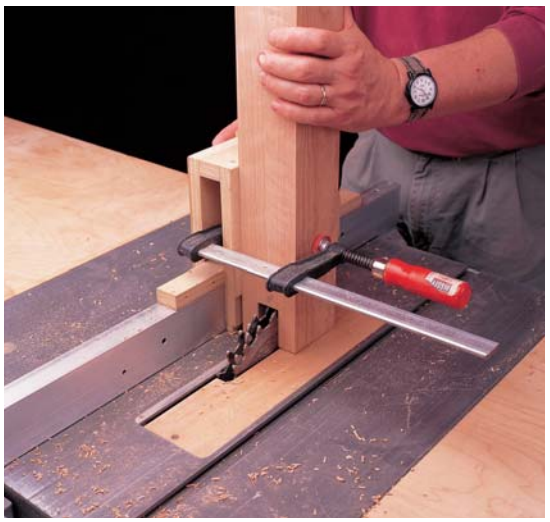
The legs of the base are straight rather than a sled-foot style, because Barrett thinks straight legs provide better contact with the floor. An apron and a rail connect the legs at each end. A notch in the top of the apron fits into a slip joint cut into the tops of the legs. Wide front and back rails hold the two end assemblies together. Access holes, cut with a router and template, provide wrench space for the square nuts when tightening the bolts. Dry (not-glued) biscuits prevent rotation of the rails around the bolts.



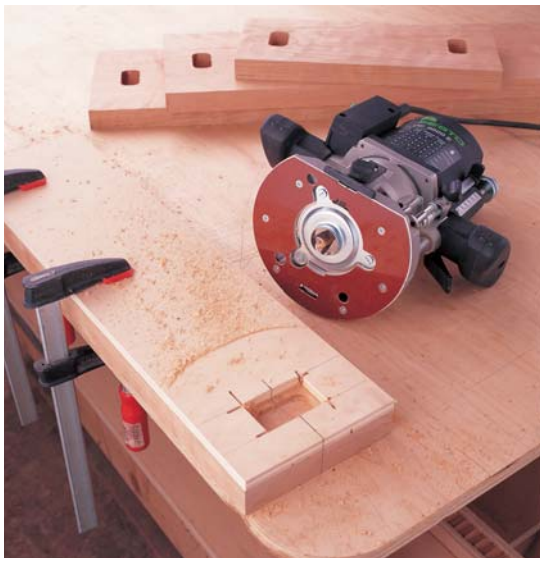

Top connects to base with ⅜" x 4" lag bolts in countersunk holes.
Benchtop, 2" thick x 24" wide x 60" long
Apron sits ⅛" above top of legs.
Apron, 1¼" thick x 6" wide x 20" long, including tenons
Oversize holes for top bolts
Short rail, 1¼" thick x 6" wide x 14" long
2" x 3" tenon
Open mortise, 1¼" wide x 1⅞" deep
Loose biscuits prevent joint rotation.
1" x 2" through mortise for access to square nuts
⅜"-dia. x 5½"-long bolts connect base components.



BY CUTTING A SLOT IN THE TOP OF EACH LEG and then notching out the end of the aprons, Barrett made a very simple but incredibly strong joint to connect the aprons to the legs and, in turn, attach the top.



BARRETT CUT THE SLOTS IN THE TOPS OF THE LEGS by making two passes over a ¾-in. dado blade on the table saw. He used a jig that rides on the rip fence to hold the leg square and upright during the cut.



BARRETT MADE A SINGLE JIG to cut all of the access holes for the nuts. He used a pattern guide bushing on a plunge router, cutting the holes in each piece with a straight bit.

Building the Bench

Barrett considers 2 in. to be the minimum thickness for a benchtop. He began with 8/4 flatsawn stock, longer than the final 60-in. length, and ripped it into 2¼-in.-wide pieces to expose the quartersawn faces. He jointed and thicknessed the planks into strips 1¾ in. by 2⅛ in.

To make gluing up the slab more manageable, Barrett glued the strips together into several segments. After the segments were joined and the glue had dried, he sanded the top flat with a stationary drum sander. The final steps in building the top were trimming the ends and then squaring the four sides to one another and to the top surface.

Making the Base

The base is connected at the ends by two aprons under the benchtop and two rails mounted about 6 in. off of the floor The aprons have simple tenons the full thickness of the stock, which fit into open mortises cut into the tops of the leg.

The legs begin as blanks made from two pieces of 8/4 stock face-glued and then milled to 3 in. sq. Barrett cut the slot at the top of each leg on the table saw, using a dado head and a shop-made jig that rides on the rip fence.

The aprons and rails are 6/4 stock thicknessed to 1¼ in. The aprons and end rails are 6 in. wide, and the aprons are 20 in. long, including the tenons. To cut the tenons, Barrett used a bandsaw, removing a 4-in.-high by 3-in.-deep piece from the bottom corners of each apron. The end rail is 6 in. by 14 in. long. The 48-in.-long rails are 8 in. wide to provide additional rigidity. Both the long and short rails are joined to the legs in the same manner, using through bolts and square nuts.

The access holes for the square nuts are 1 in. by 2 in. Barrett cut them with a router using a template bushing guided by a shopmade pattern. Then he drilled ⅜-in. holes from the outside faces of the legs to intersect the access holes for the nuts.

Barrett assembled the base so that he could check that all the parts were square to one another and then marked their locations. Then he took it apart again to cut the biscuit slots in the legs and rails. All the base components were finish-sanded before final assembly. Barrett inserted the biscuits without glue and reassembled the two ends using ⅜-in. by 5½-in. bolts with washers at both ends. Finally, he joined the ends to the two long rails.

Installing the Vise

Barrett located the vise on the front of the bench 11 in. from the end he planned for the bench stop. Mounting the vise required a filler block to hold it at the correct height.

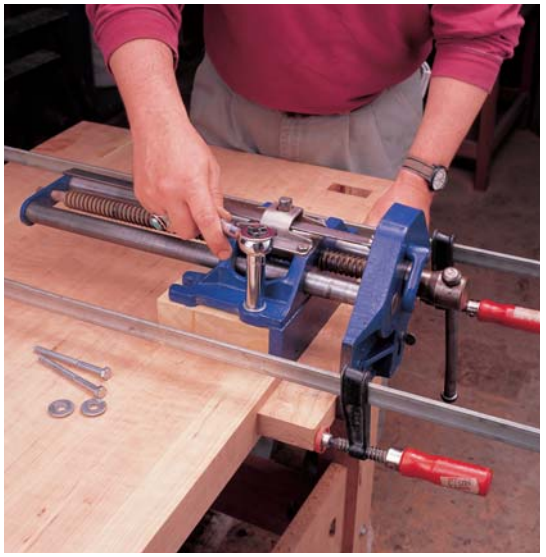
He added wooden pads to the vise slightly higher than the metal tops of the jaws. The rear wooden pad is proud of the front edge of the bench, with the metal rear jaw set flush with the edge. He used a router and template guide to create the mortise for the rear jaw of the vise. Once the vise was correctly positioned in the mortise, a clamp held it in position so that it could be connected through the block into the benchtop with ⅜-in. by 4-in. lag bolts.

Making the Stop

The mortise for the stop can be cut using a template and plunge router and then squared with a chisel. The stop itself is a piece of stock cut slightly oversize and then planed to fit the mortise. It should move freely through the mortise without play. A slot on the bottom end slides up and down on a carriage bolt, which runs through the leg. Turning a threaded jig knob tightens the stop after it is raised to the desired position.

BARRETT PREASSEMBLED THE BASE, marked the location of each piece, then dismantled it again. He marked out the locations for each biscuit slot based on the actual position of the piece.

TO HAVE THE WOODEN VISE JAWS THE WAY HE WANTED them, Barrett routed a mortise for the rear jaw. Then he screwed the wooden rear jaw in place against the front edge.



ONCE THE VISE WAS POSITIONED AND HELD IN PLACE WITH CLAMPS, Barrett drilled through the spacer block and into the benchtop for the lag bolts that fasten the vise to the bench.


Belt Sander

8

Tradition Meets the Twenty-First Century

MARQUETRY SPECIALIST PAUL SCHURCH makes a lot of woodworkers nervous when he sands off glue tape with a large belt sander. Having the panel held securely with the traditional bench dogs is, if anything, even more important than if he were using a hand tool.

If you were trained on a traditional bench and especially if you have a fondness for hand tools, your "perfect" bench will probably be classic in configuration. But as a woodworker in the new century, you have options that simply didn't exist when traditional benches evolved. Today we commonly use power tools for speed and efficiency. There are modern materials and innovative hardware that can make even the most traditional-style bench quicker and more economical to build.

In many ways, the traditional workbench is as relevant as ever. Using a router or belt sander requires a sturdy surface with effective holding devices. Traditional tail vises and shoulder vises continue to be popular because they work.

This chapter looks at some workbenches that have their roots in the past but don't hide the fact that woodworking has most certainly changed over the last several centuries. If you are dreaming of a traditional workbench, you can build it exactly to a time-honored design or you can incorporate features that will make the bench even more versatile.

English-Style Workbenches

What exactly is a traditional bench? The answer largely depends on the part of the world where the bench design originated. Although some woodworkers practice Japanese-style woodworking using simple beams for workbenches, most of the benches that have gained popularity in the New World have their roots in Europe.

European immigrants either brought their benches with them or built benches like the ones they used back home. German, Scandinavian, French, and English colonists had similar benches, but those benches differed in important respects. German and Scandinavian benches show a preference for shoulder vises. Eighteenth-century French benches used bench stops, side hooks, and holdfasts to hold the work and only rarely used vises.

Distinctive Features

Early colonists from England were accustomed to using a bench that had a wide apron with many round holes for holding pegs at various heights and distances from the vise. This very tall front apron was distinctively British. It supported long boards for edge planing. Holdfasts sometimes substituted for pegs and held boards more positively against the front apron than simple pegs.

A wide front vise held stock for joinery and edge planing. In the colonial era, most of these

EARLY COLONISTS from different regions in Europe each had different notions of how a workbench ought to look. The wide front vise on Garrett Hack's bench suggests an English heritage.

vises operated on one screw. Some historical examples have two screws, including the one from which Mike Dunbar took his inspiration. The double-screw version had two advantages. Both screws tightened at the same depth could prevent the wracking common with single-screw vises. And if the screws were tightened to different depths, they could hold nonparallel stock.

A Versatile Hybrid

While Mike Dunbar's bench shows some elements of the earliest English-style benches, there are practical adaptations that make it more useful for his woodworking. In the greatest departure from the traditional English bench, Dunbar's bench has *no* aprons. For edge planing, he clamps the stock in the wide front vise. More than 4½ ft. in width, it can securely hold a 6-ft. board without additional support. The vise operates on double wooden screws mounted through the heavy front plank of the benchtop. Wide boards can easily be clamped upright between the two screws.

Bench dogs and tail vises were unusual in colonial-era English-style benches, but the original that Dunbar copied and that dates back to this era did have simple dogs. Dunbar made wooden dogs for each of the dog holes so that he doesn't have to move them for holding different size stock. The dogs have a slight taper planed into one face. Tapped in from below, narrow side up, they sit flush to the bench surface until needed.

THE TALL FRONT APRON WITH ITS DIAGONAL HOLE PATTERN is typical of English-style benches in use around the time of the American Revolution. Pegs inserted into one of the holes support the long end of a board of just about any common width or length.

MIKE DUNBAR'S BENCH would be quite familiar to the eighteenth-century woodworker who built the 200-year-old original Dunbar used as a model. Dunbar's bench, at over 8 ft. long, has plenty of room for the front vise, which is almost 5 ft. wide.

DUNBAR'S BENCH uses low-tech dogs fashioned after the ones he found on the original bench. They are ⅞ sq. in. and slightly tapered. He taps them up tightening them in their holes as they project above the benchtop.

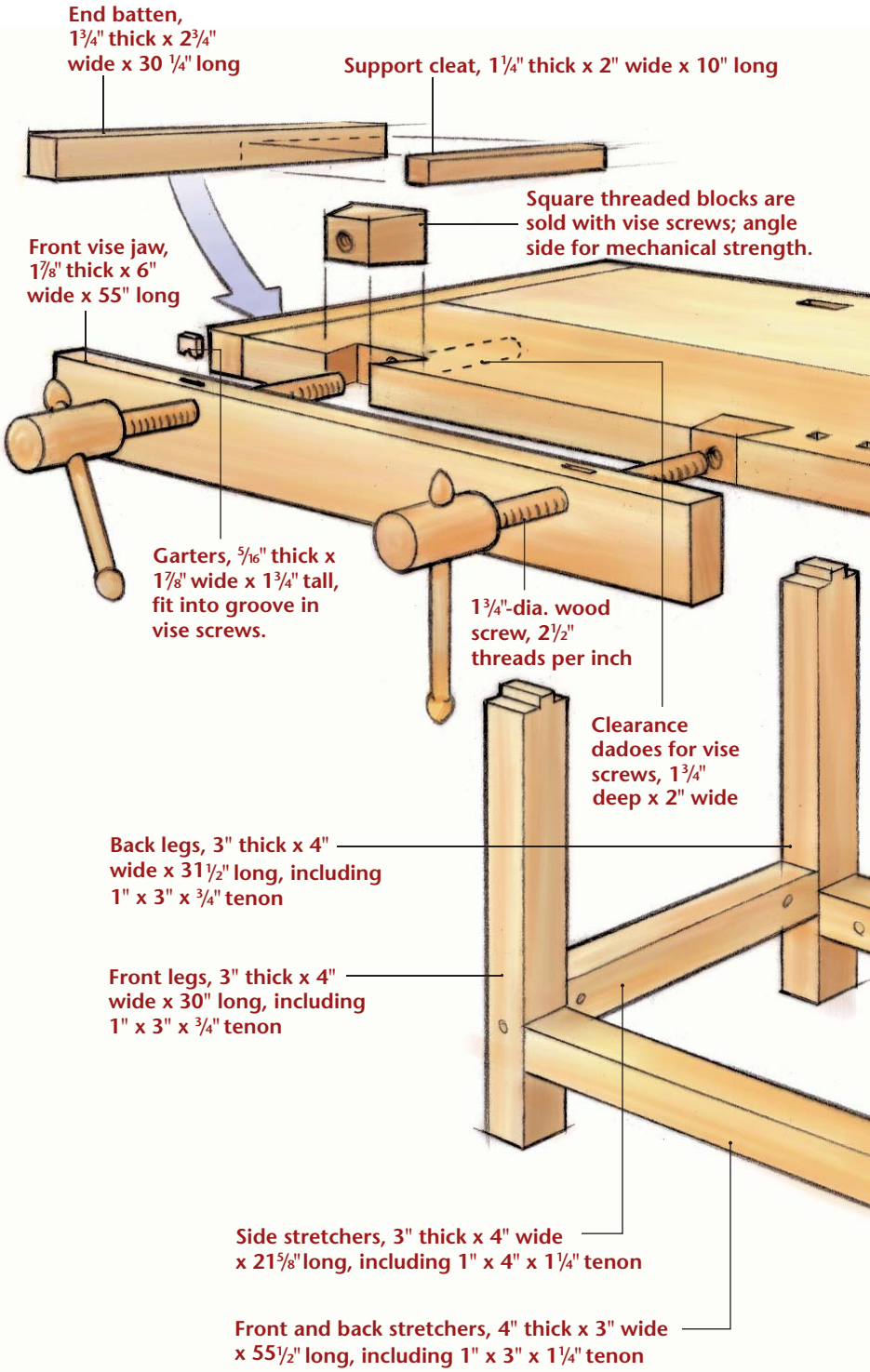
Dunbar's Bench

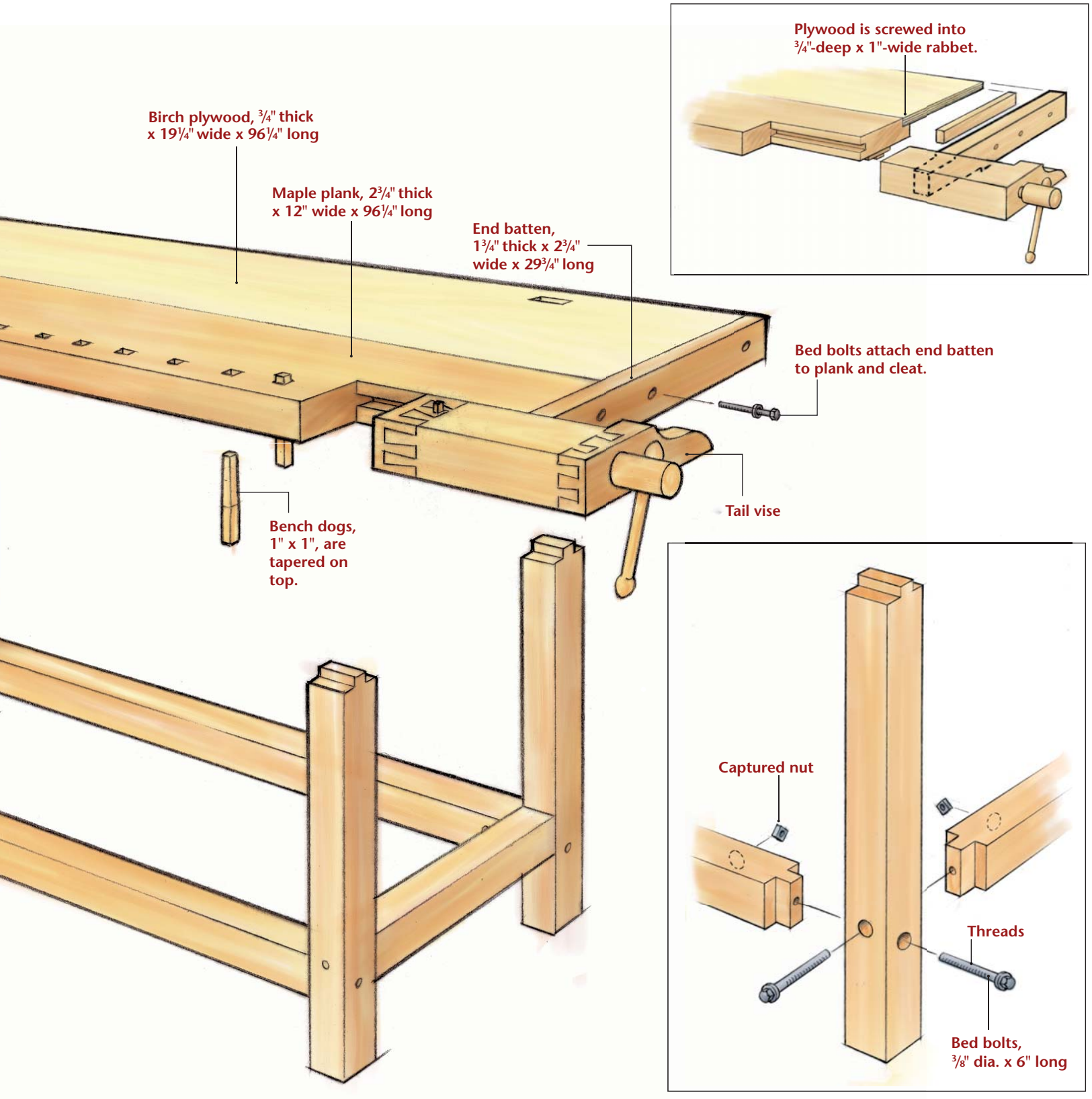
Windsor-chair maker Mike Dunbar made a name for himself practicing and teaching traditional woodworking. His bench and its construction mirror the paradox of being a woodworker who lives in the twenty-first century but whose heart is in the eighteenth.

This bench takes its inspiration from an original, discovered in the basement of a mansion, that dates back to the 1700s. The wide front vise could hardly be distinguished from similar vises centuries old. Less typical are the double screws that help minimize wracking. Although steel screws would have worked just as well, Dunbar chose wooden screws for the front and tail vises. Some vises from the period required the user to pull the front vise jaw backward after loosening the screws. Dunbar added wooden garters that mate with a groove in the screws to keep the jaw and screws moving together.

From a distance, this bench looks and functions like one centuries old, belying the manner in which it was actually built. The bench has mortised base stretchers, but instead of traditional wedged joints, Dunbar used bed bolts so the base can be easily knocked down or tightened. The top has a wide, 3-in.-thick plank of solid wood on the front side that will take pounding. But the remainder of the top surface, where it gets little use, is a mainstay of a modern woodworking shop—¾-in. birch plywood.

Dunbar's skill with a handheld circular saw saved him many hours of work roughing out mortises for the vise nuts and screws. He used a bandsaw to cut the stretcher tenons and an electric surface planer to smooth the plank for the top.




Plywood is screwed into ¾"-deep x 1"-wide rabbet.
Birch plywood, ¾" thick x 19¼" wide x 96¼" long
Maple plank, 2¾" thick x 12" wide x 96¼" long
End batten, 1¾" thick x 2¾" wide x 29¾" long
Bed bolts attach end batten to plank and cleat.
Tail vise
Bench dogs, 1" x 1", are tapered on top.
Captured nut
Threads
Bed bolts, ⅜" dia. x 6" long

HAND-TOOL SPECIALIST DUNBAR is right at home chiseling out a mortise. He first removed most of the waste with a drill bit, leaving only a small amount to trim by hand.

DUNBAR CUT the shoulders of the stretcher tenons with a portable circular saw set to the correct depth.

ESSENTIALLY DONE FREEHAND, the cut on the cheeks isn't as critical as the shoulders, since the bed bolt does most of the work of keeping the stretcher to leg joint solid.

Building the Bench

When selecting materials for the bench, Dunbar chose locally available hardwoods. Yellow birch is cheaper than maple where he lives but is unavailable above 10/4 rough thickness. So he used maple for the thicker components and birch for parts 2 in. or less in thickness. He ordered the three bench screws with mating blocks from Crystal Creek Mill (see Resources on p. 196). For connecting the base stretchers to the legs, he used bed bolts, which are available from a variety of woodworking retailers.

Building the Base

While most bench builders start with the top, Dunbar built and assembled the base first. This allowed him to use the base itself to locate the mortises in the top precisely.

The legs are a massive 4 sq. in. to provide stability and weight to the base. Because the ¾-in. plywood insert at the rear of the bench is thinner than the 3-in.-thick front slab, the rear legs are longer than those in the front. The tops of the all the legs are tenoned to fit into mortises in the benchtop. On the rear of the bench, the tenon comes all the way through a mortise in the plywood insert, whereas the front leg mortises go only part way through the thicker front slab.

Stretcher joinery is simple mortise and tenons with bed bolts through the tenons. The long stretchers are 6 in. off the floor, and the end stretchers are 8 in. off the floor. Dunbar

BECAUSE THE PLANK WAS TOO WIDE to flatten the faces on the jointer, Dunbar used his planer.

DUNBAR WAS CAREFUL to lay out the dog holes so that the dogs would not interfere with the front vise screws. He chopped them by hand with a chisel and mallet.

DUNBAR CUT THE ANGLES for the front vise blocks with a circular saw. The dovetailed shape gives the block greater holding power in the bench plank.

removed most the waste from the leg mortises with a drill, then squared up the mortise with a sharp chisel. A hole drilled into the inside face of each stretcher holds the nut. When the bolt is tightened with a special wrench, the nut digs into the wood, which prevents it from rotating.

Dunbar found a circular saw handy for cutting the shoulders on the stretcher tenons. He set the sawblade to the depth of the shoulder and then cut it freehand. A less confident woodworker might benefit from a fence clamped to the stretcher at a right angle to ensure that the cut comes out square. The bandsaw made quick work of the tenon cheeks. When cutting the long stretcher, Dunbar found infeed support at the back end provided more control during this operation.

Building the Top

The top consists of plywood for the rear, bolted end caps to hold the sections of the benchtop together, and a 3-in.-thick by 12-in.-wide plank in the front of the bench. This front is the area of the bench that will take the most pounding in joinery operations and endure the most stress from the vises and bench dogs.

The front plank is 3 in. thick to provide a strong solid area for mounting both vises. The 12-in.-wide plank in Dunbar's bench was too wide to fit on his jointer, so he flattened it on his planer. After taking a few light passes on the domed side, he took a few on the concave side to provide flat reference surfaces. Flipping the board again, he finished surfacing the top.

The next step was to lay out the leg mortises in the bottom of the plank using the base to position them. Shims helped level the rear legs. A drill removed most of the waste from the

mortises and the sides were squared with a chisel. Dunbar then routed a rabbet on the top rear edge of the plank to act as a shelf to hold the plywood panel. He cut the dog holes by drilling out the waste and squaring up the mortises with a chisel.

Preparing for the front vise required cutting angled mortises for the threaded nuts and clearance channels for the screws in the underside of the top plank. The threaded block is square as it arrives from the supplier, but a dovetail shape provides better purchase. Dunbar reshaped the block so that its smaller end is at the front of the vise. He used the reshaped block to lay out the mortise. Then he roughed out the mortise with a circular saw and finished it with a chisel. He also used a circular saw to rough out the clearance channels for the two vise screws.

THE SLOT IS THE MAIN GUIDE FOR THE TAIL VISE, so it has to be exact or the vise will bind as it moves. Dunbar used an auxiliary wooden base on a router, with guide blocks riding each side of the bench plank to make sure the cut was precise.

The tail vise operates in a 4⅞-in.-deep by 17-in.-long notch cut out of the right front end of the plank. A circular saw cut through most of the stock, but Dunbar used a handsaw to finish the corner. It is essential that the cuts be square, because the tail vise operates in this notch. The final step in cutting the notch was to rout the long groove for the tail vise guide. Dunbar finished the groove with a sharp chisel.

The end caps do more than just hold the top assembly together. On the tail vise end of the bench, the threaded block for the vise screw must be joined to the end cap (see "Building the Tail Vise" on p. 151). The end cap on the left side is simply a piece of stock with a support cleat screwed to the back. Bed bolts connect the end caps to the plank. Dunbar screwed the plywood to the end cap and to the rabbet that supports the plywood along the length of the plank.

DUNBAR EXTENDED the useful width of his bench with plywood. He attached it to the end cleats and the front plank with screws.

Constructing the Front Vise

Dunbar made the front jaw from 8/4 birch. He drilled two holes in the jaw for the two vise screws. A thin piece of wood called a garter mates with a groove in the vise screw to open and close the vise. It's made from 5/16-in. hardwood stock, slightly oversize in length so that it can be withdrawn to adjust the fit. Dunbar cut slots in the top of the jaw over each vise screw. Before gluing the garters in place, he turned the screws to make sure the garters weren't rubbing too tightly.

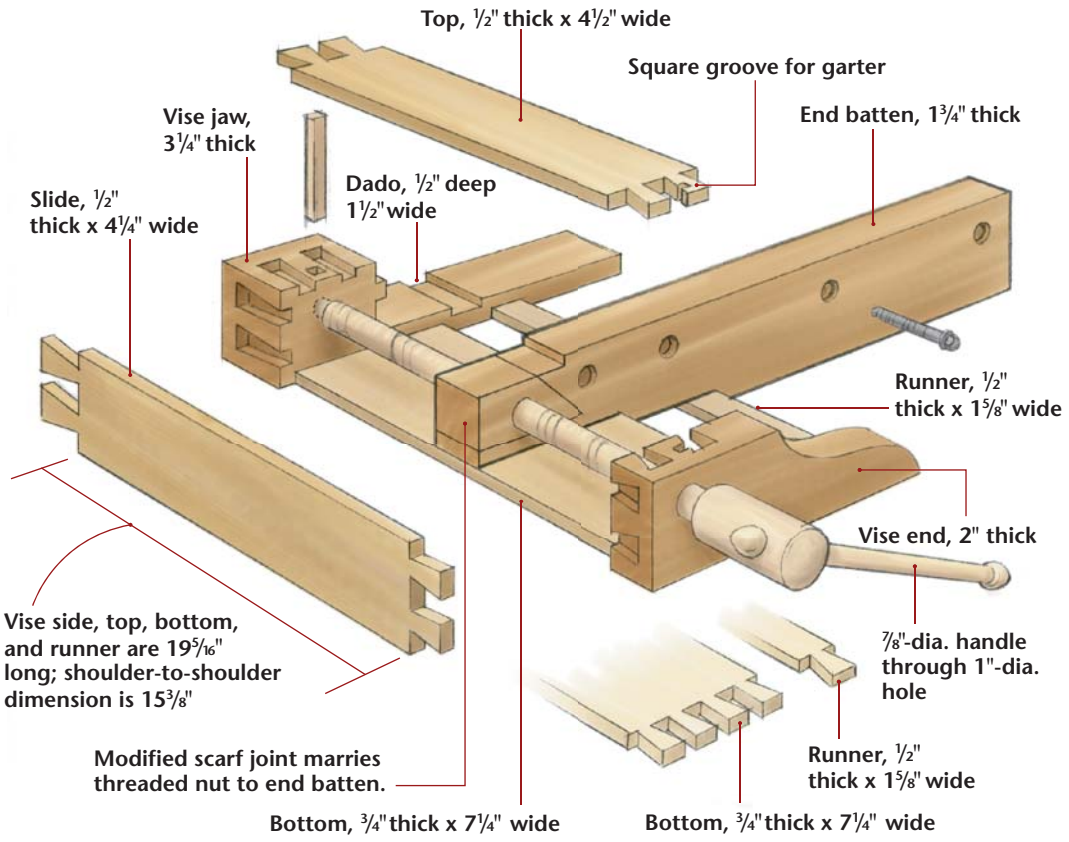
Building the Tail Vise

Tail vise construction and installation are undoubtedly the most challenging part of this project. To move the tail vise, the wooden screw must engage threads in the end cap. Dunbar chose to join the threaded block supplied with the vise screw to the end cap using a modified scarf joint.

Although there is some complicated joinery in this vise, basically it is a three-side box closed at each end. And Dunbar admits that the ogee detail on the end of the vise is more decorative than functional. The half-blind dovetail joinery requires careful layout and some patience. He recommends dry-assembling the parts and testing the action before final glue-up and installation.

GARTERS RIDE IN THE GROOVES milled into each of the screws. Their purpose is to open the jaw when the woodworker rotates the screw counterclockwise. They fit into mortises Dunbar cut into the top of the vise jaw above each screw.

Dunbar Tail Vise



THE CONSTRUCTION OF TAGE FRID'S BENCH was featured in one of the early issues of *Fine Woodworking* magazine. Thousands of benches like it, built by enthusiasts inspired by Frid's article, grace shops across the woodworking world. For many, the shoulder vise–tail vise combination defines what a "real" workbench looks like.

European Traditions

If asked to sketch a workbench on the back of an envelope, northern European–trained woodworkers would illustrate a design that is now classic. This style of workbench has a tail vise on the right and shoulder vise on the left, a narrow top, a single row of dogs, and a tool tray. The base is wider on the left than it is on the right to support the peninsula-like shoulder vise mechanism, using two wide stretchers located midway up the legs to keep the bench from wracking.

WHAT REALLY SETS THE CLASSIC EUROPEAN BENCH apart is its shoulder vise. Unlike any other vise, there are no guide bars to interfere with clamping.

A Popular Classic

The popularity of the European-style woodworking bench is largely due to the influence of three prominent woodworkers: Tage Frid, James Krenov, and Frank Klausz. Something they share is a northern European woodworking heritage. Frid came from Denmark and Krenov, from Hungary; and both learned their craft in an arduous apprentice program. Krausz, originally from Siberia, studied and worked in Sweden before moving to California.

These men, masters of their trade, authors, and teachers, have influenced generations of woodworkers. Besides the hundreds of benches Frid and his students built at Rochester Institute of Technology and later at the Rhode Island School of Design, thousands more were built as a result of his 1976 article in *Fine Woodworking* and the plans published in 1984. Krenov has taught many hundreds of students through his cabinetmaking program at the College of the Redwoods. Klausz's bench, often shown at

woodworking shows, has become something of a celebrity in its own right. Given all that exposure, is it any wonder that for many woodworkers, this style is the "proper" bench?

Versatile Features

The most distinctive part of the European cabinetmaker's bench is the shoulder vise. The vise jaw can swivel on a ball-and-socket joint, which enables clamping of angled and irregularly shaped work. Even more valuable is its ability to hold wide pieces without the interference of the screw or guides.

But a shoulder vise does require support in the form of a fifth leg and a longer foot on the left side of the bench. This base design, however, has some advantages, one being an added measure of stability from front to back when working on that side of the bench. And since the shoulder vise arm is flush with the rest of the benchtop, the top surface of the bench is effectively wider on that side.

Tail vises are less common on English and French benches, but they are a mainstay of northern European bench design. As we saw in Chapter 5, tail vises require some careful engineering to prevent them from coming apart by accidentally overtightening the vise screw. But a tail vise makes it easy for work to be clamped at an angle and will hold work clear of the bench front for sawing and shaping operations.

Tradition, driven by the fact that most woodworkers are right-handed, usually locates the shoulder vise on the left side of the bench and the tail vise on the right. But a left-handed woodworker could easily reverse these positions to make working at the bench more comfortable.

Tool trays are common on this style of bench, usually mounted at the rear. Most examples, including the Frid and Klausz benches, use a ramp at each end of the tool tray to facilitate clearing debris that inevitably accumulates there.

Smart Solution

SIMPLE BOARD JACK

Tage Frid designed what he called an "auxiliary support" to prop up long boards along the front of the bench. Essentially a removable board jack, this accessory is nothing more than a milled piece of 8/4 stock slightly narrower than the width of the tail vise jaw. The length of the board should be a fraction of an inch less than the distance from the floor to the benchtop. Holes are drilled at intervals (an inch or two apart) along the length to hold a piece of ½-in. dowel. To use the auxiliary support, clamp the board flush to the front of the tail vise with the holes facing out and adjust the height of the peg.

WATCHING ANDY RAE AT WORK, it's easy to see why many woodworker's believe that this is the ultimate configuration for a workbench. The tool tray and shelf below keep everything handy and organized, the two vises can clamp just about any project securely

Tage Frid's Bench

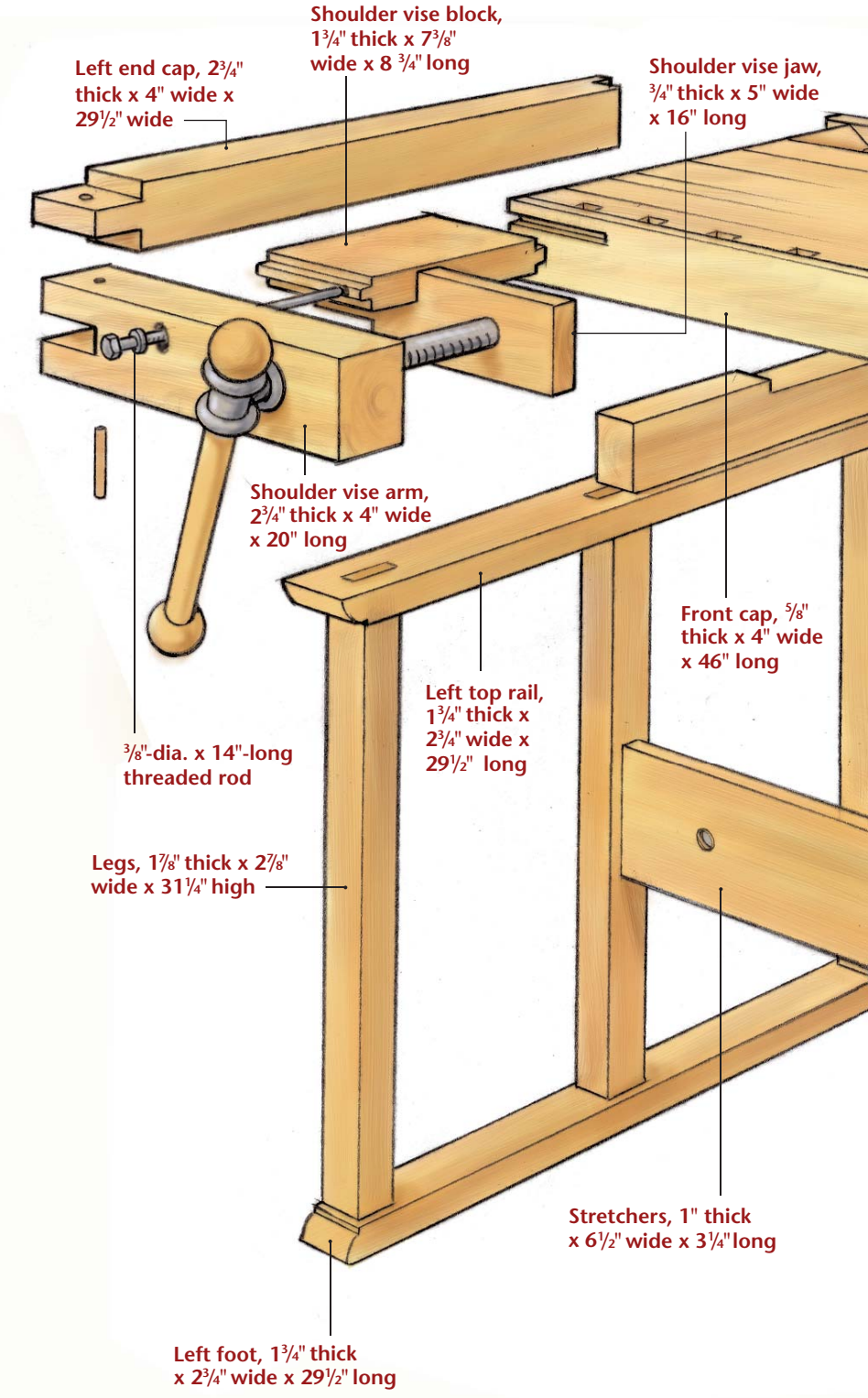
Originally designed as a student workbench, this bench was meant to be a knock-down so that students could take it with them when they completed their training. The ends were connected to the stretchers with hardware. Tage Frid used readily available machine bolts and nuts. My version uses specially designed workbench bolts with a barrel nut. You could also use ⅜-in. bolts with square nuts that fit neatly into a 1-in. drilled hole.

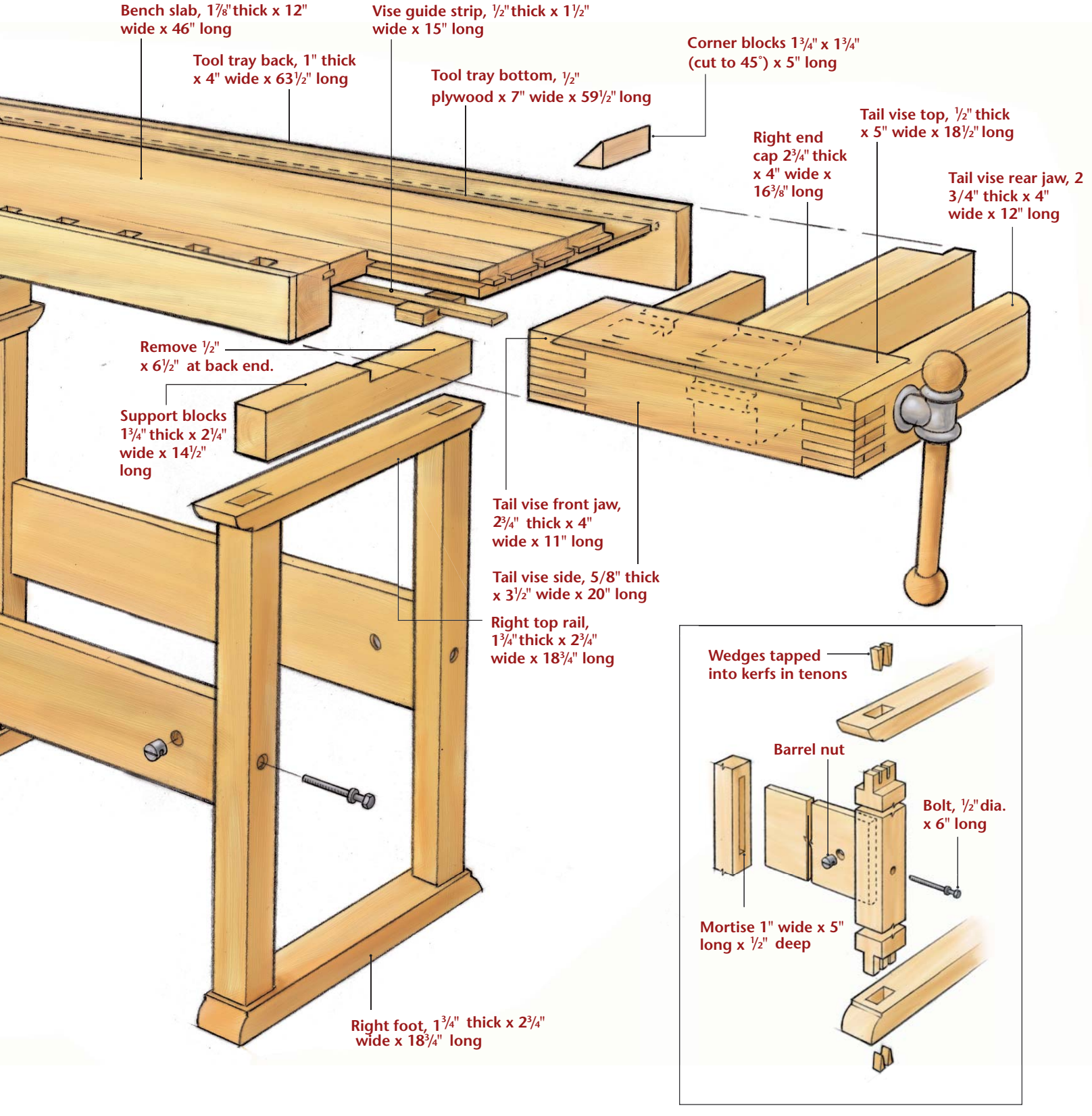
For added rigidity, Frid made a simple tenon on the stretchers by cutting a notch out of the top and bottom at each end. The tenons fit into shallow mortises on the insides of the legs, and the bolts draw the joint together. The trestle end assemblies are permanently joined with wedged through tenons.

The benchtop slab on the original is three 4-in.-wide boards joined with splines. The splines help align the planks and provide a marginal amount of additional strength. Frid cut the holes for the bench dogs on the radial-arm saw. These days, a table saw fitted with a dado head is the more common method. This bench has a tool tray with ramps made of stock cut at 45 degrees and a plywood bottom.

Frid used finger joints in both the shoulder vise and tail vise joints. They are fairly easy to cut with a machine and are enormously strong. The end cap on the shoulder vise side is joined with a single large finger and pinned with ½-in. dowel. The real strength in the shoulder vise assembly comes from a ⅜-in.-diameter threaded rod running clear through the vise and into the benchtop.

The trickiest part of the construction is the tail vise. It is essential that all the parts be square to one another. Frid recommends making the jaw tongue slightly oversize and then carefully fitting it to the groove.




Bench slab, 1⅞" thick x 12" wide x 46" long
Vise guide strip, ½" thick x 1½" wide x 15" long
Tool tray back, 1" thick x 4" wide x 63½" long
Tool tray bottom, ½" plywood x 7" wide x 59½" long
Corner blocks 1¾" x 1¾" (cut to 45°) x 5" long
Tail vise top, ½" thick x 5" wide x 18½" long
Right end cap 2¾" thick x 4" wide x 16⅜" long
Tail vise rear jaw, 2 3/4" thick x 4" wide x 12" long
Remove ½" x 6½" at back end.
Support blocks 1¾" thick x 2¼" wide x 14½" long
Tail vise front jaw, 2¾" thick x 4" wide x 11" long
Tail vise side, 5/8" thick x 3½" wide x 20" long
Right top rail, 1¾" thick x 2¾" wide x 18¾" long
Right foot, 1¾" thick x 2¾" wide x 18¾" long
Wedges tapped into kerfs in tenons
Barrel nut
Bolt, ½" dia. x 6" long
Mortise 1" wide x 5" long x ½" deep

Building the Bench

Order all the hardware before building the bench. The original plan calls for a shoulder vise screw, 1¼ in. in diameter by 13¾ in. long with a swivel end, and a tail vise screw, 1¼ in. in diameter by 20¼ in. in length. It may be difficult to find vise screws in these exact dimensions. Once you have your hardware, you can adjust the dimensions of vise parts accordingly.

SLOTS FOR THE BENCH DOGS CAN BE CUT WITH A ROUTER, radial-arm saw, or a mallet and chisel for that matter. My preference is the table saw. By using a sled with an angled fence and stop to position each successive cut, cutting the dog holes is a snap.

THOUGH THE FINISHED SHOULDER VISE LOOKS PRETTY SIMPLE, it's quite a puzzle. The assembly consists of the end cap, vise arm, a block to act as a spacer, the screw mechanism and outer jaw, and the most important component: the single bolt that holds the entire vise together.

Building the Base

I used a router to cut the mortises on the legs. After cutting a notch ¾ in. long and ½ in. deep out of the top and bottom of each end of the stretcher, I clamped the assembly together. I cut the bolt hole through the mortise on the drill press and used it as a guide to drill the bolt hole into the stretcher.

Building the Top

You can use splines in grooves cut in the planks with a dado blade, as Frid did; join the planks with dowels or biscuits; or simply edge-glue the boards. Clamping cauls make aligning the boards very easy, as long as the boards are all the same height. Let the top slab cure, plane it flat, and then glue the dog rail and front cap in place—again using cauls to align the pieces.

A dado blade on the table saw easily cuts the dog holes. For more positive clamping, the holes should tilt 3 degrees toward the tail vise. Once the glue has cured, the slab can be trimmed to finished length. I used splines to connect the slab to the end cap. The end cap grooves can be cut on the table saw with a dado blade. The groove in the bench slab can be cut with a router.

Building the Shoulder Vise

After I dimensioned all the parts for the shoulder vise and cut the grooves for all the splines, I cut the long finger joint in the end cap. Most dado sets are too small to cut a finger joint this deep. But it's easy to rough cut it on the bandsaw and then trim to final size with a single blade in the table saw. Rotating the piece between cuts will ensure the cuts are precisely centered.

If you mark all the bolt hole locations carefully during the dry fit, most of the holes can be drilled on the drill press. The long through holes can be drilled part way to get them started straight; complete them with a long drill bit.

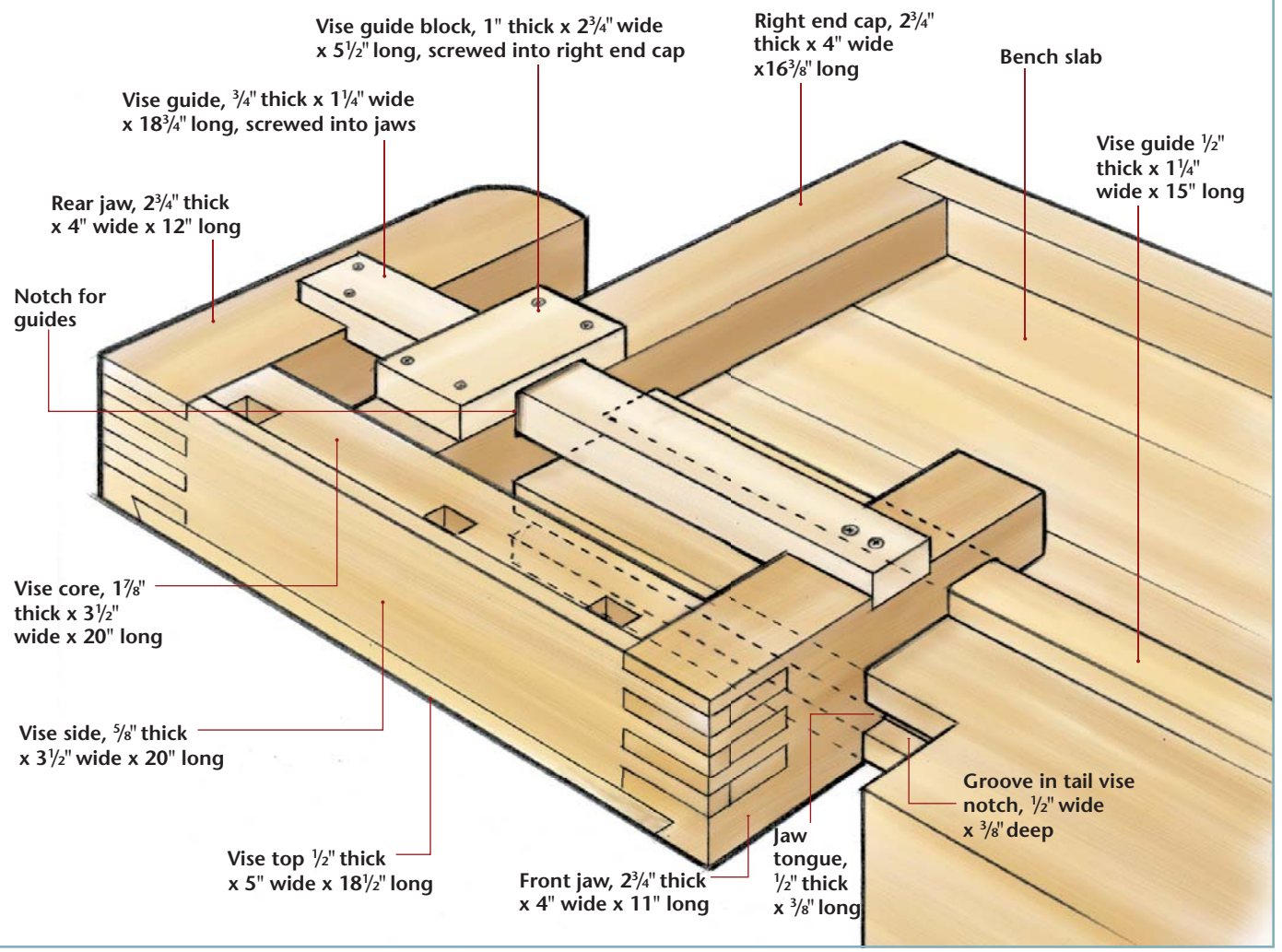
When the vise is back apart it's a good time to mortise for the vise screw flange, which is imbedded in the front arm. I used a router to rough out the recess to the right depth and finished up the edges with a chisel. Once the arm is secured with a dowel through the tenon, the through bolt can be tightened. The last step is to mount the vise screw and attach the jaw.

Building the Tail Vise

The finger joints for the tail vise can be cut in the same way as for the end cap. I cut the notches for the guides with a dado blade on the table saw. I also used the table saw to cut the dog holes as before but with the tilt toward the shoulder vise.

To prevent slop in the vise operation, I cut the vise tongue and the guides slightly oversize and adjusted the tongue and guides during fitting. Then I glued and assembled the parts of the vise on the bench corner itself, making certain the assembly was absolutely square. With the benchtop turned over, I mounted the guide block and guide strip with countersunk screws. After all the hardware was installed and working smoothly, the last step was to glue the top of the vise.

Frid Tail Vise (viewed with benchtop inverted)



The Best of Old and New

Throughout this book, I have pointed out that choosing a workbench design that suits your needs is a series of compromises. No single bench configuration will accommodate all the various tools, machines, and styles of woodworking, especially in light of the endless array of projects large and small. But what if you could have everything you want in a bench, or at least mostly everything?

THIS BENCH TAKES MODERN WOODWORKERS SERIOUSLY. It's designed to provide lots of solid workspace, more clamping options than I hope I'll ever need, both round and square dogs, a quick-action front vise, and nonwracking end vise, all within a framework with a traditional look and feel.

The Challenge

Before I began to design my "perfect" bench, I set some ground rules for the project. I wanted the bench to be accessible to any small-shop woodworker with average skills. I decided to limit the equipment necessary for building this bench to commonly available tools: a table saw, a bandsaw, a portable planer, a router, a jigsaw, a drill press, and a basic assortment of hand tools.

The workbench I had in mind would have traditional elements but take the needs of today's woodworkers seriously. While researching this book, I had the opportunity to talk to dozens of woodworkers about their workbenches. There was universal agreement that a sturdy and rigid top that could hold up under pounding is essential. The traditional solution, a solid bench slab glued up from hardwood, works for me.

A rigid base that doesn't flex or wrack under pressure from hand or power tools is also a must. A frame base with sturdy legs attached to stretchers is a time-tested solution. But I decided to increase the number of stretchers from two to four for additional rigidity and to allow room for a tool storage cabinet that I will eventually build.

Modern Conveniences

The benchtop configuration is where modern woodworking practice comes into play. To hold wide stock and panels, multiple rows of dog holes are better than a single row. I decided to have four rows along the length of the bench, taking advantage of a full-width end vise with twin screws. By having two chain-driven screws widely spaced and both rotating simultaneously, the tendency for the vise to wrack is nearly eliminated. I can also clamp anything I wish anywhere in the vise without concern that it's putting undue strain on the vise.

On the front vise, I chose to use round dogs. Their versatility and ability rotate to hold odd shaped pieces was certainly a factor, but having the round holes allows me to use the holes for hold-downs. Since I find it quite tedious to crank a vise handle in and out, I definitely wanted a quick-action vise for the front of the bench. The mechanism I chose incorporates a quick-action feature actuated by a half nut. By turning the handle counterclockwise half a turn, the vise releases.

Traditional Details

Not all the design choices I made were rational. For example, I chose square dogs for the end vise. It would have been much easier to drill holes for round dogs rather than cut all the angled mortises for square ones. But there's something about those big beefy square dogs that just felt right.

I wanted a functionally modern bench, but as the design developed, I found myself incorporating traditional elements. I've always loved the look of massive wooden vise jaws on a workbench, so I made matching wooden jaws for both vises. I decided to use a sled foot design and to round the feet and the vise jaws to the same thumbnail profile to tie the visual details together.

Ease of construction was a major consideration. There's no reason the base could not have been bolted together. But there's something about mortise-and-tenon joints, like using square dogs, that just seemed correct to me. Finger joints would have worked to join the end caps to the aprons, but the half-blind dovetails are strong, elegant, and provide one additional feature. Sometimes finger joints expand or shrink, making the rear jaw area rough. By orienting the dovetails this way, the inner jaws of both vises are one flat board with no joinery on their faces.

THE ROUND DOGS ARE perfect for the front vise area. Not only can I clamp odd-shaped or round pieces but the ¾-in. holes provide access for hold-downs and a variety of jigs that use ¾-in. dowel pins.

I REALLY LIKE THE IDEA of similar details in different places. Here the sled feet use the same thumbnail profile as the vise jaws. Frank Klausz's bench uses the same similarity of detailing, and I've always admired how elegant his bench looks.

A New Classic

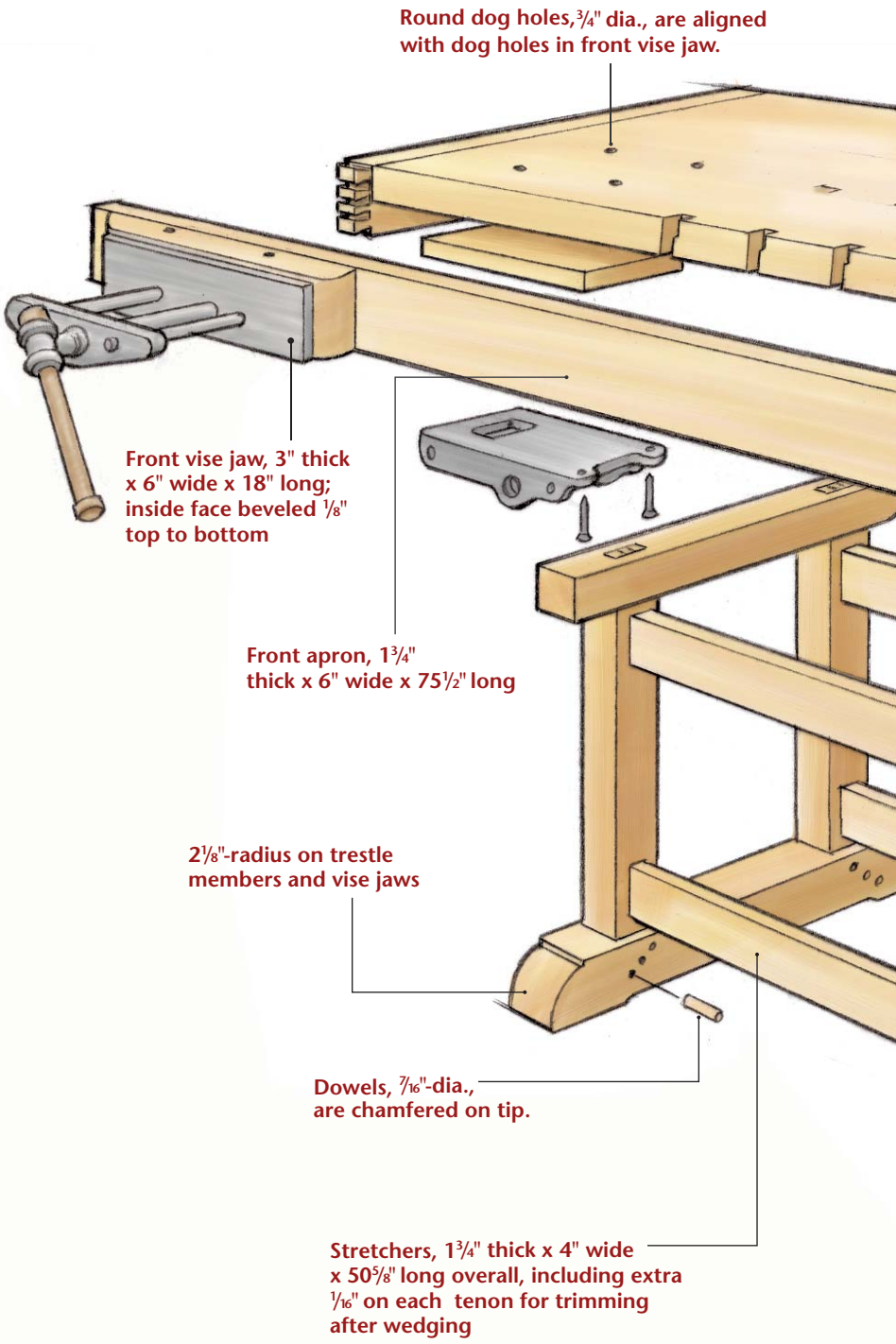
This workbench design blends the best of old and new. While the bench looks traditional, it incorporates modern innovations, including a quick-action front vise that uses round dogs, a chain-driven twin-screw end vise, and multiple rows of dog holes.

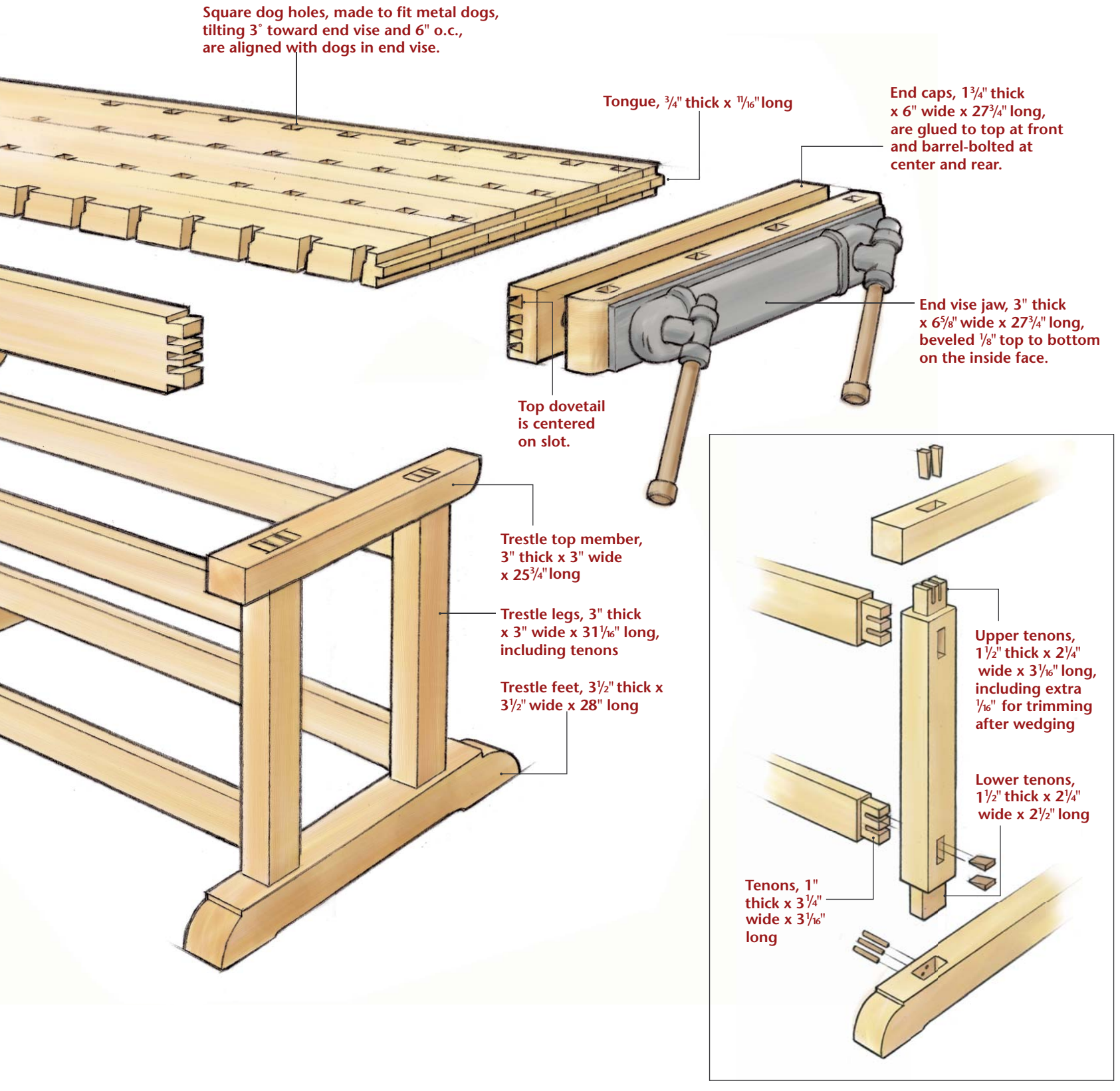
The maple benchtop is 2½ in. thick, 28 in. wide, and 6 ft. long. The aprons and end caps add rigidity to the slab. In a nod to tradition, I decided to join them with dovetails. The choice to use both round and square dogs was made because, first, I simply like square dogs. But, second, I also use hold-downs designed to fit into ¾-in. round holes and I've made several jigs that use ¾-in. dowels to hold them to the bench.

Many benches I've seen look top heavy. I wanted the benchtop and base to look proportionate. So I designed a substantial base to support the massive top. Building the feet wider than the legs helps bring mass to the bottom, but the profile adds a touch of refinement.

Splitting the stretchers, one high and one low, was a conscious decision. It leaves the perfect opening for a future tool storage cabinet that fits into the base on top of the lower stretcher. A typical single wide stretcher would have saved some time, but it would block this very natural storage area. At 4 in. tall, each stretcher contributes to the stiffness of the bench. Adding a cabinet will provide extra shear strength and stability as well.

When building the bench, start with the base. That way you can use it when you're gluing up the top. Just make sure you protect the base from dripping glue with a sheet of plastic. Build the top in segments so you can use your portable planer for final surfacing. If you have access to a wide planer, glue the top up in one slab.




Square dog holes, made to fit metal dogs, tilting 3° toward end vise and 6" o.c., are aligned with dogs in end vise.
Tongue, ¾" thick x 11/16" long
End caps, 1¾" thick x 6" wide x 27¾" long, are glued to top at front and barrel-bolted at center and rear.
End vise jaw, 3" thick x 6⅝" wide x 27¾" long, beveled ⅛" top to bottom on the inside face.
Top dovetail is centered on slot.
Trestle top member, 3" thick x 3" wide x 25¾" long
Trestle legs, 3" thick x 3" wide x 31⅛" long, including tenons
Trestle feet, 3½" thick x 3½" wide x 28" long
Upper tenons, 1½" thick x 2¼" wide x 3⅛" long, including extra ⅛" for trimming after wedging
Lower tenons, 1½" thick x 2¼" wide x 2½" long
Tenons, 1" thick x 3¼" wide x 3⅛" long

OF THE DOZENS OF WAYS TO CUT A TENON, this is my favorite. I use a sled on the table saw with a stop block. Then I make multiple passes using a dado blade. The stop block locates the shoulder cuts exactly the same all around the tenon; and, if I need to, I can make the tenon slightly smaller by raising the blade just a hair.

THE TRESTLES HAVE WEDGED THROUGH MORTISES at the top and are pinned at the bottom. The holes for the dowel pins are drilled deliberately off set. As I drive the pins home, they draw the joint together.

THIS LITTLE JIG saves a lot of time cutting all the notches for the dog heads. The router is fitted with a ¼-in. straight bit set as deep as the slot.

Building the Bench

If you build the base first, you can use it for gluing up the top slab. Once the top is assembled, you can set it on the base to finish installing the hardware.

Constructing the Base

The top sits directly on the top ends of the posts, which are mortised through the top trestle cross members. Upper and lower stretchers are through mortised and wedged to the posts. I made wedges out of walnut to contrast with the light colored maple. The lower ends of the posts fit into stopped mortises, and the tenons are pinned through the feet with 7/16-in. dowels. Holes for the dowel pins are off set so that when the pins are driven home, they draw the joint together.

The posts are easy to mortise using a drill press to remove most of the waste and then chopping the mortises square with a chisel. I cut the tenons on the table saw, making multiple passes with a dado blade and setting a stop block on a crosscut sled to locate the shoulder cuts. I cut the kerfs in the tenons on the bandsaw and then carefully cut the wedges with a miter saw.

The trestle and feet profiles were formed by first crosscutting the small step on the table saw. Then I used a bandsaw to cut the curve. I refined the profile and smoothed away the saw marks with a rasp.

The base was glued up in two operations. First, I glued the two trestle assemblies. It's critical these assemblies be flat and square with no twist. I pinned the post tenons through the feet with three dowels in each and wedged the top mortises into the cross members. After the trestles cured, I glued and wedged the stretchers in place. At every step of the way, I was careful to measure diagonally to make sure everything stayed square.

WITH SECTIONS OF THE TOP GLUED, I ran them through the thickness planer, first bottom side up, then top side up, and finally bottom side up once again to finish thickness.

THE FINAL GLUE-UP WORKS just like gluing the sections. Pressure applied to the clamping cauls above and below the slab sections align them perfectly.

Building the Top

The top's finish thickness is 2½ in. I used a bandsaw to rough rip the boards just under 3 in. wide. The 3-in. width left plenty of stock so that I could straighten the planks by jointing them along one edge. Then I ran all the planks on edge through a thickness planer to ensure they were straight and all exactly the same size.

Since I wanted four rows of dogs, I had a lot of dog holes to cut. Milling the slots for them is straightforward on the table saw using an angled jig on the crosscut sled. After each slot was cut, it fit over a small block screwed to the sled, locating the next cut (see top photo on p. 156). I used a router with a small jig to cut the notches for the dog heads. The jig has a pin that fits into the dog slot; the router moves freely inside the confines of the jig to make the cut.

Gluing up the top slab is best done in segments for a couple of reasons. First, the individual sections, though heavy, are still small enough for one person to manage. Second, and more important—at least in my shop, they can be planed with a 12-in. portable planer. I used clamping cauls to align the planks (see bottom photo on p.132).

Once the glue cured, I used a scraper and then a belt sander to clean up the excess. Then I ran the slabs upside down through the thickness planer, making light passes until the bottom surface was clean on all of the slabs. Turning the slabs top surface up, I ran them through the planer again, making very light passes until the tops of all the slabs were clean. Then I turned them over once more and ran them bottom side up until I reached the finish thickness of 2½ in.

Gluing the slabs together is a lot like gluing the individual sections. Cauls clamped above

and below align the slab sections perfectly. Then it's a simple matter to close the last of the glue joints with clamps across the benchtop, because the cauls are covered with slick cellophane tape, allowing the segments to slide between the cauls, even though they're tightly clamped. I did the final flattening with hand tools.

Trimming the slab to length requires a router, a shopmade jig and a sabersaw. The jig is simply two straight and parallel boards glued and nailed to two blocks as thick as the top. I clamped the jig square to the slab and used it as a guide to rout a dado first on the top and then on the bottom of the slab. The two parallel straight edges remained clamped to the top as I flipped it over to rout the other side, ensuring that the two shoulders would match. Then I used a sabersaw freehand to cut through the ¾-in. tongue that fits into corresponding grooves in the end caps.

USING A ROUTER WITH THE JIG IN THE BACKGROUND trims the benchtop to length, squares it up, and cuts the matching tenon shoulders—all in one operation. The length of the tenon is not critical, so it can be cut off with a sabersaw or portable circular saw.

THE END CAPS HAVE A GROOVE milled the width of the tenon. The caps should fit onto the slab tongue easily to allow the top to expand and contract with seasonal changes. Apply glue to this joint only near the front apron for the same reason.

End Caps and Front Apron

The front apron serves as the rear jaw for the front vise, and the right end cap is the rear jaw for the end vise. So it's important that these parts are flat and square to the top. I used half-blind dovetails to join the front apron to each end cap and located them to keep the rear jaws of each vise flat and smooth. Fit and cut the dovetails at the end vise first, leaving the front apron slightly long. Then mount the front vise bracket and locate the holes for the front vise before cutting the dovetails on the left side.

The end cap grooves can be cut using a dado blade on the table saw. Using a drill press to drill the bolt holes and the holes for the twin-screw end vise screws will ensure that they are square, which means drilling them before permanently installing the end cap. The distance between the two screws is dictated by the length of the chain. To determine the vertical location add 1½ in. to the thickness of the top slab to allow the vise nuts to clear the underside of the top. Two bolts tightened with barrel nuts secure the end caps to the top slab. The hole for the rear bolt is elongated to allow the top to move. After dry-fitting the end caps, I secured them temporarily with the bolts while I laid out and cut the dovetails.

The front apron has tails on the right end, which I cut before cutting the pins in the end cap. After securing the front apron in place with clamps, I scribed the pins on the end cap.

After fine-tuning the joinery, I installed the end vise nuts before gluing the end cap. Only the front 3 in. to 4 in. of the tongue on the

BY ADDING A SPACER BLOCK under the front vise hardware, I increased the working depth of the vise to the 4 in. I wanted. Once the mechanism is mounted, I transferred the hole locations for the guide bars and vise screw to the front apron so it could be drilled before its installation.

I MADE SURE THE FRONT VISE WORKED WELL before I cut the dovetails in the left end cap. The location of the front apron is determined by the right end cap dovetails. If anything was to move, it had to be the front vise itself.

slab and the groove in the end caps are glued. This limits wood movement to the back end of the benchtop but allows the top to expand and contract freely.

Mounting the Vises

The vises came with very thorough instructions, making the hardware straightforward to mount. I added a spacer block under the front vise mounting bracket to increase the clamping capacity of the vise. The block and bracket are mounted to the underside of the bench with 5/16-in.-diameter lag screws.

I dry-assembled the front apron into the left end cap so that I could locate the exact position of the clearance holes for the vise screw and guide bars. Using a drill press, I drilled the holes in the front vise jaw and the front apron at the same time. It's worth checking the fit of the front vise screw before assembly. Next, I marked out and cut the dovetails on the left end cap. Finally I glued the apron to the front of the slab and into the dovetails, connecting it to the end caps.

Before installing all of the end vise hardware, I tested the under-the-bench clearance and operation of the screws in the end vise. If you chose to profile the edges of the outer vise jaws, do it before final hardware assembly.

Attaching the Top and Base

Although wood movement on the top ought to be minimal, there will be some expansion and contraction. This is why I wouldn't want to impede the natural movement of the top. Two fasteners along the centerline of the bench are plenty. Some woodworkers use a simple dowel in the base inserted into a hole in the top. But I like having the top secured to the base. I think the bench is easier to handle if the top doesn't simply lift off. Two lag bolts is all it takes. I drilled holes up through the two cross members for the lag bolts. I left the holes in the cross members open to make removal of the top a 5-minute job.

Adding the Finishing Touches

I didn't want a slick finish, as tempting and beautiful as it might be. Clamps, hold-downs, and vises depend on friction to hold parts securely. I used my old stand-by finish: varnish thinned with turpentine wiped on with a rag. It seals and protects the wood without making it too slick. To make sure moisture absorption is even on all sides of the bench, it's important to coat the top and underside of the bench equally.

THE MECHANISM FOR THE CHAIN-DRIVEN END VISE screws takes some fussing to get it to run smoothly. I dry-fit the end vise several times before I got it right. Once the vise operated like I wanted it to, I glued the end cap and shaped the vise jaw detail.

IN THE SHAKER TRADITION, the base of Jon Leppo's workbench is built like a sturdy chest of drawers. The Emmert patternmaker's vise replaces the leg vise, which is customary on Shaker benches.

Shaker with a Twist

The Shakers introduced yet another tradition into workbench history. Their long, cabinet-based benches, as well-designed and constructed as their furniture, can still be admired in Shaker museums.

Jon Leppo incorporated the basic design of the Shaker-style workbench when he built his. Almost all Shaker benches have a cabinet-style base, with drawers and cabinets for storing tools. In a modern update, Leppo used ball-bearing full-extension slides for the drawers and added twin tail vises plus a patternmaker's vise on the front. The sides of traditional Shaker benches were usually built with frame-and-panel construction. Leppo added raised panels for a more elegant look; and to speed the joinery, he connected the rails to the posts with biscuits. Many Shaker benches have a sliding bench jack, and Leppo decided to incorporate that useful feature into his design as well.

Leppo's benchtop is a relatively short 8 ft. in length, so that it would fit into his shop. Compare that to the average 12-ft. to 15-ft. length for a historical massive Shaker bench. Shaker benches also tended to be wider than usual, some as wide as 38 in. Leppo's benchtop is a bit over 33 in.

And now for the twist. Leppo swapped the typical Shaker leg vise on the front of the bench with another historical treasure: a 1930s-era genuine Emmert vise. Since he makes a range of furniture, he likes the Emmert's ability to

TWO TAIL VISES MIGHT SEEM EXCESSIVE, until you try to hold a tabletop flat on the benchtop. With dogs working in four different spots, the workpiece is held in place gently but firmly while Lippo planes the top.

hold odd-shaped workpieces. He drilled two rows of round dogs across the width of the bench to match the two dogs in the Emmert.

As if having this versatile, top-of-the-line vise weren't enough, Leppo built two tail vises into the bench. And he devised some pivoting bench dogs for holding odd-shaped work in the tail vises. These dogs have a round shank that will rotate in the square dog holes or can be used in the round holes around the Emmert.

Despite its departures from tradition, Leppo's ingenuous hybrid would no doubt have earned him the admiration of the Shakers. Despite their well-known reputation for simplicity, they avidly embraced modern innovations and contributed a few of their own. They are credited with inventing both the washing machine and the circular saw.

Bench Profile

Untraditional Tradition

Massachusetts piano maker Henry Studley built his magnificent wall-hung tool chest over the course of a 30-year career at the Poole Piano Company. Using ebony, mother of pearl, ivory, rosewood, and mahogany—all materials used in the manufacture of pianos—he built a tool chest that remains in a class of its own.

Studley's bench is equally unique and uses many of the same materials. But it's the vises that set it apart from other workbenches. The nickel-plated face vises are truly beautiful to admire and have a smooth in operation and a micrometer precision. The hand wheels allow just the right leverage to hold a workpiece securely, whether he was shaping a large piece of mahogany for a piano or a small brass part. This mixed media was important to Studley because he worked with brass, steel, mother of pearl, and ivory as well as wood.


Tool Chest
Legacy

9

Innovative Workbenches

JOHN BARBEE USES HIS BENCHTOP for a variety of procedures, including drawing, assembly, and as a flat surface to stage parts.

Most of the benches we've looked at so far are fairly traditional. While they may incorporate modern hardware or materials, they rely in large part on the woodworker's favorite material: solid wood. For all its utility and charm, solid wood has its limitations. Using it to make large, perfectly flat benchtops for drawing, assembly, and vacuum veneering is expensive and labor intensive, and wood won't stay flat for very long. But the torsion box, popularized by Ian Kirby is an almost perfect method for constructing a strong, flat, stable, and relatively lightweight benchtop.

The torsion box is but one example of how woodworkers use their ingenuity to come up with new workbench solutions. Unless you have unlimited space in your shop, you'll find it difficult to allot floor space for all the workbenches you need. In this chapter we'll see workbenches that knock down, fold up, and are carried away, as needed. We'll also see how one woodworker, unwilling to pay the price of premium hardwood and hardware, built a versatile bench with materials from a local home center. While these benches bear little resemblance to the traditional workbench that many woodworkers dream about, they serve their purpose admirably.

BRIAN BOGGS'S FINAL ASSEMBLY BENCH is a torsion box made perfectly flat. He uses it for, among other things, a platform to adjust the leg lengths of his famous chairs. He levels the chair and marks each leg for trimming. Once he's cut the legs to exact length, the chair sits flat without rocking.

JUDITH AMES'S CENTER WORKBENCH uses the top for drawing, lay-out work, and vacuum-forming curved parts. Once the parts are under pressure, she puts the bag, parts and all, on the shelf below.

A Different Kind of Benchtop

There are many tasks that we do in the shop that we can't really do at a traditional cabinetmaker's bench. The variety of operations needed to build even simple woodworking projects ranges from drawing to finishing, with glue up, assembly, and dozens of other tasks in between.

Benches made for cutting and shaping wood need to be heavy, resist wracking, and take pounding. They are often relatively narrow so that we can reach across them. But for drawing, assembly, veneering, and organizing parts, our needs in a workbench are quite different. Resistance to wracking and mass are not as important. While auxiliary benches need to be strong, especially for operations like assembly, the primary requirements are that the benchtop be large, flat, and smooth.

Drawing

Any piece of plywood will do for a drawing table, of course, but having a surface with straight edges and a flat surface certainly makes the job easier. I find I like the drawing surface up much higher than my normal workbench height, around 40 in. for drawing compared with around 35 in. for woodworking. It's easier on my back.

One solution is to make several benches with relatively short legs of differing heights. That way you can stack them for tasks requiring different heights: the lowest for the assembly of large pieces, the highest for drawing.

HANK HOLZER USES the top of his three-tier stacking bench for veneer work. The second tier is where Holzer puts his vacuum bag during clamping operations.

Veneering

Traditional veneer work often involves cutting, matching, and taping veneer together. Since this is often fine work that needs to be closer to the eye, a table for traditional veneering should probably be around the same height you find comfortable for drawing.

The size of the bench you need for veneering depends on the scale of the projects you do. For laying out an entire tabletop you will probably need a surface at least as large as the table itself.

Veneering, whether done traditionally using a hammer or press or with a vacuum bag, requires a significant amount of glue. For that reason it's wise to protect the benchtop or, even better, to use a surface material that makes glue easy to remove. Plastic laminate is a good choice. Even more important when working with veneers is the cutting surface itself. Paul Schurch uses a material specially designed for this purpose.

When gluing veneer using conventional clamps, the biggest challenge is getting the clamp pressure even, especially when gluing larger size projects. One solution is to build a pair of top and bottom torsion boxes, like Ian Kirby uses to clamp veneer. His method is designed to spread the clamping pressure evenly.

A vacuum bag works great for clamping veneers also. But since the plastic bag lacks stability, you have to have the bottom platen flat to begin with to clamp up a panel that's flat. In vacuum veneering, when the air is evacuated from the plastic vacuum bag, there is tremen-

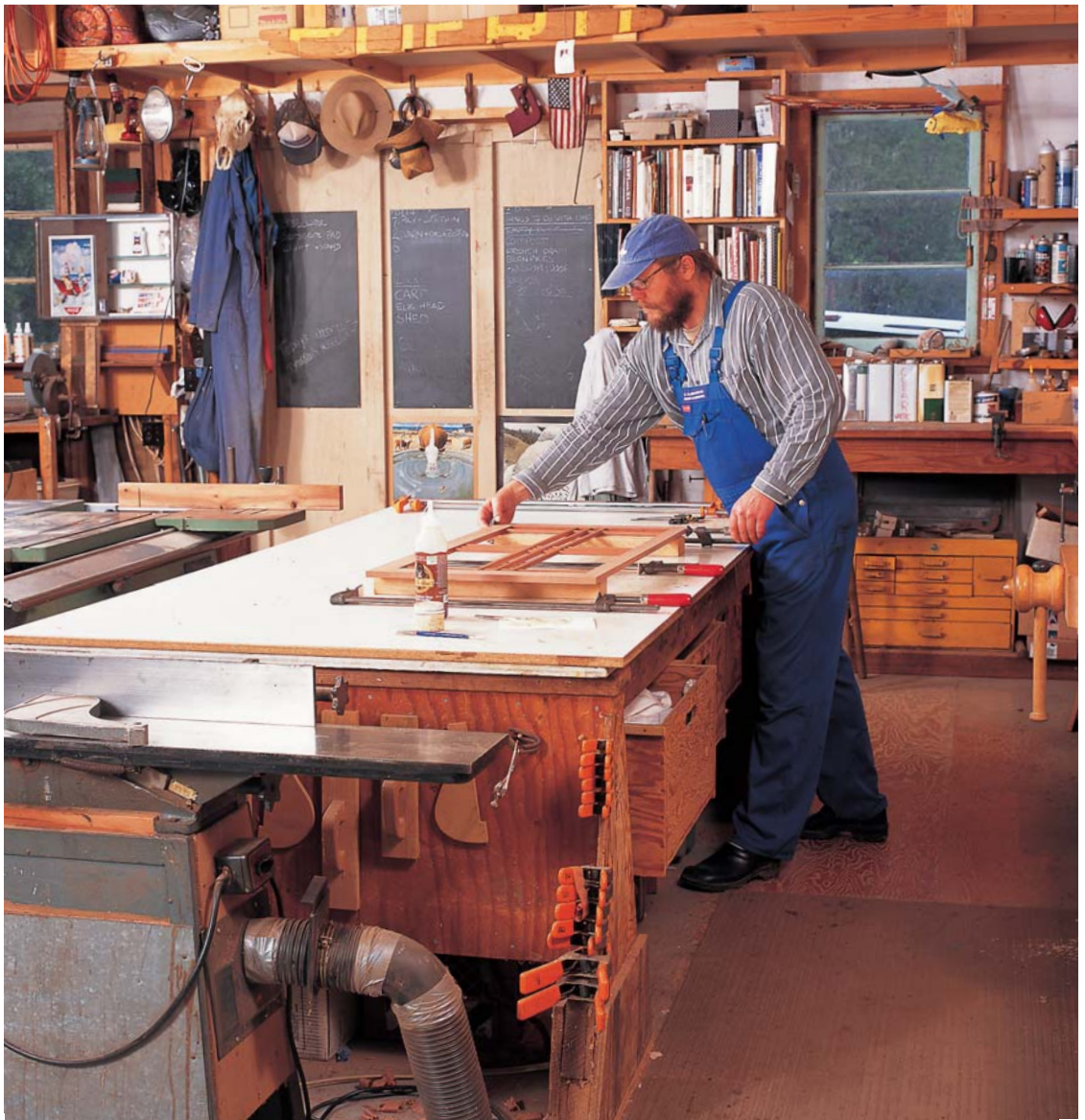
PAUL SCHURCH STUDIED veneer and marquetry techniques in Europe, where he learned to cut veneer with a chisel. A wooden bench surface would be cut to shreds in a very short time, so Schurch uses a more durable plastic cutting surface.

dous pressure pushing not only down but, literally, from every direction. It's easy to underestimate the amount of pressure until you build, for example, a form for a curved door—and see that what you thought was a massively built form get crushed like a matchstick as soon as pressure is applied.

Gluing and Assembly

One of woodworking's first lessons is realizing the importance of flat reference surfaces when gluing solid panels, say for a tabletop. Any twist whatsoever will cause endless difficulty with the remainder of the project. Doors, to use another example, will never close properly against a cabinet frame unless they're perfectly flat.

PAUL SCHURCH USES A VACUUM BAG to make many of the curved parts for his furniture. A large smooth surface is essential for proper operation of the bag.



EJLER HJORTH-WESTH'S ASSEMBLY TABLE doesn't just free his main bench for joinery but also provides the all-important flat surface for gluing, drawing, and stacking parts in progress. The large drawers below the bench are used for storage.

Even dry-fitting parts requires a perfectly flat surface so that you immediately detect any twist or misalignment and can make any corrections accordingly. Your main workbench will be flat, of course, and offers a great gluing platform. But you may not want to tie it up while you're waiting for the glue to cure.

If you have a separate assembly bench, you can set up blocks, clamping cauls (which I normally use), or prop-up pipe or bar clamps in advance. Once you have the pieces clamped up, you can go back to work on your main bench while the glue dries.

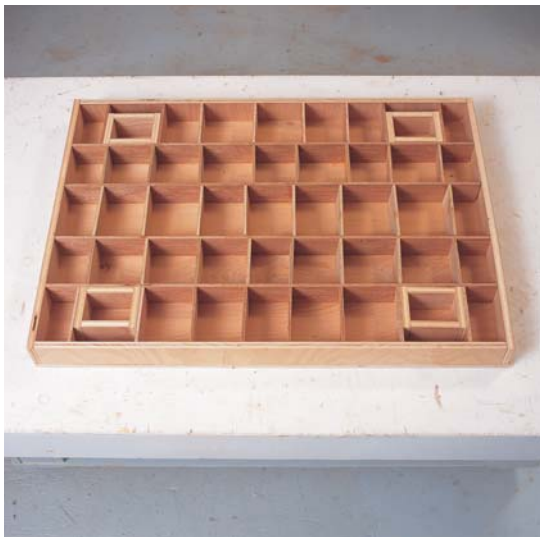
Although there are many ways to make a large flat benchtop, final assembly is truly where a torsion box comes into its own. I covered mine with plastic laminate to resist glue and make clean up easier. It stays completely flat and rigid because of its honeycomb interior structure, and yet since it's semihollow, it's relatively light and portable.

The Torsion Box

A torsion box is comparable to an airplane wing spar or an I-beam. By vertically separating the top and bottom surfaces of the spar with spacers, the structure becomes stiff. To understand how it works, lay a piece of ¼-in. Masonite 3 in. to 4 in. wide flat on the floor and then raise one end, you'll be able to just about bend it into an L-shape, it's so flexible by itself. But set it on edge in a honeycomb pattern and glue a "skin" to each side, and you have a structure that's flat and nearly self-supporting—the torsion box.

In our airplane wing example, the ribs of the wing form the shape of the skin. The skin itself gives the wing added rigidity. The thicker you make the wing, the stiffer it is. Likewise with an I-beam, the taller you make the beam, the stronger it is. So the thicker the torsion box, the more rigid it will be.

A TORSION BOX makes an exceptional flat surface for final assembly. If you build furniture of any size, your assembly bench should probably be lower than the bench you use for general woodworking.



THE INTERIOR OF A SIMPLE TORSION BOX reveals the ¼-in. plywood used for internal support. John Weidner made pockets in the box into which he can insert legs of different lengths to adjust the height of the bench.

How a Torsion Box Works

Resistance to expansion and compression is the central reason the torsion box is so stiff. When bending any material or structure, the outside of the radius must stretch or the inside of the radius must compress. To bend the benchtop assembly, you have to stretch or compress the top or bottom skin itself. As the thickness increases, the structure becomes stiffer. This is because the top and bottom skins must stretch or compress more as the distance between them, the thickness of the benchtop, increases.

A TORSION BOX BENCHTOP is relatively light and easily lifted, so that John Weidner can interchange legs of different lengths. He can use the same base and benchtop as assembly table, rolling shop cart, or infeed table for his table saw.

If the thicker, the better rule is carried to an absurd level, we should make torsion boxes as hollow cubes. This results in a very rigid structure, but it's not very practical if you want a large work surface. So it's a balancing act, deciding the thickness in relation to the size of the work surface.

A benchtop of the same dimensions made of solid wood would be incredibly heavy. But a torsion box, being semihollow, will be light for its size and incredibly strong for its weight. This opens a wide range of possibilities. John Weidner built a torsion box workbench to accept legs of different lengths. With the shortest legs in place, it's an assembly bench at just the right height for the scale of furniture that he builds.

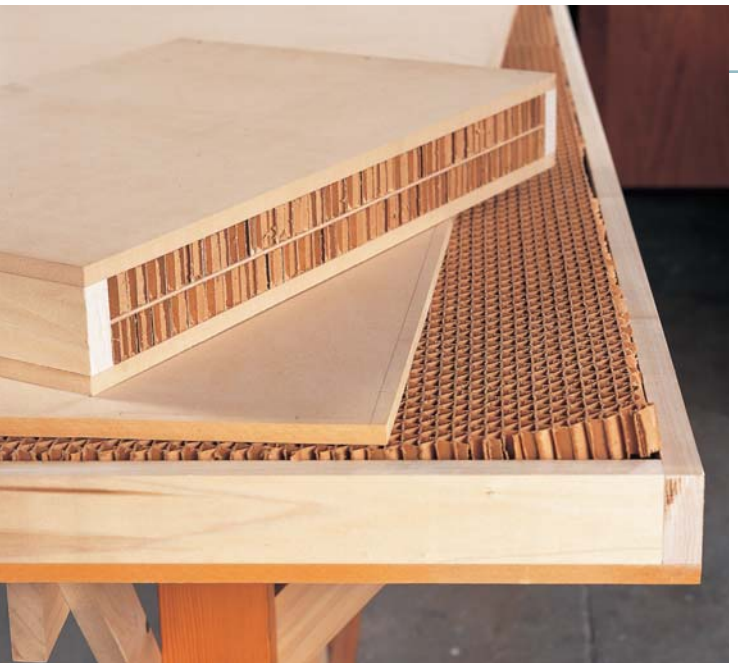
But the benchtop is light enough that it can be easily removed so a different set of legs can be inserted. With longer legs, the bench is the same height as the table saw, becoming an infeed support. Weidner can use an even longer set of legs to raise the table for drawing.

Building the Core

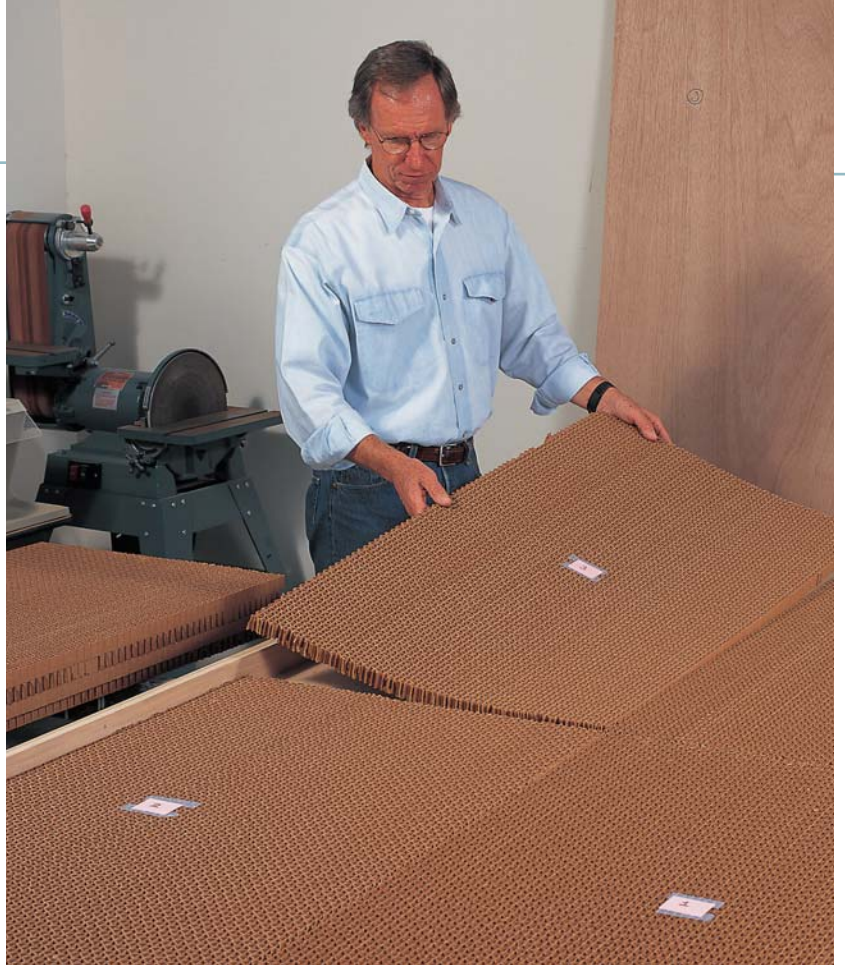
There are two basic methods for building the core: one from squares of notched plywood and the other with some sort of honeycomb material or foam.

Plywood arranged in a grid is what most woodworkers imagine when they think of torsion box core. By setting up a dado blade on the table saw and using a crosscut sled, anyone can build a notched core in no time. The notches fit into one another and overlap, forming the grid pattern.

Honeycomb cardboard is a great way to fill the core of the box. It's readily available by mail order, is light and strong, and glues very well to wood. The down side, if any, is it compresses slightly when clamped, so you must allow for that.



THE CORE OF JOHN BARBEE'S TORSION BOX begins with a sheet of ⅛-in. Luan and then two 1-in.-thick layers of corrugated cardboard on each side. This is covered with two layers of ½-in.-thick ultra lightweight medium-density fiberboard (MDF). Then laminate covers the entire benchtop.



FIRST, THE PERIMETER IS ATTACHED TO THE TORSION BOX; next, glue is applied, and then a layer of cardboard. Glue is applied to each side of the ⅛-in. center core, more cardboard is added, and finally glue is applied to the upper layer of ultralight MDF.

Rigid Styrofoam is used mostly as insulation, but it also makes a good choice to use for cores. It stays flat and compresses less than cardboard. Relatively inexpensive, rigid Styrofoam and is available in 4-ft. by 8-ft. sheets in a wide range of thicknesses.

Remember to plan out the perimeter of the torsion box as part of the design for the core. This will be your drawing straightedge against which your T-square goes, a reference for assembling square panels, and a straight surface against which you can test the straightness of solid boards—among probably hundreds of other uses—so it's important for the edges to be straight and square.

Surface Materials

Plywood and other manufactured materials offer the best top and bottom skin for a torsion box. MDF and Masonite are both good choices because their thickness is generally more uniform than plywood and their top surfaces are smoother as well. (For more on composite materials see p. 39.)

You may want to cover the top working surface with plastic laminate. This gives you lots of choices in color and surface texture, making the surface either slick and glossy or matt, which is what I like. Keep in mind that the more shiny and hard the surface, such as that of plastic laminate, the less friction you'll have for clamping purposes. But smoother surfaces make it easier to remove dots of hardened glue.

Whatever you apply to the top, you should apply to the bottom. Otherwise, the box is almost sure to distort over time, due to differing moisture absorption.

Glues

The strength of the glue bond between the core and the skin is critical. Yellow glue works fine for assembling the interior pieces if you're using a notched plywood core. It also works well for the perimeter joinery, since it's very strong and flexible. But for gluing the top and bottom

IT'S IMPORTANT TO MONITOR THE VACUUM IN THE BAG. If there is any significant leakage, the pump will cycle too frequently and the motor may overheat. This vacuum pump from Vacuum Pressing Systems has an adjustable amount of vacuum and an automatic pressure switch.

pieces to the core, use a hard glue, such as West System Epoxy, Plastic Resin, and Unibond 800. The distributor for the corrugated cardboard core, Vacuum Pressing Systems, also distributes Unibond 800, which they recommend for gluing the core to the top and bottom. These glues provide a much more rigid joint than the common yellow woodworking glue.

Clamping Methods

It's always a challenge to apply pressure evenly to a large surface. There are a host of methods, such as piling up sand bags and using platens and cauls, but inevitably there is more pressure in some spots and less in others. The problem is that the glue tends to migrate away from areas with more pressure toward areas with less pressure. This migration presents a very real potential for lumps and hollows in the very surface you want to be perfectly flat.

A vacuum press can apply equal pressure to all the surfaces. The vacuum bag has provided a technological advance that even the smallest of shops can take advantage of, adding veneered panels glued up right in the shop to the range of possible project components.

Storing Large Worktables

You can build a torsion box just about any size you wish, but larger is usually better. The standard 4-ft. by 8-ft. sheet of plywood is certainly a good size to consider, but even better is one that's slightly larger, because it's easier to glue a 4-ft. by 8-ft. veneered panel when there's a bit of margin all around.

Of course you can build several torsion boxes in different sizes if you have room for them, but in a small shop, floor space is often at a premium. Yes, it's great to have that large flat surface for veneering or assembly, but where do you put it when you don't need it? Since they're essentially self-supporting, the boxes are relatively easy to store—they can be set up on sawhorses or even hinged to the wall so they fold out of the way until you need them.

BRENT MERKLEY BUILDS LOTS OF TORSION BOXES not only for workbenches but for furniture projects and shop-built machines as well. He can quickly knock down and store this torsion box auxiliary workstation in his plywood rack.

Making Your Own Vacuum Bag

John Barbee discovered that none of the commercially available vacuum bags was large enough for his 3-in.-thick, 4-ft. by 8-ft. torsion box. Following the advice of San Francisco area furniture maker Brent Merkley, Barbee decided to make his own vacuum bags out of plain heavy plastic. His neighbor Tim Boswell told Barbee about a sealant developed for the aircraft industry.

Boswell's method of sealing the vacuum bag works like a dream, quickly forming an airtight bag around the torsion box. But the true test came when Barbee applied vacuum to the box. There were a few small leaks that quickly sealed up with either some added finger pressure on the sealant or with patches of duct tape. Once the pressure stabilized, the pump came on only for a few seconds every 3 minutes to 4 minutes, about as close to a perfect seal as you get with a homemade vacuum bag.

For Barbee, the biggest advantage of making a bag like this is that he doesn't have to lift his project and slide it into a bag. He simply folds the bag around his benchtop without moving it an inch.

***TOP*: THIS SPECIAL SEALANT,** used in the aircraft industry to make vacuum bags, forms an effective seal between two layers of plain plastic sheeting. Here John Barbee is pressing the plastic into the sealant to form the vacuum bag.

***BOTTOM*: THE INTAKE HOSE IS A CRITICAL ATTACHMENT,** and the white plastic mesh keeps the intake portion of the hose clear. If the hose cannot freely evacuate air from the bag, the bag won't clamp properly. If the connection leaks, the pump will cycle too frequently, eventually burning out the motor.

The "Murphy" Bench

Perhaps you remember the beds that fold up into a built-in on the wall. Popular with apartment dwellers, this sort of bed frees up valuable floor space for the living area during the day. By night, the full-size bed flips down to offer a good night's sleep. Woodworker Curtis Erpelding applied a similar strategy to his veneering table. Erpelding uses a winch to raise and lower the bench. The legs fold against the bottom so they are out of the way.

Knock-Down Bases

Folding sawhorses are one solution to supporting a large benchtop, but some of these are on the spindly side. You run the risk of having your work come tumbling to the floor if they get overloaded. A sturdier knock-down base prevents such disasters. But assembling a base with hardware takes time to tighten all the connections.

Jim Tolpin took a different approach that avoids the need for hardware. Crossing two

CURTIS ERPELDING USES A VACUUM BAG SYSTEM for gluing large panels. His setup folds up against the wall when it's not needed. Not only that, Erpelding can hoist it up and down with an electric winch and when it reaches the floor, he can detach the whole thing and roll it around on casters.

THESE STOW-AWAY BASES, built by woodworker and author Jim Tolpin are made from inexpensive particleboard reinforced with cleats where they connect. When not in use, the base and the top can be stored flat against the wall.

pieces of sheet goods and joining them with a notch makes a secure joint that can assemble in seconds. Particleboard is cheaper than plywood but needs some support at the notch both to add strength and to prevent wear. To reduce the weight of the base, Tolpin cut large circles out of the sheets.

Thinking Outside the Box

Woodworker and manager of the *Fine Woodworking* shop, John White never tires of inventing shopmade devices to ease his work. His workbench is an example of how a conventional beginning can lead to a totally unconventional result. When he needed a new workbench, White studied traditional designs. Like

JOHN WHITE DEFINITELY THOUGHT OUTSIDE THE BOX when he designed this bench. Using pipe clamps for holding work at the bench is not new, but White took the concept to an entirely new level. His bench uses pipe clamps to hold boards on the flat, on edge, and on end.

NOT JUST A BOARD JACK, John White's lower support shelf positions the board at just the right height to plane the edge. It's entirely adjustable for boards of different widths and supports the board along its entire length.

THIS PIPE CLAMP "TAIL VISE" works in the same way as a traditional vise used with dogs. Panels or wide work is easy to clamp and very secure.

many woodworkers, he found that while traditional benches can clamp smaller pieces well, they fall short for wide boards or frame and panel assemblies.

After several tries, White arrived at a design that incorporates many of the clamping abilities of a traditional workbench. Remarkably, it manages to do this without a single traditional vise. Instead, White uses pipe clamp fixtures and black pipe that can be found in home centers. Positioned under the benchtop along its length and width, and from floor to benchtop, the clamps serve the same functions as an end vise and bench dogs, a front vise, even a board jack.

The pipe clamps cost much less than either commercial vise screws or off-the-shelf quick-action vises. The construction of the bench requires only readily available hardware, ⅜-in.-diameter by 6-in. lag bolts and drywall screws.

White's frugal approach included stock selection. He used Douglas fir framing lumber, cutting the structural members from the centers of 2x10s and 2x12s. Even the cutoffs don't go to waste; they're used for sawhorses and other useful shop projects.

For the center of the bench, White used MDF to make interchangeable panels that lift out so that the pipe clamp "tail vise" can be adjusted to stock of different lengths. Not only are the MDF panels economical to make, they're disposable.

WHEN RUSS FILBECK TEACHES his furniture-making classes in remote locations, he fits his entire shop in the back of his pickup truck. By moving a couple of parts, his shaving horse transforms into a sit-down workbench.

10

Benches for Special Tasks

Most of the benches we've seen so far are meant for general woodworking. But the classic bench can't serve all the tasks in the shop. A woodworker who needs a bench on a job site wouldn't be inclined to haul a 300-lb. classic bench across town. Some specialized areas of woodworking need dedicated benches that have very different configurations. A boatbuilder often needs a very long bench for working hull planks or spars. A chairmaker needs a bench that will hold unusually shaped parts, as does a woodworker who makes rustic furniture.

In this chapter, we'll look at benches for specific woodworking tasks. Not only are these benches often different in size and configuration from cabinetmaker benches but they often use specially designed holding devices. Deciding on a design for general woodworking involves compromises to accommodate a wide variety of needs and projects. Here, we'll narrow the focus, showing a variety of benches made for specific tasks. Among the examples shown here, you may just find the right one for your special task.

ANDY RAE'S LOW ASSEMBLY TABLE is at the perfect height for working on furniture. The bench provides a glue-up surface, a finishing table, a place to lay out parts, and storage for tools and supplies. It also helps keep the main bench uncluttered in his busy shop.

Assembly and Finishing

Whatever a woodworker's final product, the last step before finishing usually involves joining and gluing parts. Yellow glues commonly used in furniture construction have a relatively short open time, 10 minutes or less. In practical terms, this means that final assembly usually happens under tight time pressure. Laying out the right number and size of clamps before hand is a good strategy. It's also best to have the bench surface protected before the glue begins to drip on it. To free up the main bench and provide more work space, woodworkers have developed special assembly benches.

Bench Height

For small-scale projects like boxes, toys, and clocks, the main bench is usually large and flat enough so that a special bench for assembly is unnecessary. But for furniture and cabinets that have larger parts, an additional bench surface helps provide more area for layout and clamping. In the last chapter we looked at benches with wide very flat surfaces so that assemblies can be clamped flat and square. These benches are often about the height as a main bench. For gluing up subassemblies, such as panels or trestles, this is a comfortable working height.

At final assembly or for finishing, the now three-dimensional piece of furniture or cabinet can become pretty bulky. Most woodworkers build low benches for assembly so that all the parts of the piece are within easy reach. Depending on the scale of the projects to be assembled on them, these benches range in height from just off the floor to a few inches below the usual bench height.

Rolling Carts

Very often, the machines to make parts are at one end of the shop and the assembly area is at the other. That's the beauty of rolling carts. You can use them to hold parts, tools for persuading stubborn joints, and clamps. The cart can be moved to any space convenient to where you're working and then shoved out of the way, when necessary.

If a cart is simply a means to keep your tools nearby, it doesn't need to be especially strong or intricate. Chairmaker Brian Boggs's cart is just 1x4s, scraps of plywood, and casters, but it functions as a finishing table, assembly line spot, and chair part storage rack all in one. Not surprisingly, the rack sitting atop the cart looks a lot like Boggs's chairs, but it's nonetheless designed for function, not beauty. Pads made from pipe insulation foam held on with duct tape provide a way to safely store the

SAM MALOOF AND LONG TIME CO-WORKER MIKE JOHNSON work on one of Maloof's famous rockers on a very nicely made low trestle-style assembly table. Once a chair reaches this stage, it's important to have lower work tables so that all parts are within reach.

EACH OF BRIAN BOGGS' WONDERFUL CHAIRS has at least 17 parts. Keeping track of parts for just a single set of four chairs requires having a reliable system. Boggs certainly does have a system. This rolling cart organizes, protects, and transports the parts to his assembly area.

DAVID WADE'S FINISHING BENCH is just a few inches lower than conventional bench height so that he can easily reach all areas of the piece he is finishing. The bench is so simple to make, he can easily replace it or build others of different heights as needed.

prefinished parts, without scratching them, until he's ready for the final assembly.

David Wade, who has rubbed finish on hundreds of Sam Maloof's chairs, uses an equally low-tech design for his finishing bench. It's just a plywood box on wheels covered with an old piece of cardboard. Wade can spin the cart around to access all the parts of the piece of furniture.

Rolling carts have many other uses in the shop besides assembly. It's helpful to have tools nearby when tuning up stationery shop machines. Built to take weight, a cart can help transport heavy parts around the shop and save back strain. If the height of the bench is set at exactly the same height as a machine table, the cart can double as an infeed or outfeed table. In that case, locking casters to keep the cart from running away at a critical moment, are a good idea.

Smart Solution

PROTECTING THE ASSEMBLY BENCHTOP

Keeping glue drips off the benchtop is easier than removing dried glue afterward. So during assembly or finishing, it's smart to use cardboard or paper to cover the benchtop. While newspaper is an old standby, newsprint can transfer to the workpiece. Wide paper that comes on rolls is faster to lay out. It's so convenient that George Levin keeps rolls of it mounted at the end of his assembly bench. He uses the paper to keep glue off of the benchtop, for drawing out his plans, and to help protect the top when he applies finish.

Portable Workbenches

The Workmate® revolutionized the meaning of the word *workbench*. My first Workmate was purchased in 1979 and has been in almost constant use ever since. When my dad bought it and brought it out to the construction site I was working on, it seemed like one of those tools without much substance. "How could those plastic screw threads last more then a few weeks?" I remember wondering skeptically. But I decided to give it a try nonetheless.

Oh my goodness, what a tool! It would fold up into the size of a suitcase, support any amount of weight I could heft up onto it, and

FESTOOL'S MULTIFUNCTION TABLE, like the rest of the Festool line, is part of an integrated system. There is a straightedge guide, which when fitted to the table and used with their portable circular saw makes the table into a wonderfully accurate cut-off saw.

was just the right height for a miter saw—plus, and most important, it allowed me to clamp something securely and very quickly. Before I knew it, I had purchased another. I attached a power strip to each so I could plug in a variety of tools, drilled holes in them endlessly to attach various jigs, left them on job sites, out in the rain, and abused them horribly…and continue to do so to this day. And did I mention those plastic screw threads have withstood this sort of abuse for 25 years so far?

The Workmate's modern cousins, from companies like Festool®, take the concept of a portable folding workbench to a new level. The Festool Multifunction Table is not only a workbench but also a saw table. A hinged straightedge attaches to one side to guide a portable saw or router. You can use it to make very precise cuts with the saw or simply as a work surface. The top has a grid of ¾-in. holes, just the right size for round dogs.

Bench on the Go

While on the job site, my usual routine was to place a hollow-core door atop my pair of Workmates to give me a bit more room to spread out. Finally, after years of doing this, I decided to build some legs for the door and turn it into a light workbench.

The hollow core door is quite flexible, so it won't support much weight on its own. A series of braces reinforce the top enough to easily

WHEN I SET UP ON A CONSTRUCTION SITE, I want a bench that's light to carry, quick to set up, strong enough to support my weight, and offers a fair amount of work surface for me to spread out. After years of contemplating, I finally got around to building it.

support my weight. I could do something more sophisticated to attach the braces, but it takes only 5 minutes to screw them in place. It's easy to carry, folds up in nothing flat, and, with the lower shelf, gives me enough room to keep my tools organized.

Rustic Portability

Woodworker Andy Rae enjoys working outdoors. Taking inspiration from rustic woodworkers, he designed a lightweight, extremely portable bench. The top is a rough plank that Rae has flattened to create a smooth top surface. To hold his work, he added a small vise on one end and drilled holes for holdfasts. Assembly is easy, just few taps of a hammer drives the tapered round tenons at the ends of the legs and stretchers into round mortises under the benchtop and base members.

Disassembly is equally fast. When not in use, all the parts stow away, taking up very little space until Rae has a yen for working outdoors once again.

A THROWBACK TO AN ERA when folks routinely brought the shop to the work instead of the other way around, Andy Rae made this portable bench from an old vise, some small logs, and a single plank for the top. It's drilled for dog holes, which also accommodate holdfasts.

Benches for Working on Irregular Parts

Chairmakers and woodworkers who make rustic furniture have a common challenge: how to hold workpieces that are not nicely square and flat. Not only have these individuals come up with a variety of work tables and holding devices for this purpose, they've designed some benches that don't even look like workbenches.

JOHN NYQUIST SPENDS A FAIR AMOUNT OF TIME hand sculpting his trademark chairs. To make the work as comfortable as possible, Nyquist constantly adjusts the height of the chair horse he uses to hold the workpiece during the shaping process.

DAVID WADE, SHOWN DETAILING ONE OF SAM MALOOF'S CHAIR SEATS, uses a worktable that looks more like an ironing board than a bench. The peninsula is simply a 2×12 covered with old carpet and propped up on one end.

A Chair Horse

John Nyquist's sculpted chairs are extraordinarily detailed. He spends a great deal of time with every imaginable shaping tool to carve the contours. He prefers to do this work standing. To work comfortably, he must constantly adjust the height of the work. His adjustable chair horse provides the perfect clamping surface.

Patterned after a device he saw in an old catalog, the top is a simple plywood box built narrow enough to fit between the legs of the chair. Slots in the horse's legs and top supports make changing heights fast and simple. All he needs to do is loosen four knobs, change the height and tighten them again.

Ironing Board Detailing Bench

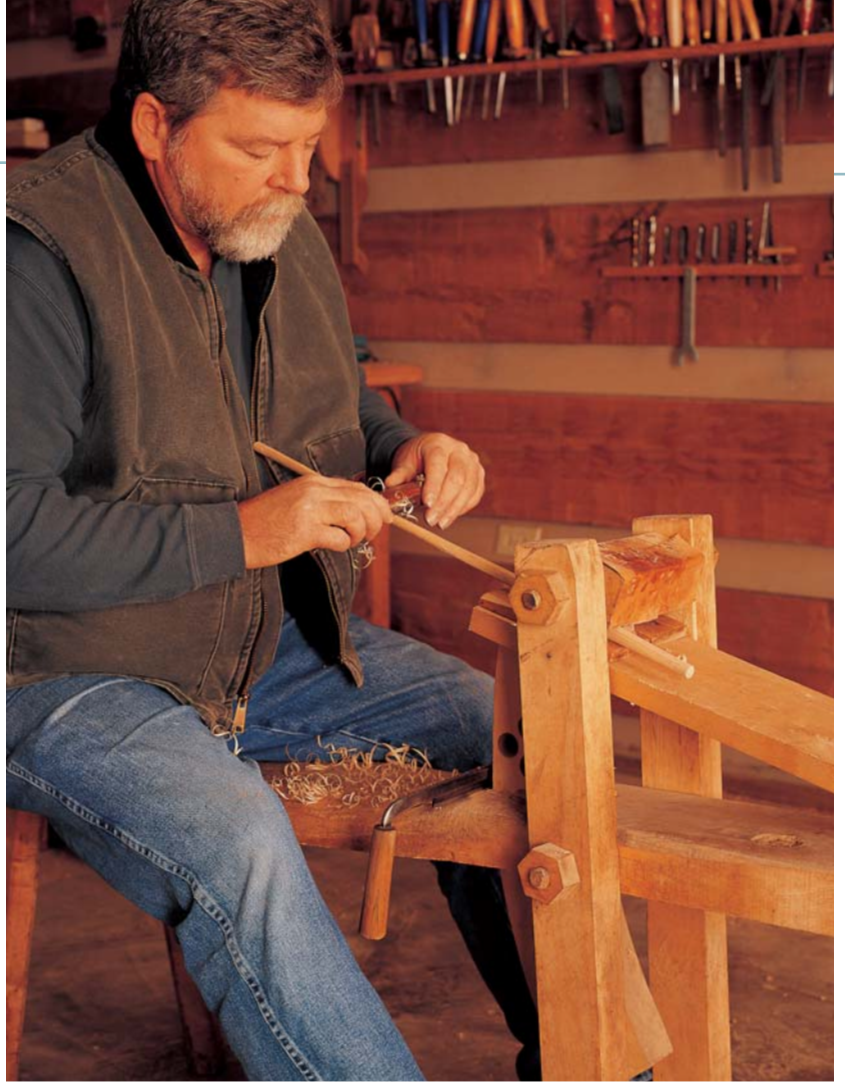
Sam Maloof designs, cuts out, joins, contours, and does all the assembly of his chairs. Then he normally hands them off to one of three dedicated woodworkers who meticulously detail Maloof's distinctive chairs.

David Wade's workstation bears little resemblance to any sort of conventional workbench. The long arm he works on is simply a cantilevered 2x12 covered with carpet. He can clamp a chair in any number of positions under, over, and around the padded bench. This configuration for benches is so efficient that it's used throughout Maloof's shop and has remained unchanged for decades.

Shaving Horses

A shaving horse holds long narrow parts for shaping with a draw knife or spokeshave. In earlier times, chair parts, broom handles, and spokes for wheels were carved on these benches. Chairmakers often traveled from place to place to ply their trade, so a portable workbench was essential.

The wood that is worked on a shaving horse is often green. Traditional chairmakers often take advantage of wood shrinkage to create an extremely strong, long-lasting joint. They drive dry tenons into mortises in green posts. As the wood dries, the opposite forces in the dry and wet parts tightened up the joint. But green wood is far heavier than seasoned wood so the portable shaving horse could be brought right to the trees from which the green parts were cut.



HARKENING BACK TO A TIME when men like David Wright made furniture under a shady tree, this shaving horse could have been made centuries ago. There's not a single piece of metal in its construction. Even the "hardware" is threaded wooden nuts and bolts.

You won't find shaving horses for sale in the pages of woodworking catalogs. If you want one, you'll have to build your own. Maybe that's why there are so many versions of this venerable style of bench. Chairmaker, Russ Filbeck, uses a version that starts out as a conventional shaving horse but turns into a workbench in just a few seconds. Like historical examples, it holds work for shaping long, narrow chair parts. But

RUSS FILBECK'S SHAVING HORSE looks pretty conventional at first. It's ideally suited for Filbeck to shape the rungs of the ladder-back chairs he builds. It's designed so that he can build an entire chair with the equipment he can fit into the back of his pickup truck.

BY CHANGING THE SEAT LOCATION and adding a glued-up section of maple, Filbeck can convert his shaving horse into a sit-down bench. The benchtop is drilled for dogs or holdfasts, so he can drill holes or chop mortises with equal ease.

Filbeck can remove the bridge with its holes and pegs, move back the tiller, and reverse the seat. After he adds a small benchtop drilled for holdfasts, he can use the horse to work the chair seats as well.

Not a Straight Line Anywhere

Furniture maker turned sculptor, Micki Voisard keeps an eye out for unusually shaped wood from the manzanita trees that grow on her property in California. She finds inspiration in the most irregular shapes, and they find their way into her work—whimsical animal sculptures, such as a frog in sneakers, a giraffe on roller skates.

The workbench of such a woodworker has little need for a conventional flat surface, but it does need a means of clamping the branches from which her sculptures spring. The benchtop itself is made of framing lumber and is just large enough to support a simple set of carving tools while she works. The vise Voisard mounted to one end is fairly conventional, but padded with wooden jaws it has some give to hold the branches for carving.

Other Woodworking Specialties

Chairmakers and carvers are not alone in devising clever solutions for holding unusually shaped work. The long parts of a boat require a very different kind of bench and holding strategy. And woodworkers who build stringed instruments are in a class all their own.

A Bench for Boats

Ejler Hjorth-Westh came to this country to build boats. He built his oar-powered lap-strake dory using 8-ft. strips of plywood scarfed together end to end. A scarf joint is a long

tapered joint used to lengthen a strip of wood or plywood. Hjorth-Westh built a special bench to handle long planks. He has a removable insert in his boatbuilding bench designed to facilitate cutting the scarf joints. He cuts the joints with a handplane down to a feather edge. The bench supports the plank its full length right out to the end he's working on. The opening gives him plenty of room to work. Working on the edge of a 20-ft. curving plank thin enough to be quite flexible is no small task. But Hjorth-Westh rigged two pipe clamps to grasp the plank, hold it on edge, and steady it enough for him to shape it—all without a helper.

A CARVER WHOSE EVERY WORKPIECE IS A NATURAL BRANCH as it comes from the tree hardly needs a conventional bench. Micki Voisard's bench, which usually resides on the deck of her California home, has a small bench-top and a simple vise fitted with wooden jaws.

FURNITURE MAKER EJLER HJORTH-WESTH makes his living in the summer months fishing in the lap-streak dory he built. Planks for the dory are upward of 20 ft. long. He rigged this bench setup to hold each plank on edge so he could smooth its contour.

JEFF TRAUGOTT USES HIS SIMPLE MAIN BENCH as a base for a series of removable forms and jigs for making his custom guitars. He mounted a pivoting clamping fixture on sturdy steel post for shaving the braces on the underside of the guitar.

A Luthier's Bench

The finely made thin parts of a violin or a guitar require secure but delicate clamping during every stage of the process. Guitar maker Jeff Traugott's workbench is actually quite simple by cabinetmaker's standards. For example, it has a leg and apron base that is screwed together. The top is a sheet of ¾-in. plywood.

The magic, however, is not in the bench but in what Traugott attaches to it. Instead of separate workbenches for each step in building a guitar, he's made a series of special clamping fixtures and sanding and assembly jigs that can easily be fastened to and then removed from the main bench. Not only does this enable Traugott to work more systematically, it makes efficient use of the both the bench and the floor space in his shop.

Dedicated Task Benches

A cabinetmaker's bench, if properly planned, can serve for a wide range of shop activities. But if you have the space in your shop, you should consider specialized benches for tasks you do frequently. That leaves your main bench free for the jobs it does best: cutting and shaping parts.

Sharpening Station

The flat benchtop is a good surface for sharpening tools, but metal filings and the slurry from water stones can make a real mess. One solution is to make a removable sharpening table like that shown on p. 105.

But frequent sharpening of hand tools makes for better and safer woodworking. When an edge tool needs honing, it's easier just to go to a place where stones and a grinder are set up on a permanent basis. That's where a sharpening station comes in.

GARRETT HACK'S SHARPENING STATION holds all the basics, including a grinder and sharpening stones. A hand-tool expert, Hack sharpens his handsaws himself and has a saw vise permanently mounted to the bench.

A dedicated sharpening bench should be sturdy enough to hold a grinder and absorb its vibration. The benchtop should be just big enough to hold your stones, lubricant, and rags. The surface will be subject to water and oil spills, so a finish that wipes clean is a good idea. At the same time, it shouldn't be too slippery, or the stones will move during sharpening and honing.

A Bench for Routing

The vises and dogs of a cabinetmaker bench will securely hold a piece of stock for routing. Many router operations, especially joinery, require seeing the location of the bit. If you are on the tall side, or your work involves a lot of routing, you may find bending to see what you're doing begins to strain your back.

Woodworker and router expert Pat Warner owns dozens of routers and, not surprisingly, it's the tool he uses most. Warner has invented methods and jigs and fixtures so that he can make a router do what most woodworkers need a whole shop full of tools to do. To go along with all of his clever jigs, Warner also built himself a special bench. At 40 in. high, it's taller than the average bench, but just right for Warner, who's 6 ft. 1 in. tall. The benchtop is fairly narrow, and the base is two uprights with long feet for stability. To strengthen it, Warner added cross braces below.

GIVEN THAT HE'S WRITTEN HALF A DOZEN BOOKS ON THE TOPIC, it's fair to say Pat Warner knows something about routers. His take on the sort of ideal bench for routing is one that's higher than normal and narrow enough to clamp jigs to its top and ends.

Bench Options

Passing It On

Woodworking is a craft steeped in traditions going back thousands of years. There is great pleasure in passing this knowledge to our children. Some of today's woodworkers are lucky enough to have learned from parents or grandparents.

But how do you make a bench that's right for a small person? Obviously, the height of the bench depends on the size and age of the child. The height requirements for an adult bench simply need to be adjusted proportionately to the child's height. And the trick of standing with the palm flat to the floor and measuring the distance works just as well for kids. But kids do something that adults don't—they grow. So if a bench is to be useful for more than a year or two, you should plan on some way to adjust the height from time to time.

Age will also determine the configuration of the bench. Small-scale but fully operational vises may look cute, but will a very young child actually use them? For a child of 5 years or 6 years, a bench that simply resembles an adult bench may be enough for play. Older children who actually build projects at the bench, can use a standard vise instead of a child-size replica.

When is the right time to introduce a child to woodworking? A working shop is a dangerous place for a young child without careful adult supervision. Richie Starr, a middle school teacher in Vermont and author of *Woodworking with Kids*, has taught 10-year-olds to 14-year-olds for more than 30 years. He has successfully shown that children this age are capable of both designing their own projects (with help) and using tools safely.

AUTHOR AND WOODWORKER ANA CARTER likes having her children around the shop. With benches built just for them, they can experience that wonderful feeling of satisfaction that comes from building a project with their own hands.

IDEALLY SUITED FOR THE BUDDING WOODWORKER, this child's bench from Lee Valley Tools is available only intermittently. With two vises, tool storage, and even bench dogs, it's definitely a real bench, simply scaled down.

Resources

Bases

Adjustabench
232 Stokes Avenue
Trenton, NJ 08638
609-882-3300
www.geocities.com/adjustabench
This is an adjustable-height workbench base assembly. You can build or buy a top for your bench then bolt on this base assembly for a bench that will adjust in height. The assembly is quite rigid and easy to adjust. It has a castor option to make the bench portable.

McMaster-Carr
Atlanta 404-346-7000
Chicago 630-833-0300
Cleveland 330-995-5500
Los Angles 562-692-5911
Philadelphia/New York
732-329-3200
www.mcmaster.com
McMaster-Carr is a mail-order company that carries metal workbench bases, wood and metal tops, and any nut bolt or machine part you could ever imagine. If you check out their Web site, you'll soon see this vastly understates the variety of their line.

Vises and Vise Screws
(See also "Retailers," p. 198.)

Advanced Machinery
Zyless Vise
P.O. Box 312
New Castle, DE 19720
800-727-6553
www.advmachinery.com
This is the vise I would take along if I were to sail around the world on a small boat. It's light and versatile and clamps on to the edge of any bench. The array of accessories makes this tool a vise, clamp, drill press, lathe, and more.

Beall Tool Company
541 Swans Road NE
Newark, OH 43055
800-331-4718
www.bealltool.com
They sell wooden screw threading books and tools. Beall has developed the technology and tooling to thread screws efficiently and accurately. Instead of a conventional die to cut threads on the screw, he's developed a router jig so a rotating cutter cuts the threads.

Crystal Creek Mill
P.O. Box 41
DeWitt, NY 13214
315-446-1229
These precision wooden vise screws are made to order. Howard Card doesn't share how he manufactures his wooden screws and nuts. He makes each one to order, any length or configuration you would want if you're contemplating making a vise with a wooden screw.

Dieter Schmid—Fine Tools
Cauerstrasse 18
10587 Berlin, Germany
49 30 342 1757
www.fine-tools.com/spindel.htm
This link takes you to a page of German vise screws and vise hardware. This is where you'll find photos of Ulmia style hardware for front vises. There is also a chain-driven front vise mechanism like the one from Lee Valley for end vises.

Emmert Vises

The Iron Hand
www.mprime.com/emmert/index.htm
With more information than you ever wanted to know about patternmaker's vises, Carl Matthews' is the ultimate site for Emmert vise fans. He has photos of each model, links to resources like spare parts, a lot of the history of the vise, and links to other workbench sites.

Union Hill Antique Tools
www.tooltimer.com/emmert.htm
This is the site of downloadable original plans for Emmert installation, complete with wonderfully original drawings. Here you can also find old tools, including Emmert vises for sale and a great links page to tool collector's sites.

Roger Van Maren
www.rogervm.homestead.com/Emmert.html
On this site, Van Maren shows how to mount an Emmert vise. Van Maren restored an old Emmert and mounted it to his bench according to the original instructions. The rear jaw comes out flush with the front edge of the bench.

Vacuum Bagging

Airtech International
5700 Skylab Road
Huntington Beach, CA 92647
714-899-8100
www.airtechonline.com
They sell vacuum bag sealant tape for making your own vacuum bags. Look for product number AT-200Y. This is the sealant John Barbee used to seal the vacuum bag in Chapter 9.

Vacuum Pressing Systems
553 River Road
Brunswick, ME 04011
207-725-0935
www.vacupress.com
Here find vacuum pumps, vacuum bags, special glue, corrugated cardboard for torsion boxes, and more. This is a single source for the Unibond 400 glue, the cardboard inserts, and other vacuum bag supplies used in torsion box construction.

Austin Hardwoods
610 North Santiago Street
Santa Ana, CA 92701
714-641-2833
www.th-h.com
Find hardwoods, butcher-block tops, hardware, all shipped to your door. The business itself is in southern California, but they ship nationwide. They stock domestic hardwoods, exotics, figured woods, veneers, tools, and supplies.

Bench Building Classes and Workbench Plans

Marc Adams School of Woodworking
5504 East 500 North
Franklin, IN 46131-7993
317-535-4013
www.marcadams.com
This is a world-class woodworking school in Indiana offering instruction for all skill levels. Classes in just about any facet of woodworking you can think of, including design, joinery, hand tool and power tool skills, and of course, workbenches. Week-long classes focus on a particular topic with well known instructors.

Lon Schleining
1416 East Burnett Street Suite C
Signal Hill, CA 90755
562-595-5868
www.woodbender.com
The author's Web site has links to all the sources listed here and also has plans for some of the benches in the book and a Q&A section. Schleining teaches seminars on bench building at woodworking shows, guilds, and schools nationwide. Check the Web site for his travel schedule and availability.

Workbench Plans
www.workbenchplans.com
This site has lots of bench tips and resources. A link takes you to **www.plansnow.com**, where you can download workbench plans, including some free plans.

John Nyquist
2110 West Seventeenth Street
Long Beach, CA 90815
562-437-7616
www.nyquistfurniture.com
Plans for the Nyquist bench include drawings for his tail vise, both available from his site. There are also plans for the chair horse Nyquist uses.

Benches Made to Order

David Charlesworth
Harton Manor
Hartland, Bideford
Devon EX39 6BL, UK
01237441288
www.davidcharlesworth.com
Find workbenches with removable center tray sections made in the United Kingdom to Charlesworth's design.

Rob Cosman
P.O. Box 3260
Grand Bay, NB E5K 4V5 Canada
506-738-9663
www.robcosman.com
A site for custom-made traditional workbenches with shoulder and tail vises. Cosman doesn't make many benches, but he does take a commission for one or two at a time.

Curtis Erpelding
7854 Square Lake Road
Port Orchard, WA 98367
360-895-2663
www.curtiserpelding.com
Erpelding makes custom furniture and occasionally a workbench like the one he made for Gary Blaise on the back cover of *Fine Woodworking* #131.

Workbench Manufacturers

Carlsson Workbenches
Qvarnsövägen 25
570 83 Rosenfors, Sweden
049520662
www.winglink.com/mhb/english/
Find workbenches with wooden vise screws made in Sweden. This is the company that made the bench Ejler Hjorth-Westh uses.

Workbench World
9 Blaikie Street Unit 5
Myaree, Western Australia 6154
61 8 9330 5758
www.workbenchworld.com.au
This Australian bench maker builds a line of benches that runs the gamut from mechanics' benches to those for woodworkers. They build kits, benches to order in addition to their stock line.

Diefenbach Workbenches
33498 East US Highway 50
Pueblo, CO 81006
800-322-3624
www.workbenches.com
A full line of German made workbenches is found here. The company will make special benches to order, for example a left-handed bench with the vise locations reversed from the normal configuration.

Ulmia
Altheimer Str. 1
D-88515 Langenenslingen, Germany
49 (0) 7371/966920
www.ulmia.de
German benches, accessories, tools, and hardware are found here.

Laguna Tool
17101 Murphy Avenue
Irvine, CA 92614
949-474-1200
www.lagunatools.com
Laguna Tool carries a full range of workbenches and stationary power tools imported from Europe.

Tools and Portable Benches

Festool USA
Tooltechnic Systems, LLC
140 Los Carneros Way
Goleta, CA 93117
888-337-8600
www.festool-usa.com
Festool carries full line of very high quality power woodworking tools made in Europe including a fold-out portable bench They have sales outlets in nearly every state.

Lie-Nielsen Toolworks
P.O. Box 9
Warren, ME 04864-0009
800-327-2520
www.lienielsen.com
Lie-Nielsen sells very high quality hand tools, replacement parts like plane irons, and books on woodworking. Don't miss the section about the use and care of individual tools on their Web site.

Retailers

Woodcraft
P.O. Box 1686
Parkersburg, WV 26102-1686
800-225-1153
www.woodcraft.com
Woodcraft carries the full line of Sjöberg benches. They also carry the quick-release front vise hardware I used for the bench in Chapter 9 and good-quality screws for tail vises and shoulder vises. There are 74 stores nationwide.

Woodworkers Supply
5604 Alameda Place NE
Albuquerque, NM 87113
800-645-9292
www.woodworkerssupply.com
One of the largest woodworking product lines, Woodworkers Supply carries bench plans, vises (including a quick-action front vise mechanism), Jorgenson vises, and thousands of cabinet hardware items. There are stores in Albuquerque, NM; Casper, WY; and Graham, NC.

Garrett Wade

161 Avenue of the Americas
New York, NY 10013
800-221-2942
www.garrettwade.com
For decades, the New York-based Garrett Wade company has sold workbenches, accessories, tools and hardware. A leader in workbench development, Gary Chinn will be happy to special order any Ulmia bench you find on the Ulmia Web site.

Grizzly Industrial, Inc.

800-523-4777
www.grizzly.com
Grizzly carries premade butcher-block tops, metal bases, tools, machines, and hardware. They have a great Web site and catalog, showing the truly amazing range of machinery, tools, and equipment they carry. Showrooms in Springfield, MO; Muncy, PA; and Bellingham, WA. Don't miss the chance to see their gigantic showroom in Springfield, MO.

Hartville Tool

Hartville Hardware
940 West Maple Street
Hartville, OH 44632
800-345-2396
www.hartvilletool.com
Hartville Tool carries workbench plans, accessories, vises, and hardware. They have the Wilton quick-action front vise and the Jorgenson quick-action front vise in two sizes.

Highland Hardware

1045 North Highland Avenue NE
Atlanta, GA 30306
800-241-6748
www.highlandhardware.com
Highland Hardware carries the Hoffman and Hammer line of workbenches, Veritas vises and accessories, 2¼-in.-thick maple butcher block bench tops, tools, and hardware galore.

Lee Valley

Lee Valley Tools Ltd.
P.O. Box 1780
Ogdensburg, NY 13669-6780
OR:
P.O. Box 6295, Station J
Ottawa, ON K2A 1T4 Canada
800-871-8158
www.leevalley.com
Lee Valley carries the Veritas line of workbenches, the twin-screw end vise, the Tucker patternmaker's vise, bench plans, cast-iron bases, bench accessories, hold-downs, and hardware. Their site offers lots of woodworking tips.

Rockler Woodworking and Hardware

4365 Willow Drive
Medina, MN 55340
800-279-4441
www.rockler.com
Rockler carries Sjöberg workbenches, lots of bench accessories tools, and hardware. They have stores nationwide and a great Web site and catalog. Rockler has the full line of T track hardware and accessories.

Index

T

U

V

W

CRAFTS & HOBBIES

A Complete Guide to Creating Your Perfect Bench

Ask any experienced woodworker what makes the perfect bench and the answer will be: "it depends." What it depends on is what you build and how you like to work. For the time being, try to put your mental pictures of the "proper" bench aside. Instead, concentrate on asking yourself what you need in a bench.

—From Chapter One: "*The Perfect Bench*"

The Taunton Press
63 South Main Street
P.O. Box 5506
Newtown, CT 06470-5506
www.taunton.com

The Taunton Press
Inspiration for hands-on living®

Look for other Taunton Press books wherever books are sold or visit our website at www.taunton.com.

Taunton Product #077901