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2019

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Vol. 41 / No. 242

BUILD YOUR OWN CNC ROUTER

Plus:

**5 Must-Have Tools
for Your Shop**

**Clean, Accurate Mortises
with Your Drill Press**

**The Right Clamps for Every Job
We Share Our Favorites**

Tips & Tricks for:

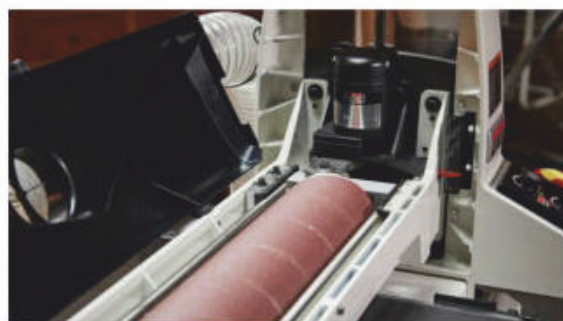
- Ripping Live-Edge Lumber
- Routing Small Workpieces
- Outdoor Glueup Strategies



SUPERIOR FINISH FROM BEGINNING TO END



THE NEWLY RE-ENGINEERED 2244 OSCILLATING DRUM SANDER FROM JET HAS AN EXCLUSIVE OSCILLATING FEATURE THAT HELPS CREATE THE BEST SANDING FINISH WITH THE LEAST AMOUNT OF DUST



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from the editor

Sawdust

When Chris Fitch, our creative director, first approached me with the idea of building a CNC router in *Woodsmith*, I had my doubts. It seemed like an incredibly ambitious project. But there's one thing I've learned working with Chris over the years — never underestimate his ability to make even the most challenging tasks achievable.

And that's certainly the case here. Chris suggested that by using a kit containing the necessary motors and electronics, along with some readily available hardware, he could build a decent-sized CNC router for substantially less than the cost of purchasing one. Because I still wasn't entirely convinced, he built a prototype any way and used it in his own shop for over four years. Based on the knowledge he gained from that experience, he tweaked the design in a few spots and the final product is the machine that you see on the cover of this issue. We've even made a short video of Chris describing the features of the machine and walking you through how it works. You can view it on our website, *Woodsmith.com*.

Because this is a fairly large project, we've broken it up into two parts. In this issue, we'll show you how to build the bed of the machine and the sliding gantry. Then in the next issue, we'll cover making the router mount and wiring up the electronic components.

The woodworking aspect of the project isn't difficult — it consists mostly of plywood butt joints and woodscrews. But once you're done with the construction, you'll need to spend some time configuring the electronics and troubleshooting any technical issues. If you're not already familiar with CAD software, you'll have to learn a couple of computer programs before you can actually start using the machine. This shouldn't pose too much of a challenge, but it is something to be aware of before you get started.

If you're more of an analog woodworker (like myself) take a look at any of the other three projects in this issue. We've got a set of handsome outdoor furniture, a classic sugar chest, and a trio of smart-looking tabletop plant stands. Hopefully among this mix, you'll find something that piques your interest.

SHOP TOURS. As we head into the summer months, I want to mention that if your vacation plans happen to take you through Des Moines, Iowa, feel free to stop by for a tour of our shop and facility. (You can reach us through the customer service information in the margin at right.) We always look forward to connecting with fellow woodworkers.

Vince

Woodsmith®

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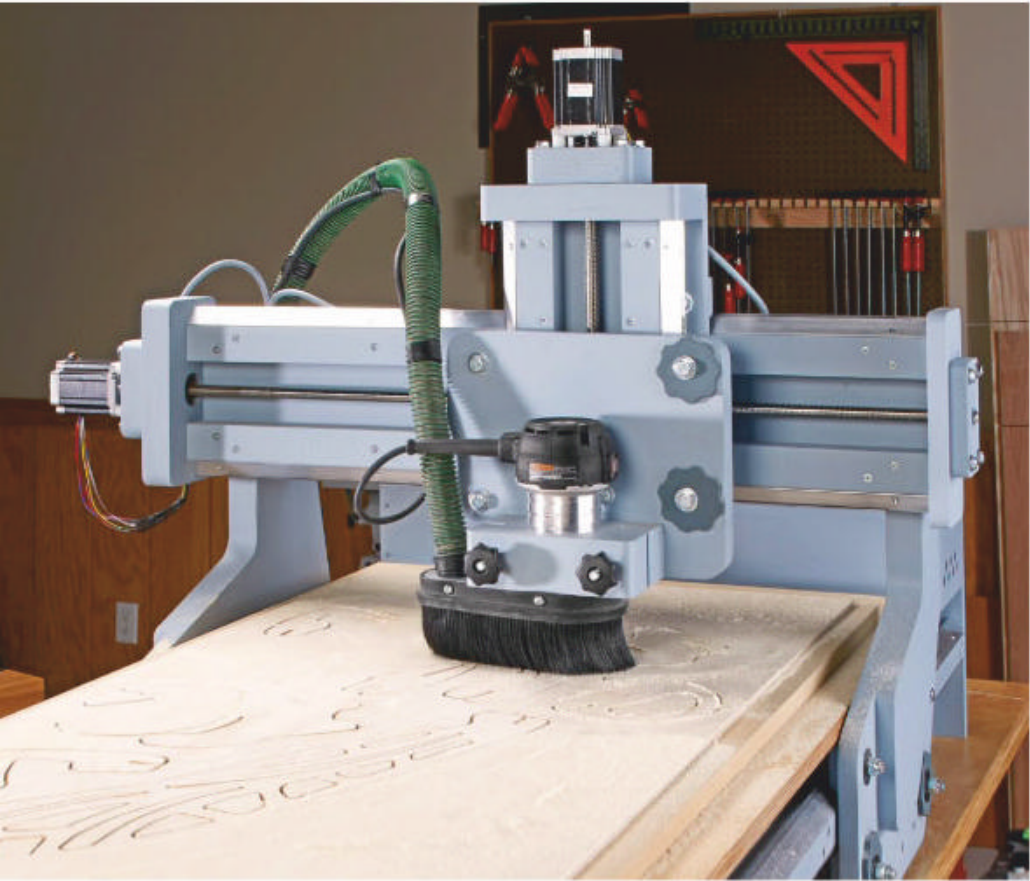
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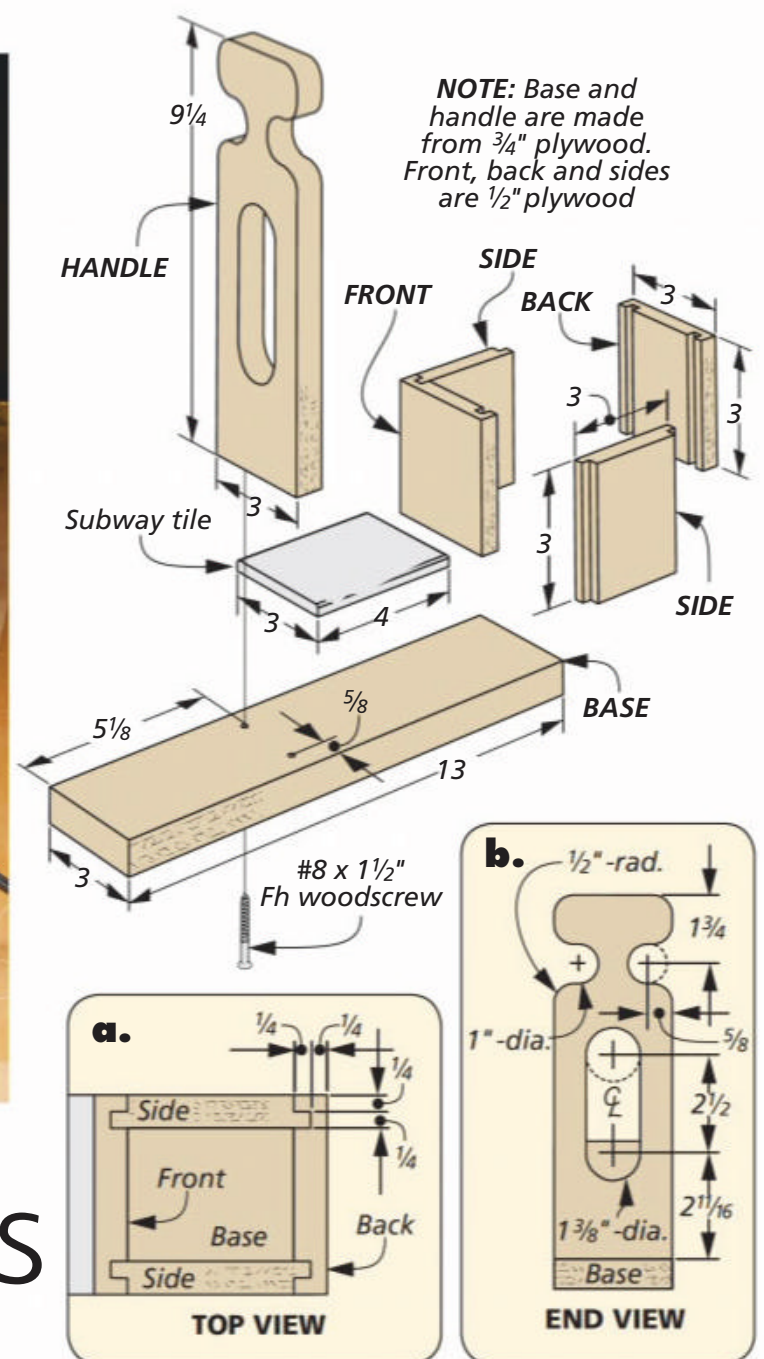
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Tips & Techniques

Glue Gun Holster

One tool I often use in the shop is my hot glue gun. It usually surprises people, but I can't imagine working without it. Storing and moving it around the shop is a pain, however. That is, until I built this glue gun holster.

CLEAN & CONVENIENT. As anyone that has used a glue gun knows, as they heat up and sit, they can get a little messy.

Some glue always seeps out of the nozzle. In addition, the hot tip can cause burns if the gun falls over or touches your skin. This caddy takes care of both of those problems.

A plywood base serves as the foundation for this holder. Attached to this is a plywood holster for the gun. I shaped the top to also act as a handle.

At one end of the base, I added a small box to hold a handful of glue sticks. To solve the problem of dripping glue, I trimmed down a subway tile and put it between the holster and the stick holder. Now, I can move my glue gun around the shop without worry.

Dave Garrig
Twin Forks, Utah



Win This Forrest Blade

Simply send us your favorite shop tips. If your tip or technique is selected as the featured reader's tip, you'll win a *Forrest Woodworker II* blade. To submit your tip or technique, go to *SubmitWoodsmithTips.com*. There you can upload your tips and photos for consideration.

The Winner!

Congratulations to Dave Garrig, the winner of this *Forrest Woodworker II*. To find out how you can win this blade, check out the information at left.

Crosscut Sled Box Joint Jig

After building my first crosscut sled, I realized how versatile it could be and was excited to expand its capabilities. When I had a project that required box joints, I realized the jig you see here was the perfect add-on to my crosscut sled. This box joint jig is easy to make and takes most of the trial and error out of cutting box joints. And best of all, it's much smaller and easier to store than a standard box joint jig.

MICRO-ADJUSTMENT. The jig consists of a fence and cleat that slides along the track on my sled. The micro-adjust mechanism allows you to fine-tune the jig and takes the guesswork out of cutting box joints.

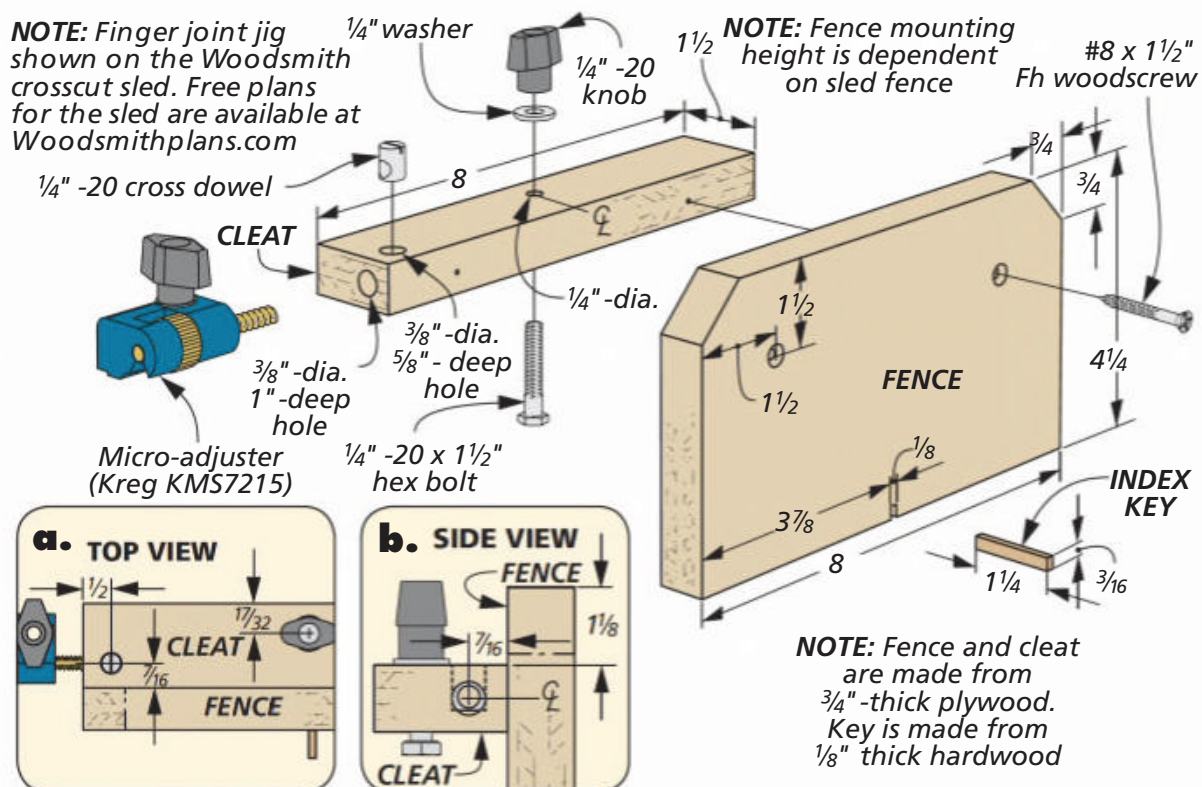
The fence is a piece of plywood with an index key glued into a slot. The width of the index key should match the desired size of the box joints. Because I make different size box joints, I made a few different fences that can be swapped out quickly.

USING THE JIG. Using the jig is a simple process and similar to other box joint jigs you may have used. It slides onto the track and its position can be fine-tuned with the micro-adjuster. If I'm cutting larger box joints, I use a dado blade. But for most joints, I leave my rip blade in the saw. After a test cut to confirm the setup is correct, I know that I'm going to have perfect box joints every time.

*Fredrick Benter
Owatonna, Minnesota*



NOTE: Finger joint jig shown on the Woodsmith crosscut sled. Free plans for the sled are available at Woodsmithplans.com



QUICK TIPS



Axis Limits. Shane Burk of Lubbock, TX installs a pencil into the chuck on his CNC head. This way, he can draw axis limits on his CNC bed and pre-draw part locations on his worksurface. By pre-drawing, Shane can maximize his material and make sure his parts fit before he cuts.



Cheaper Sweeper. Steve Schroeder of Waukesha, WI discovered that a door sweep makes the perfect cleanup brush. The sweeps are available in long lengths and are inexpensive. By cutting a piece into shorter lengths, Steve now has a brush at each tool.



▲ The plug for the inside of the PVC roller is cut using a hole saw. The pilot bit matches the size of the threaded rod.

PVC Outfeed Support

I designed my workbench to be the appropriate height to act as an outfeed support for my table saw. But, when I replaced my old table saw, the bench was suddenly too short to serve that purpose. Instead of building a new bench, or trying to raise it, I built a roller support that clamps on my bench.

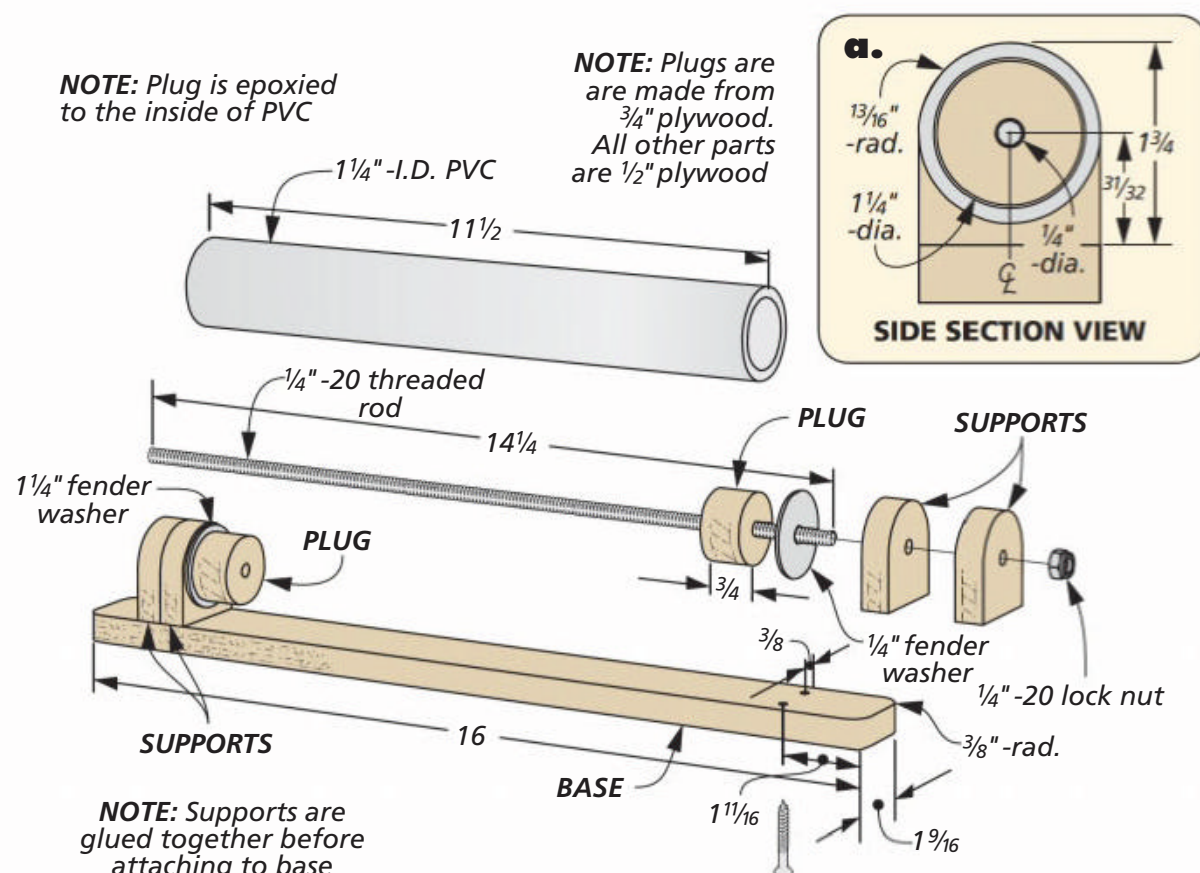
PVC ROLLER. I constructed the roller out of some PVC pipe that I had in my shop. I plugged each end with plywood, and a length of threaded rod fits through the pilot hole in the plugs. The rod serves as an axle and allows the roller to spin. A pair of supports on each end raise the roller to match the table saw height. A large fender washer on each



end spaces out the roller from the supports. Everything is then attached to a plywood base.

To use the roller, I simply attach it to my benchtop using a pair of small clamps. With the roller installed, my workbench once again is the perfect outfeed support.

Craig Turner
Lafayette, Louisiana



DIGITAL WOODSMITH

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If you have an original shop tip, we would like to hear from you and consider publishing your tip in one or more of our publications. Jump online and go to:

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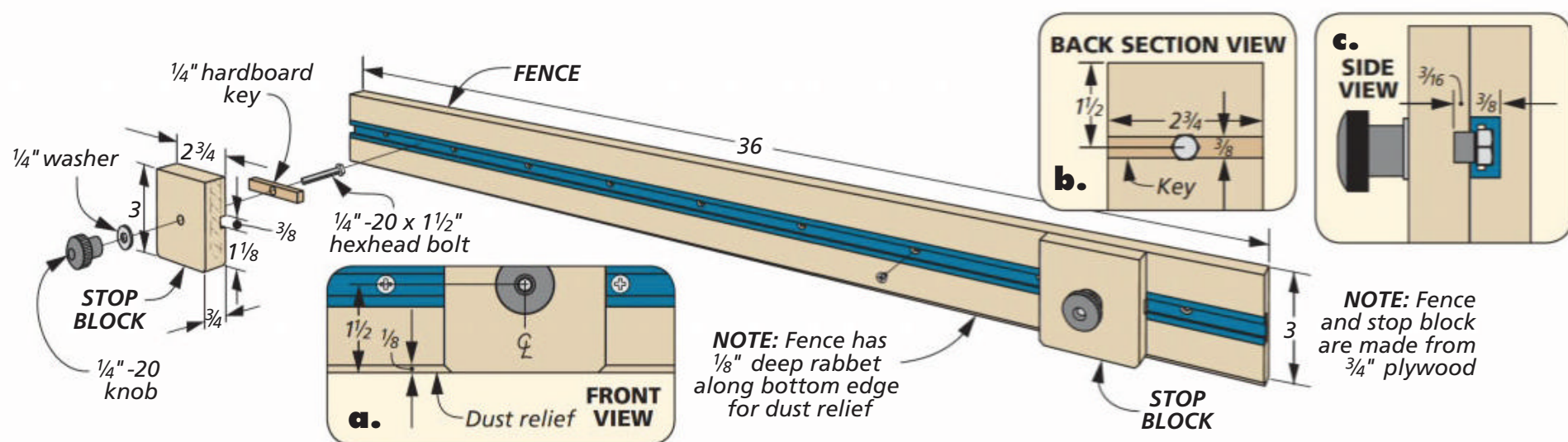
Quick Hinge Mortise Jig

Cutting mortises for hinges is something I usually do with my handheld router and a chisel. But when I needed to quickly cut mortises on the edge of some doors, I built the adjustable jig for the table saw that you see above.

MITER GAUGE EXTENSION. The jig is a plywood miter gauge fence with a T-track recessed in it. A pair of stop blocks that ride in the T-track set the start and stop positions of the mortises. By using a rip blade in the table saw, I can make a cut

with the workpiece against each stop, then nibble away the waste in between. Then, I flip the workpiece around to cut the second hinge location.

*William Aulick
Cincinnati, Ohio*



QUICK TIPS

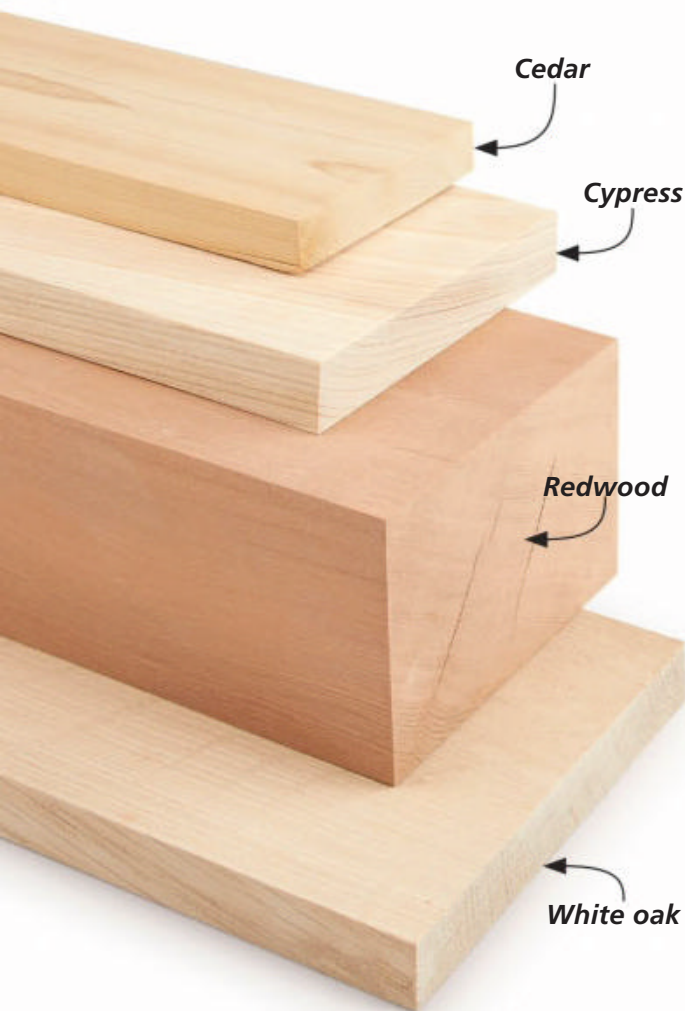


Makeup Dispenser. Bob Zimmerman of Des Moines, IA uses a self-dispensing makeup container to hold solvents that he uses in his shop. The dispenser has a pump top so Bob can grab a towel and push it on the lid. This loads the towel with the perfect amount of solvent.



Paint Roller Paper Towel Holder. Joe Kern of Atkins, IA gets a little extra mileage from a spare paint roller. He found it serves as the perfect holder for a roll of paper towels when it's not in use. He hangs it close to his workbench, and now a roll of paper towels is always close at hand.

Building for the **Outdoors**



▲ Good material selection will give you a solid foundation for outdoor projects, and act as the first layer of protection.

Whenever the subject of outdoor furniture comes up, it conjures an image in my mind that I'm sure you're familiar with — or can at least picture. It's that old, weathered piece of furniture that's seen better days. The finish is nonexistent, the wood is dry and cracked. A few of the joints are probably loose as well.

But that doesn't mean that outdoor projects you build are destined for the same fate. By making careful material selection and taking some preventative measures, you can keep your outdoor projects looking great.

THE CULPRITS. Before I talk about the steps to take for protecting your project, let's identify the forces that take a toll on outdoor furniture. The big three are insects, moisture, and ultra-violet (UV) light damage. While we can't completely avoid all of these things, we can give ourselves a fighting chance with some careful planning.

A GOOD FOUNDATION. One of the first things I think about when building outdoor furniture is material selection.

For indoor projects, I usually choose the wood based on appearance. When it comes to a project that will live outdoors, there's a little more thought that needs to go into it.

There are a handful of species that excel in the elements and they can be seen in the photo at left. Domestic woods such as white oak, cedar, redwood, and cypress all stand up to moisture and are insect and rot resistant. Tropical hardwoods such as ipe and teak are good choices as well. That's not to imply that they're rot or waterproof. Given enough time and moisture exposure, they can break down. But the density and natural oils of these woods will keep moisture and insects at bay the longest, and are a great option for use in outdoor furniture.

A GOOD BOND. After selecting the material for your project, the next thing to give some thought to is adhesive. Set aside your standard wood glue. While most yellow glues are somewhat water resistant, there are some better options.



▲ To beat the heat and moisture, choose a glue that is waterproof. These include epoxy, polyurethane glues, and products such as *Titebond II* and *Titebond III*.

▲ Polyurethane glue requires moisture to activate it and allow it to bond. Once the foaming is done and the glue is dry, it's impervious to water and makes a good choice for outdoor gluing tasks.

Waterproof glues, such as *Titebond II* or *III* are the ticket here. They work like standard glues, but with the added benefit of being designed for exterior use (photo above).

You're not limited to these, however. Two-part epoxy makes a great outdoor adhesive. Epoxy comes in many forms and can offer longer working times for complex glue-ups, such as a trellis.

It would be a disservice to not mention polyurethane glues. It's waterproof once dry, and makes an excellent outdoor glue. The foaming action as it dries can be a turnoff, however (upper right photo).

If your project has fasteners, such as screws or other hardware, make sure to pick up stainless steel or coated hardware. Nothing ruins a project like a stain from a bolt that's started to corrode.

UV INHIBITORS. Just because you've chosen a wood that's durable doesn't mean you can stick your project outside as soon as the glue dries. UV damage and surface moisture will quickly turn the wood into a rough gray mess. That's where the second layer of protection enters the game — a quality outdoor finish.

What separates an indoor finish from an outdoor finish? The biggest thing is the addition of UV inhibitors. Those same UV rays that give you a sunburn also take their toll on the surface of wood and bleach it to a bland, gray color. In addition, the finish needs to act as a barrier to keep moisture out.

For a little extra moisture resistance on end grain furniture feet, I like to pack the end grain with epoxy. See the How-To box at left for more on this.

MAINTENANCE. Your choices for a finish range from penetrating exterior oils to outdoor varnishes, epoxy sealers, and of course, paint (left photo). While these vary in the amount of protection they offer (oils the least, paint and epoxy sealers the most), they all require one thing — maintenance.

Over time, UV rays will degrade the finish and in particular, the UV inhibitors. A maintenance coat of finish is the best protection you can offer. The time between coats varies with sun exposure and the type of finish you're using.

Before you start building your next outdoor project, spend a little time planning it out. If you do, you'll end up with a piece that always looks as good as the day you built it. **W**



▲ A variety of finishes offer good outdoor protection. You can use outdoor oil, spar varnish, and even paint. No matter which finish you choose, the biggest factor is maintenance. Every type of outdoor finish will need to be reapplied periodically.

How-To: KEEP YOUR FEET DRY

End grain is the most susceptible when it comes to moisture. The straw-like fibers quickly absorb water through the ends. An easy trick to combat moisture is to "pack" the end grain with epoxy. By creating a reservoir with tape, a layer of epoxy can be added to the feet.

Create a tape dam and flood it with a healthy serving of epoxy. After curing, remove the tape and sand the epoxy smooth. ►





Routing Small Parts

In many shops, the router table is an indispensable tool for its ability to create custom profiles. Most router tables have a surface large enough to accommodate a substantial-sized workpiece. However, one place where many router

tables encounter challenges is routing small workpieces.

The problem is that large openings in the tabletop and fence can cause a small part to catch or “dip” below the surface. This can not only spoil the cut, but it’s also unsafe. But that doesn’t mean you need to give up on routing small parts. Making cuts safely and accurately requires a different strategy and some simple, shop-built helpers.

THE PROPER MINDSET. It may seem counterintuitive, but the best way to go about routing small parts is to avoid it whenever possible. However, that doesn’t mean you can’t use small parts. Instead, the solution is to do any routing operations on a larger blank before cutting the part to final size at the table saw. The photo at left shows what I mean. It’s a great way to make small parts, like corner moldings. But there are times when this method just isn’t possible.



▲ For small moldings, rout the profile on an oversized workpiece and then rip it to final size at the table saw.



▲ A zero-clearance table, used in conjunction with an auxiliary, zero-clearance fence offers a custom solution for small parts routing.

HANDSCREW HOLDER. If I absolutely must cut the part to final size before routing, then securing the part in a hand-screw is the perfect, quick option (main photo). An added advantage of using a hand-screw is that the jaws can be skewed for holding irregular-shaped parts. I even keep one close by with

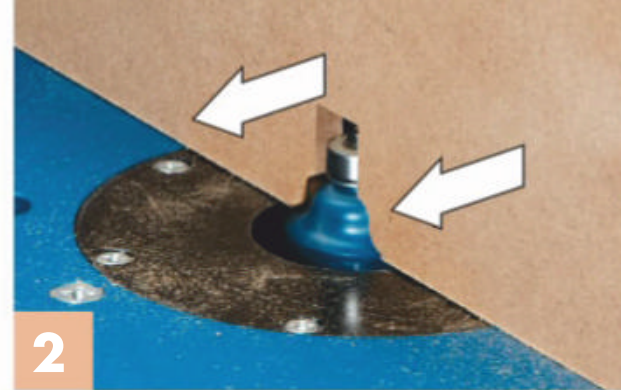
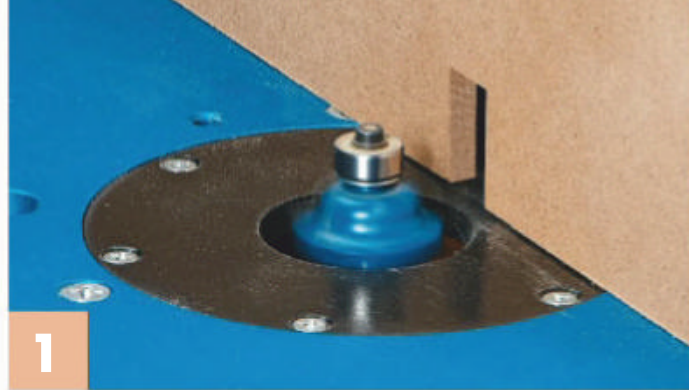
adhesive-backed sandpaper on the jaws for the best gripping power.

ZERO-CLEARANCE OPTIONS. But what do you do when the workpiece is small, but too big to hold with a handscrew? Well, there are a couple of ways to modify your router table to better deal with these types of small parts. And both of them address minimizing the openings where a piece could potentially catch and spoil the cut.

AUXILIARY FENCE. For router table fences that have a fixed bit opening, the best option is to attach an auxiliary hardboard face using double-sided tape. Before attaching the hardboard, cut a small notch equal to the diameter of the router bit bearing (Step 1).

To create the zero-clearance opening, simply slide the fence forward over the spinning bit, so the opening matches the shape of the bit (Step 2). Since only a small part of the bit is exposed, the workpiece will always be fully supported, as you see in Step 3.

ZERO-CLEARANCE TABLE. As shown in the right photo on the previous page, the idea behind a zero-clearance table



▲ Making the zero-clearance fence starts by cutting a bearing-sized opening in the hardboard (Step 1). Then attach the hardboard to the fence and slide it into the spinning bit (Step 2). The smooth, gap-free face means the workpiece is always fully supported (Step 3).

mimics that of the auxiliary fence. Here, I covered the tabletop with hardboard and a small hole for the bit. Combined with the fence, you end up with a setup that's safe for routing small parts.

SMALL PARTS SLED. If routing small parts is more common than not in your shop, then you might want to check out the box below. This small parts sled offers a more permanent solution. **W**

Shop-Made Extra: SMALL PARTS ROUTING SLED

When the need arises for routing multiple small parts quickly and safely, this small parts sled fills the bill nicely. Basically, the sled holds the workpiece so that it acts like a larger workpiece. The larger size is easier to control and keeps your fingers well clear of the bit.

SIMPLE CONSTRUCTION. The sled features a pair of adjustable stops that capture the workpiece between them. The tapered knobs lock the stops in place and serve as handles.

To secure the workpiece against the base, a modified toggle clamp is the perfect solution. The rubber tip has been replaced with a block of wood. And the upper nut is replaced with a star knob for quick adjustments. You can find the plans for the sled at Woodsmith.com.



▲ This small parts sled essentially turns a small workpiece into a larger workpiece. The large footprint of the sled makes it easier to push the workpiece past the bit. The tapered knobs not only lock the stops in place, but they also double as handles.



Plans for building the small-parts routing sled are available at Woodsmith.com

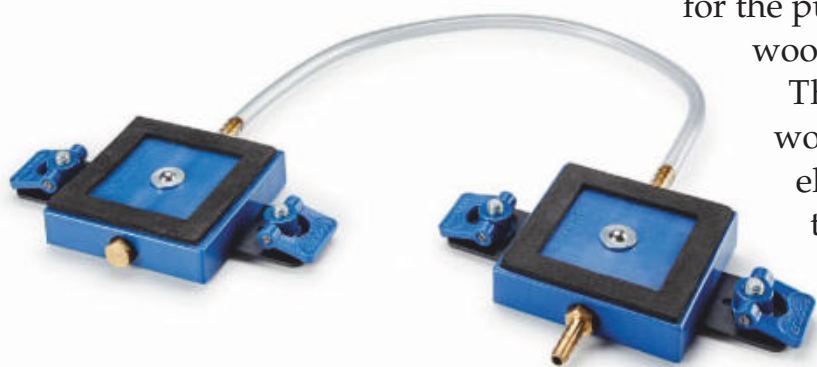
great
gear

5 cool tools for Better Woodworking

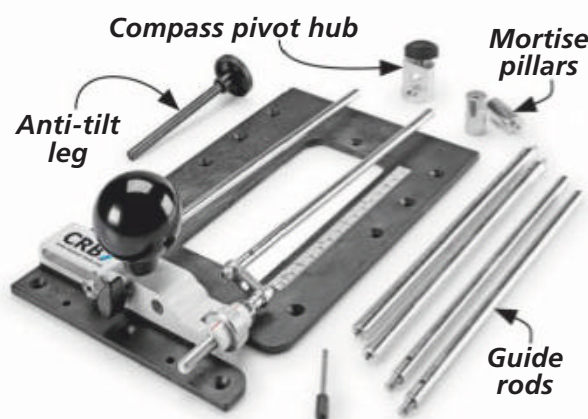
It's funny how sometimes the little things make all the difference in the world. Take the five products on these two pages for instance. You can perform most woodworking tasks without them. But the increased level of safety, convenience, or comfort these tools can add makes them well worth considering for your shop. All of these can be found in Sources on page 67.

[1] Rockler Vacuum Clamps

A vacuum pump is a great tool to have around to use in conjunction with a veneer press. But if you're like me, the vacuum pump doesn't get put



▲ Two clamp pods are included in each kit. Up to four pods can be combined in a series for clamping large workpieces.



▲ With the provided accessories, you're able to perform seven different functions with the CRB7 Combo Router Base.

to use outside of doing veneer work. Investing in a set of these inexpensive vacuum clamp pods from Rockler (left photo) not only provides a new use for the pump, but also solves a typical woodworking problem.

These clamp pods secure a workpiece from the bottom side, eliminating the need for traditional clamps that get in the way when routing, planing, or sanding (main photo). A pair of T-bolt holdowns slip into a standard T-track table, or they can be mounted to a workbench with screws.



Best of all, a set of two clamp pods will only set you back about \$60.

[2] CRB7 Router Base

Very few tools offer more bang for your buck than the router. So any product that promises to make my router even more versatile quickly gets my attention. While the CRB7 Combination Router Base from M.Power has been around for several years, they continue to refine it and add new accessories to make it even better (photos above).

The CRB7 (priced at \$110) comes packaged as shown in the left photo above and includes two sets of guide

rods to fit just about any router. The guide rods fit into a machined aluminum block on one end of the base that has built-in micro-adjustability for dialing in the router's position on the base or workpiece.

In addition, the CRB7 can be used for its straightedge guide function (right photo on the previous page), as a large or small circle compass, or for making repeatable dados and edge-guide routing. A pair of mortise pillars can even turn your router into a simple mortising machine.

[3] Homeright Spray Shelter

Doing any type of spray finishing work in a small shop always poses problems. The risk of getting overspray on tools and worksurfaces is very real. Investing in a pop-up *Spray Shelter* from *Homeright* is the perfect solution for containing the mess.

The *Spray Shelters* are available in several different sizes. The small pop-up shelter (photo below) easily fits on a workbench, folds flat for convenient storage, and only costs \$30.

A trap door in the rear of each shelter allows for a simple filter and box fan to be added. This no-fuss containment system is quick and easy to use.

[4] Oneida Router Hood

It's true that the router is one of the most popular woodworking tools. And it's also one of the messiest. It can be



▲ The detachable cuff allows the dust hose to be removed easily. Two different sizes of chip covers provide plenty of room, no matter what size router bit is installed.



difficult to contain the dust and chips generated when doing hand-held routing work without some kind of dust control. That's where the *Universal Router Hood* from *Oneida* (\$42) comes into play (photos above).

Designed to fit a multitude of routers, the base of the router hood attaches to a standard vacuum hose and captures the dust and debris from above and below the router bit. The clear base provides an unobstructed view of the workpiece.

[5] Bosch 12-Volt Router

Cordless routers have been around for a while. But in the past, bulky batteries and heavy, awkward designs resulted in less than ideal usability. But *Bosch*

is looking to change all that with its newest addition to its 12-volt cordless tool lineup (photos below). Their new *Brushless Palm Edge Router* (\$150, battery not included) features an offset spindle and ergonomic design that fits comfortably in one hand.

Weighing in at just over 2 lbs., this compact trim router has all of the features you'd want in a full-size router, including an easy-to-use spindle lock, a fast-acting macro depth adjustment, as well as a fine-depth adjustment knob that locks in place for precise routing.

Adding increased versatility and convenience to your shop doesn't have to cost a ton of money. Sometimes it's the little things that lead to better results. **W**



▲ Protect your shop from overspray with a pop-up *Spray Shelter* from *Homeright*. The small version shown here is just right for benchtop finishing work.



▲ The clever design of *Bosch's* new 12-volt *Palm Edge Router* allows for a comfortable one-handed grip (left photo). A built-in spindle lock means there's only one wrench needed for bit changes (right photo).





Drill press Mortises

One of the best parts of woodworking is that there are several approaches to accomplish nearly any task. So you can tailor techniques to the tools you have, your shop space, and even personal preferences. It also eliminates the notion that there's one "right" way to do something.

You can see how this plays out in creating mortises for mortise and tenon joinery.



▲ Four-flute end mills do a great job of creating smooth mortises in a drill press. For sources, turn to page 67.

The standard technique we often use in *Woodsmith* is a two-part operation. First, the majority of the waste is removed with a Forstner or brad point bit. Then a chisel straightens the side walls and squares up the ends.

However, I was looking to streamline the process, especially when I have a lot of mortises to make. The options range from using a router to investing in a dedicated mortising machine.

A BIT DIFFERENT. While paging through some back issues of *Woodsmith*, I came across a technique that sticks with the drill press, but swaps out the drill bit for an end mill, as shown in the left photo. End mills are bits typically used for shaping metal in milling machines. They work in a similar way to how a spiral bit shapes wood in a router table. However, you can use them in a drill press for working wood, too.

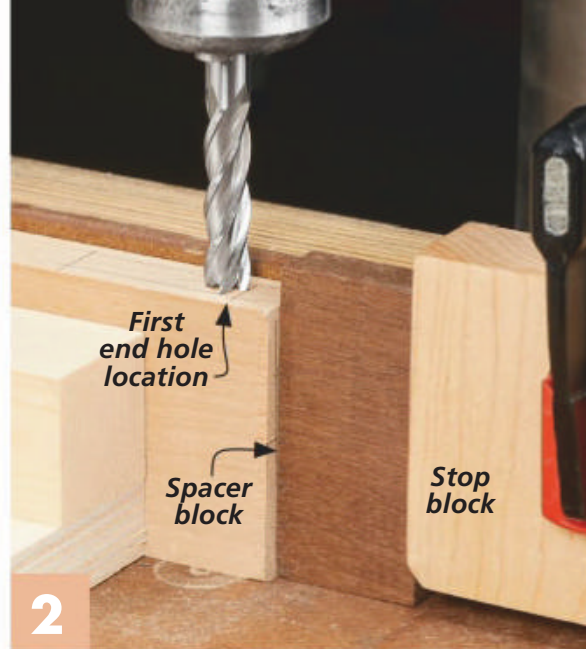


▲ This technique works best with the drill press set to its maximum speed, usually around 3000 RPM.

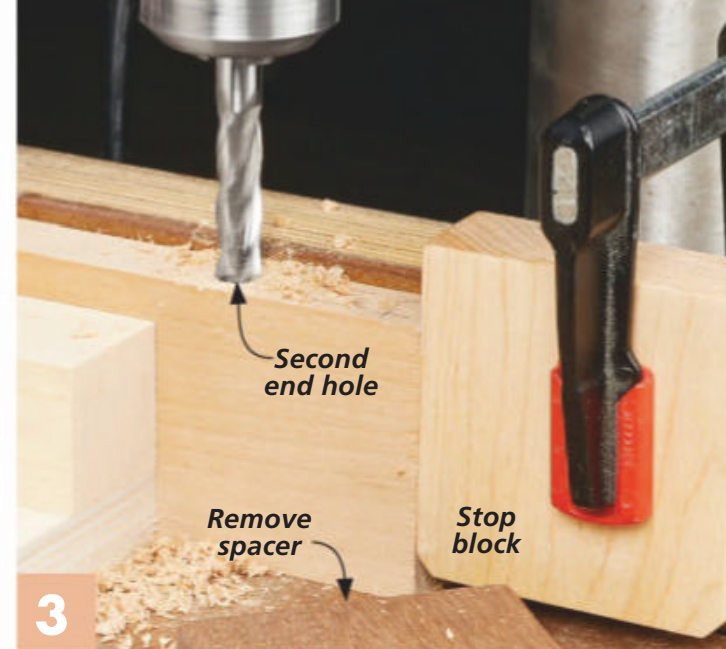
Although they come in a range of sizes, I suggest a $\frac{5}{16}$ " bit for working in $\frac{3}{4}$ "-thick stock. A $\frac{3}{8}$ " bit can be used for bigger jobs. The advantage of using an end mill is that it not only drills vertically like a drill bit, it also cuts side to side.



1 ▲ A depth line on the end of the workpiece makes setting the depth stop on the drill press straightforward.



2 ▲ Use the spacer block with the stop block to locate the end of the mortise near the end of the workpiece.



3 ▲ The other end of the mortise is set by pulling out the spacer and butting the workpiece against the stop block.

This means you can skip the chisel work and create a mortise with smooth walls.

GETTING SET UP. For the most part, this approach will feel pretty familiar if you've used the drill press method before. But still, there are some key differences that I want to point out.

Let's start with the drill press speed. I keep mine set around 1500 RPM most of the time. But an end mill works best at high speeds. So crank up your drill press to its max, as shown in the right photo on the previous page. On most drill presses, that's around 3000 RPM.

I lay out the mortise on one workpiece and use that to set the drill press fence and the depth stop, as shown in Step 1 above. In order to get mortises with a consistent length, I also use a stop block and a spacer block attached to the fence. You can see this in Steps 2 and 3. And that leads us into the technique.

DRILLING HOLES. The mortise-making process breaks neatly into two parts: drilling and routing. I learned this from woodworkers who use horizontal slot mortising machines. The drilling step clears away the bulk of the waste material and creates a path of least resistance for the bit to follow in the routing step.

I start by drilling each end of the mortise, as shown in Steps 2 and 3. Then work along the length of the mortise, creating slightly overlapping holes, as in the main photo on the previous page.

This photo also shows an additional accessory. It's an auxiliary fence that's held in front of the workpiece. It constrains the piece you're working on and keeps it from drifting away from the fence. This way, you only need to concentrate on moving the piece side to side.

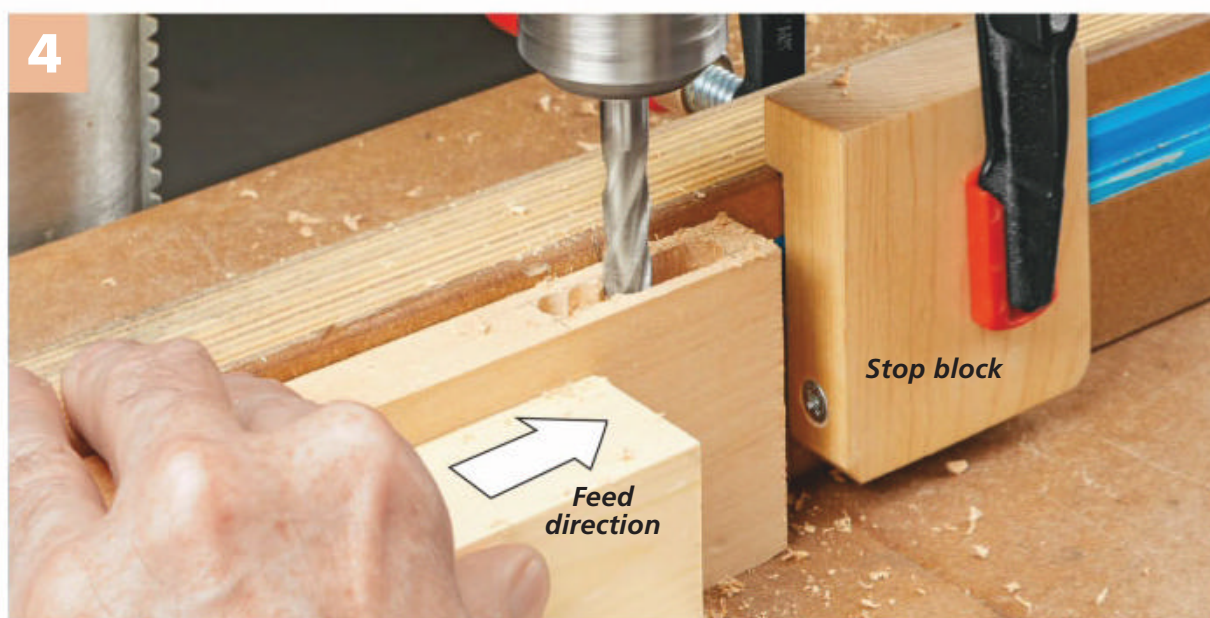
ROUTING. In the second phase of the operation, you'll slide the workpiece

side to side to smooth the walls with the spinning bit. Rather than doing this at full depth, I like to rout in two or three passes, lowering the bit between each pass. This is explained in Step 4.

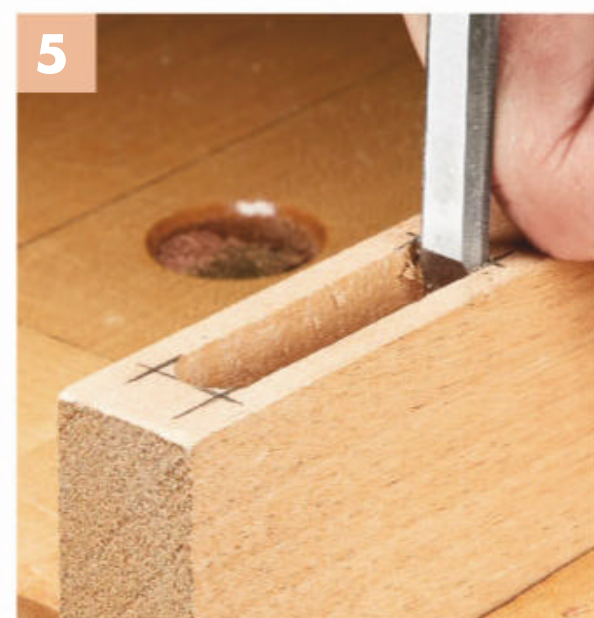
As you do this, you may feel the workpiece stutter as the bit cuts. Here's where the high speed and the auxiliary fence earn their keep.

I want to make a side note: Some woodworkers will resist the idea of applying lateral forces on a drill press for routing or even sanding. I get that. And it's a big reason for drilling out the waste first. If this method gives you the heebie-jeebies, don't do it. Try another technique instead.

With this approach, I leave the ends rounded and shape the tenon to fit. But you can square the mortise if you like (Step 5). Either way, the smooth walls of the mortise are ready for glue. **W**



4 ▲ The routing step removes the remaining bits of waste between each hole. For most mortises, you can lower the bit to about half the depth of the mortise, then slide it side to side to smooth the walls. Repeat this at full depth to finish the mortise.



5 ▲ Depending on your preference and the needs of the project, you can square the ends of the mortise with a chisel.



Succulent Plant Stands

These small plant stands are designed with succulents in mind. They're an easy, elegant build that will show off your favorite little plants.

The only way I would qualify for having a green thumb is if you counted the green ink stains from the money that I've peeled out of my wallet to pay for all the plants that I ultimately killed. If houseplants have recurring nightmares,

it's me carrying them to the checkout at my local garden center. But there's an exception to this sad truth. It comes in the form of succulents like the ones you see in the plant stands above.

These hardy, low-to-no maintenance plants are super easy to grow. They come in a wide variety of shapes, sizes and colors. They don't need much soil, and they store moisture in their thick leaves and stems.

These simple requirements inspired these plant stands. Each one is made from glued up 8/4 mahogany. (One long

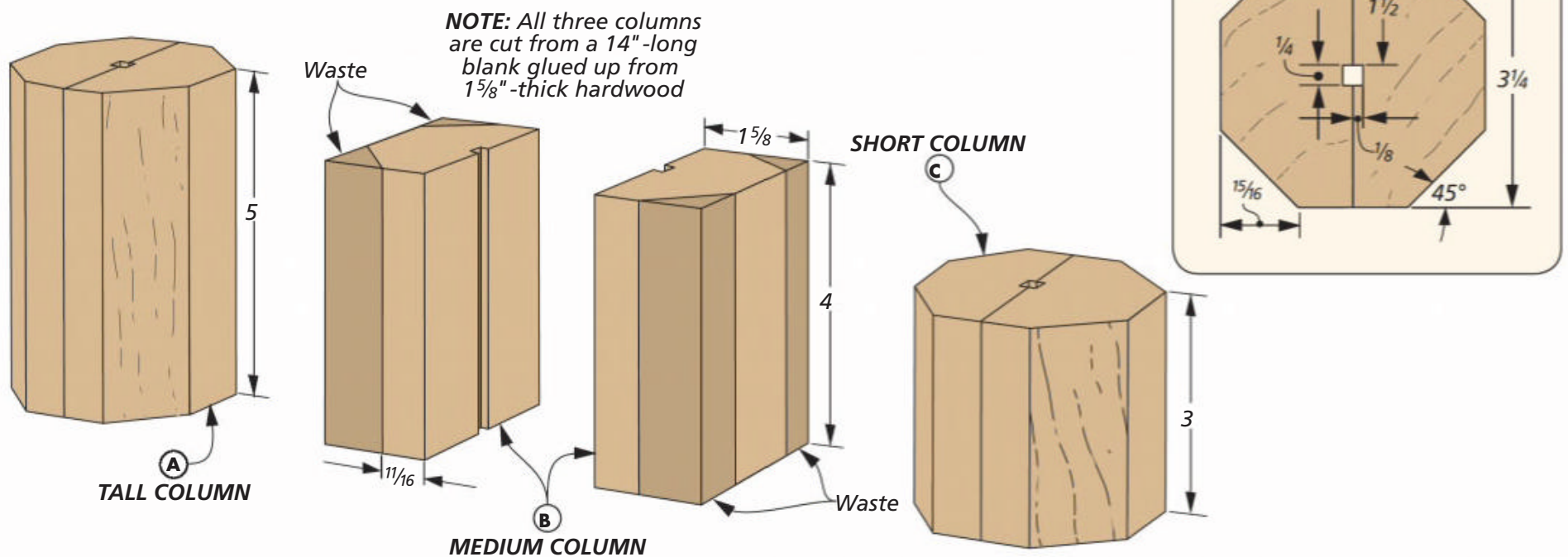
blank makes all three columns.) Later, you'll rout a recess in the top that will hold the plants. A half-lapped pedestal made out of leopardwood complements the columns. The fun begins with making the columns.

THE COLUMNS

Making the plant stands starts with creating the blank for the three columns. The one demand that succulents make is for good drainage. As you see in the main drawing and Figure 1 on the next page, before gluing

Materials & Supplies

A	Tall Column (1)	$3\frac{1}{4} \times 3\frac{1}{4} - 5$
B	Medium Column (1)	$3\frac{1}{4} \times 3\frac{1}{4} - 4$
C	Short Column (1)	$3\frac{1}{4} \times 3\frac{1}{4} - 3$
D	Pedestal Halves (6)	$\frac{3}{8} \times 1\frac{1}{4} - 4\frac{1}{4}$



up the blank for the columns, I cut a groove down the center of each blank half with a dado blade in my table saw. This will serve as that all-important weep-hole for the succulents.

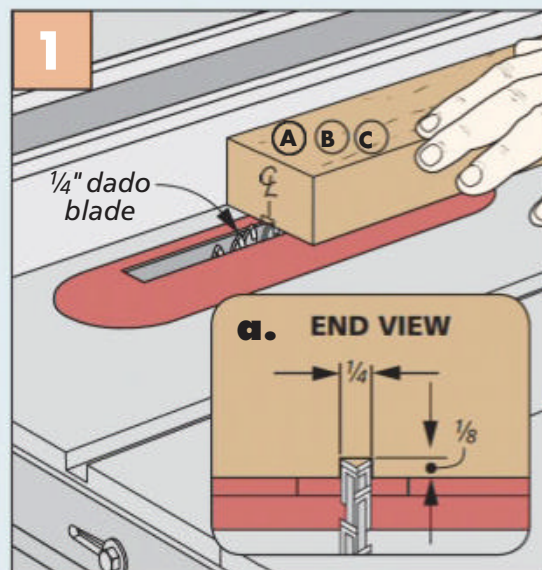
GLUE UP THE BLANKS. I placed a length of dowel in one of the grooves during the glue up (Figure 2). This acts as an alignment key. Once the glue is dry and the clamps are put away, you can remove the dowel. Then it's time to do the final shaping of the blank at the table saw.

OCTAGON. Looking at the main drawing and detail 'a' above, you'll see that the final shape of the column is octagonal. To create this shape, tilt the blade of your table saw 45°. An easy way to make sure the sides are the same is to draw the location of the bevel cuts on the top of the column blank. Then set the fence for the first pass. When the cut is complete, rotate the blank to make the bevels on the remaining sides. Figure 3 shows how to do this.

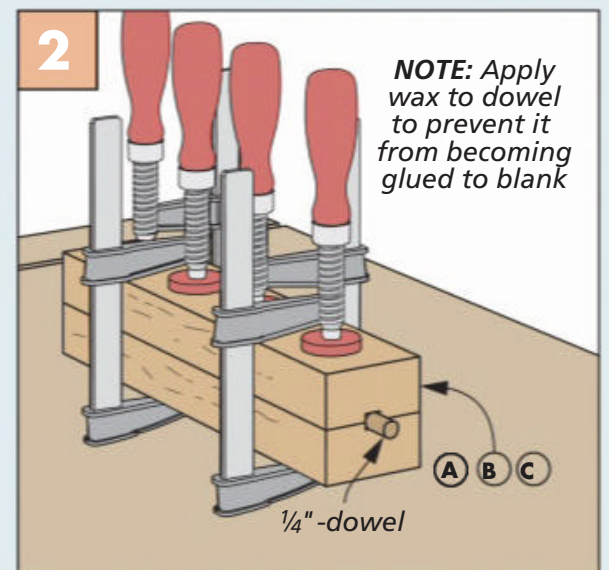
CHOP-CHOP. The glued up blank is 3 1/4" square, which is a little too big for the deepest cut I can make with my table saw. So to cut the three columns to their final length, I stepped over to my miter saw (Figure 4). Notice in the drawing that the short column is being cut first. This is followed by the medium, then the tall column, leaving you with plenty to hold on to each time.

There's a little more work to do on the columns, so turn the page to keep moving on this compact project.

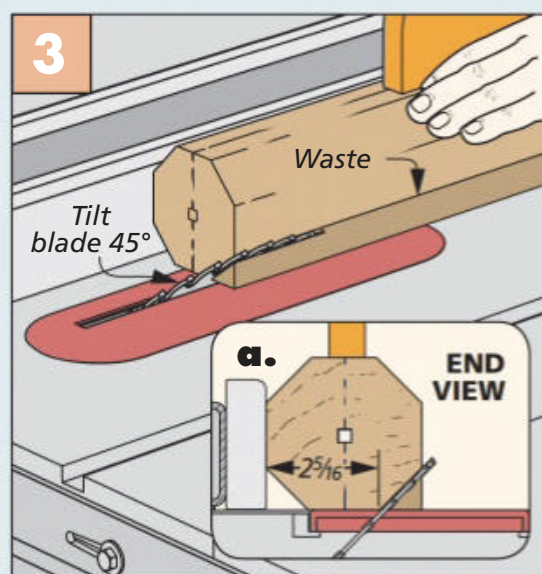
How-To: MAKE & SIZE THE COLUMNS



Dado Down Center. At the table saw, cut a groove down the center of the long blank halves.



Glue Up with Spacer. Use a length of dowel to keep the weep hole aligned when gluing up the two halves.

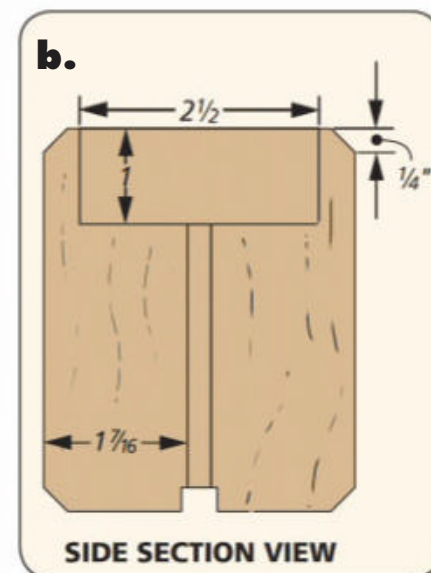
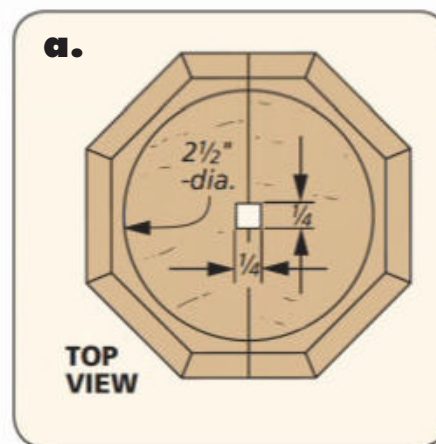
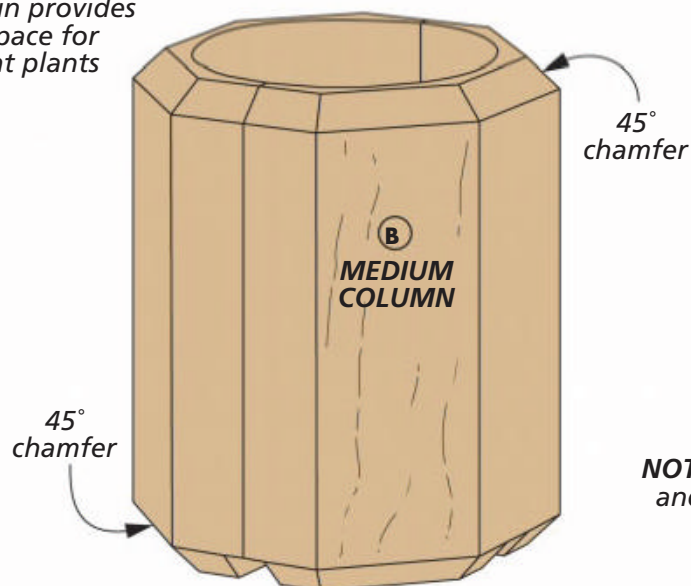


Shape the Blank. To shape the blank, tilt the blade of your saw. Rotate the blank after each cut.



Cut to Length. The miter saw makes quick work of cutting each of the columns to their final length.

NOTE: Basin provides ample space for succulent plants



NOTE: Basin procedure, grooves in base, and chamfering the edges is the same for tall and small column

Finish the COLUMNS & PEDESTALS

As I said, there's a little more to do on the columns. This starts with creating a basin for the plants, followed by cutting two grooves in the bottom to fit over the pedestal. To finish each column, you'll chamfer the top and bottom edges. So dig out your router and let's get moving.

ROUT THE BASIN. While you're getting the router, grab a pattern bit to use with it. To aid those two, you'll need to make a jig that fits over the top of the column. The pattern bit will ride along the walls of the jig to shape the basin. (To make the jig, see Shop Notes on page 65.)

The column needs to be held firmly in place while doing all of this. The ideal tool for this job is the vise in your workbench. Figure 1 below shows this.

Also, it's a smart idea to make the basin in multiple passes. When the sawdust is swept up from that job, take the columns over to the table saw.

GROOVES. The bottom of the column has a pair of intersecting grooves to allow it to fit over a pedestal you'll make later. The grooves are perpendicular to each other and cross in the center. Cut these with a dado blade at the table saw. Figure 2 shows you how to do this.

CHAMFERS. There's one detail left to complete the column — easing the top and bottom edges with a chamfer. It's easy to do this at the table saw (Figure 3). To begin, set up a stop block on your miter gauge for the column you want to trim. The initial setting lets you chamfer

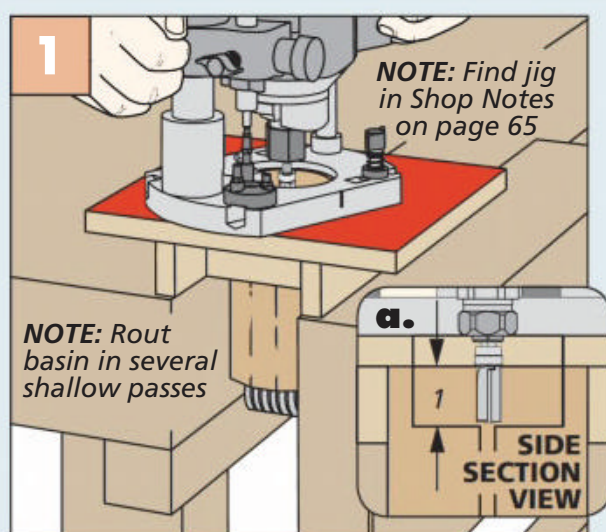
all edges on both ends of each column. Readjust the stop block for each column. Then it's on to the pedestals.

THE PEDESTALS

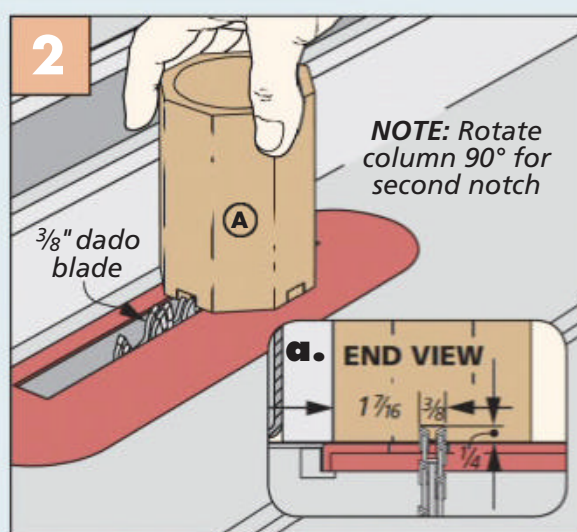
Each pedestal is made of two thin pieces of hardwood (I used leopardwood) that are joined together with half laps. The pedestal fits into the grooves that you cut in the bottom of the column. So start by planing your pedestal stock to thickness, testing the fit in the grooves. Then you can cut the individual sections to size.

NOTCHES. As you can see in the main drawing and detail 'a' on the next page, both pieces have a long shallow notch in the top edge

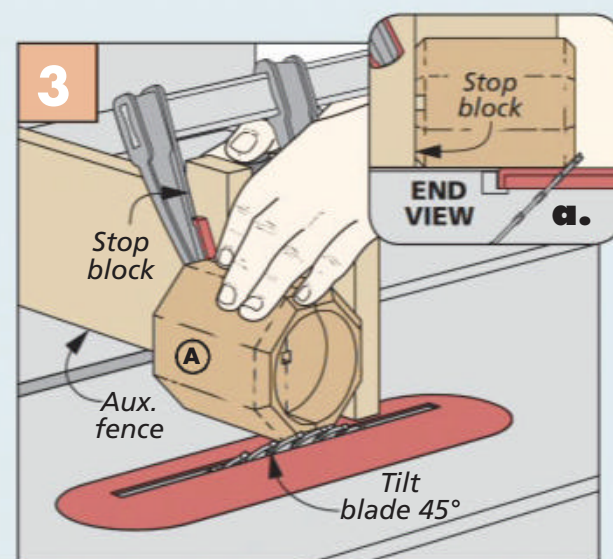
How-To: COMPLETING THE COLUMNS



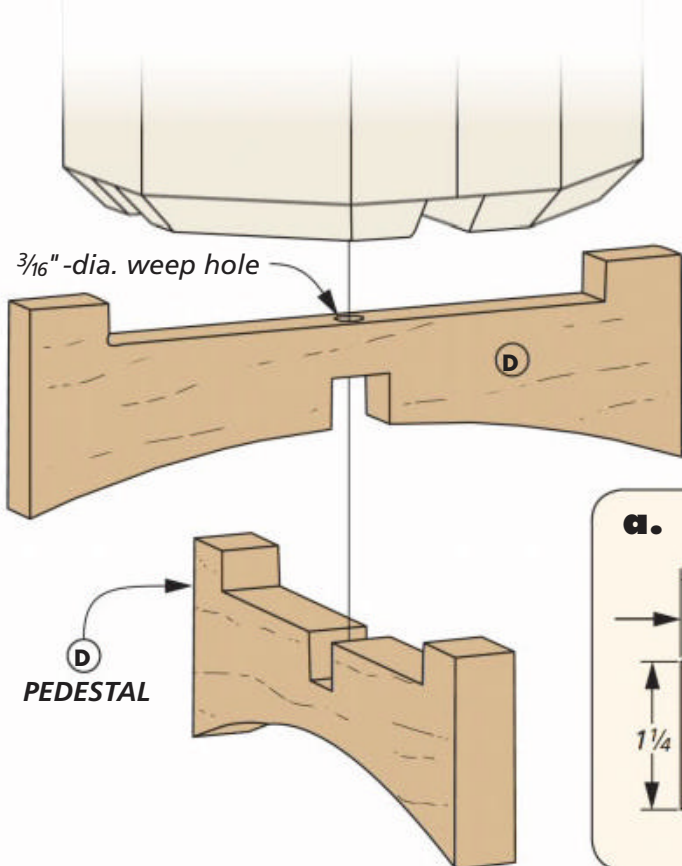
Rout the Basin. A pattern bit follows the sides of the jig, creating a smooth opening in the top of the columns.



Notches. A dado blade in the table saw is used to create the crossing grooves in the bottom of column.

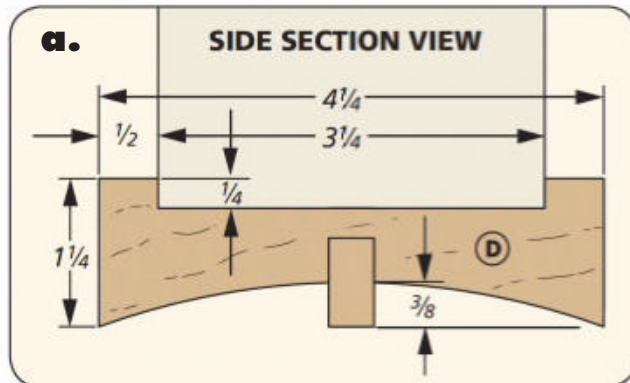


Chamfers. Cut chamfers on the ends of the column with an auxiliary fence and stop block clamped to the miter gauge.



NOTE: The pedestals are made from $\frac{3}{8}$ "-thick hardwood

NOTE: Drill weep hole after pedestal is assembled



▲ Align the notches of the pedestal pieces and hold in place with double-sided tape. Then you can sand the arcs flush.

that traps the column in place. To make the notches, I used the table saw with a dado blade. As is shown in Figure 1 below, there's an auxiliary fence attached to the miter gauge.

This lets me nibble away the waste on the workpiece safely.

LAP JOINT. While still at the table saw, cut the deep notches in each piece that form the half-lap joint. As you can see in

the details of Figure 2, even though the depth of these notches are different, you don't have to change the blade height. This is to account for the decorative arc on the underside of the pedestal, which you're going to make next.

ARC ON PEDESTALS. The arcs on the pedestal halves need a little attention. You want the junction between them to look nice, so I went about making and matching the parts in a specific way.

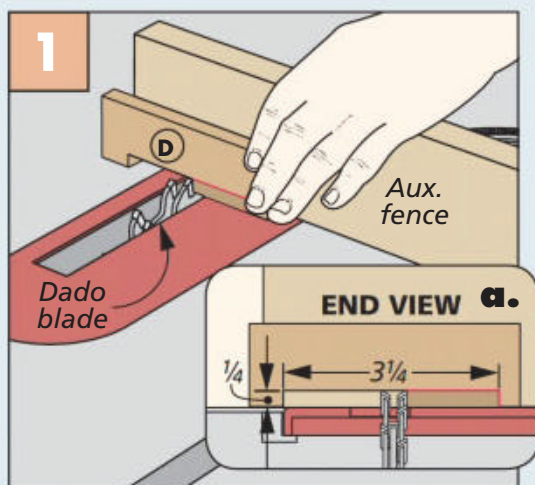
Over at the band saw, cut one of the pieces and sand it smooth (Figure 3). I used this piece as a pattern for the rest. After all the pieces were cut, I separated them into groups of two for the next step. This involved sanding them smooth. I used a roll of adhesive-backed sandpaper to do this. It conforms to the shape of the arc nicely. The photo above shows how to do this.

ASSEMBLY. A dab of glue is all it takes to join the pedestal halves. When the glue is dry take the pedestals over to the drill press. There, you need to drill a hole in the center of each one to line up with the weep hole in the column (Figure 4).

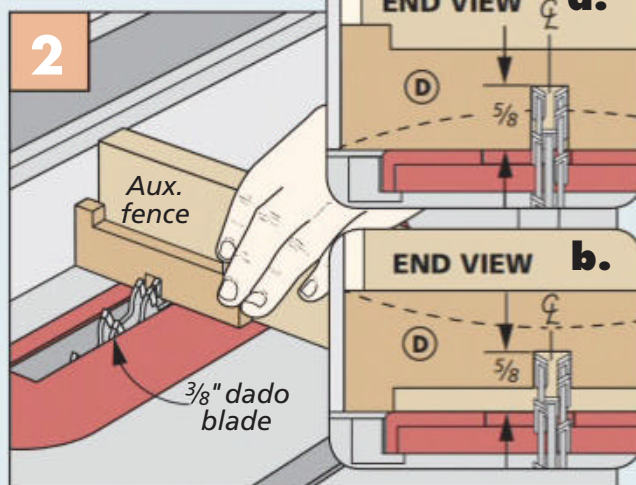
FINAL DETAILS. After applying a couple of coats of linseed oil, you can bring the two parts of the plant stand together. Just set the column over the pedestal. The snug fit means no glue is required.

With that, you've completed some cozy little homes that your succulents will thrive in for a long time. Now your task is to gather the plants and whatever they like to live in; sand, potting soil, or just the basin alone. **W**

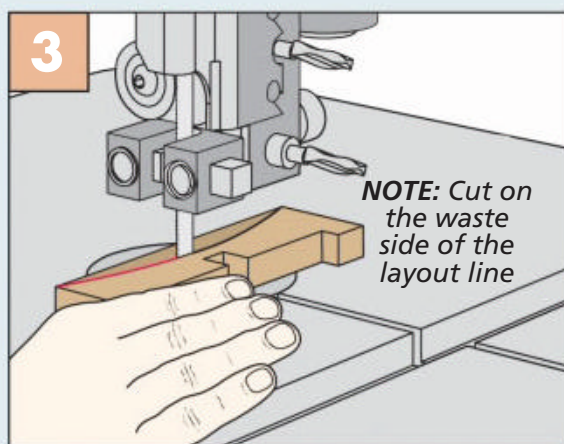
How-To: MAKE THE PEDESTAL



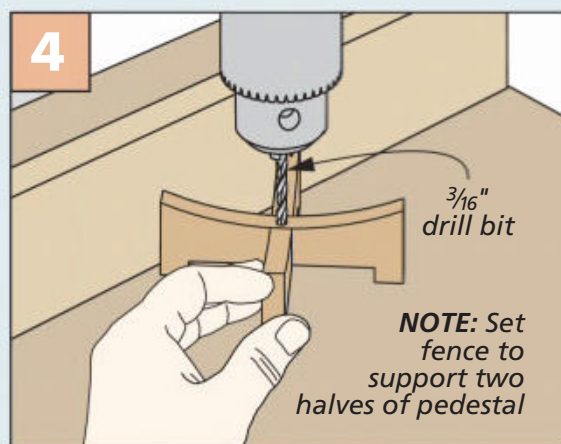
Notches. With an auxiliary fence attached to the miter gauge, cut the long notch that holds the column.



Lap Joint Next. Both halves of the lap joint in the pedestal pieces can be cut with the same blade height setting.



Arc on Pedestals. Cut the arc on one piece. Sand it smooth and use it as a pattern for the remaining parts.



Drill the Weep Hole. Drill a weep hole through the center of the pedestal to complete the drainage system.

CNC Router



Turn your woodworking shop into a machining, cutting, carving, and milling powerhouse with our shop-made, CNC machine.

In the past, computer numerically controlled (CNC) machines were predominantly found in large industrial settings. But just as computers have gotten smaller, so have the CNC machines, and the types of jobs they can complete has increased. It was just a matter of time before CNC technology crept into the woodworking shop.

We thought it was time we introduced our own shop-built CNC router. The entire project (minus software) costs about \$1,300. With a working area of 24"x48", it's a lot of bang for your buck. It's ideal for tech-savvy woodworkers looking to add a CNC router to their shop.

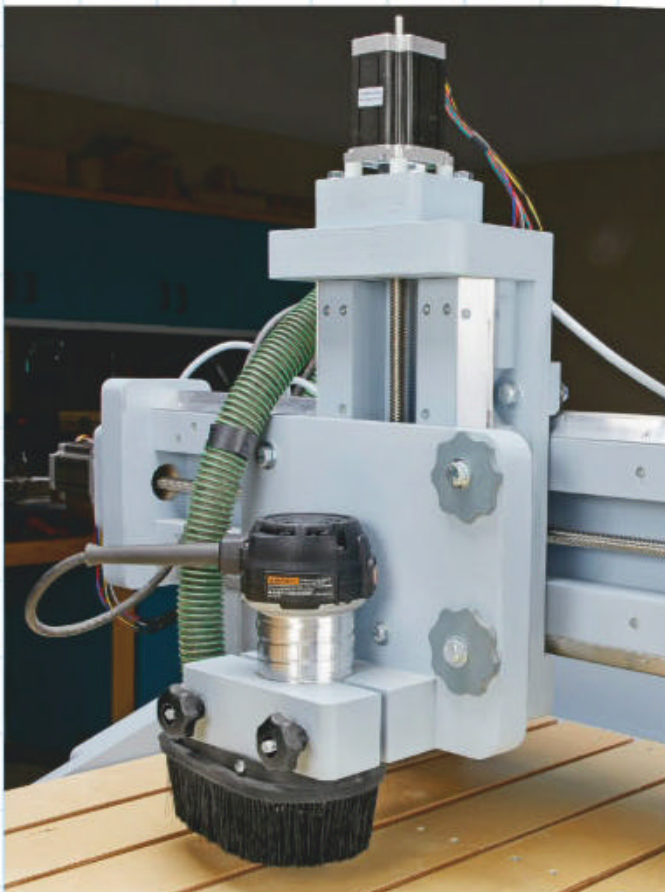
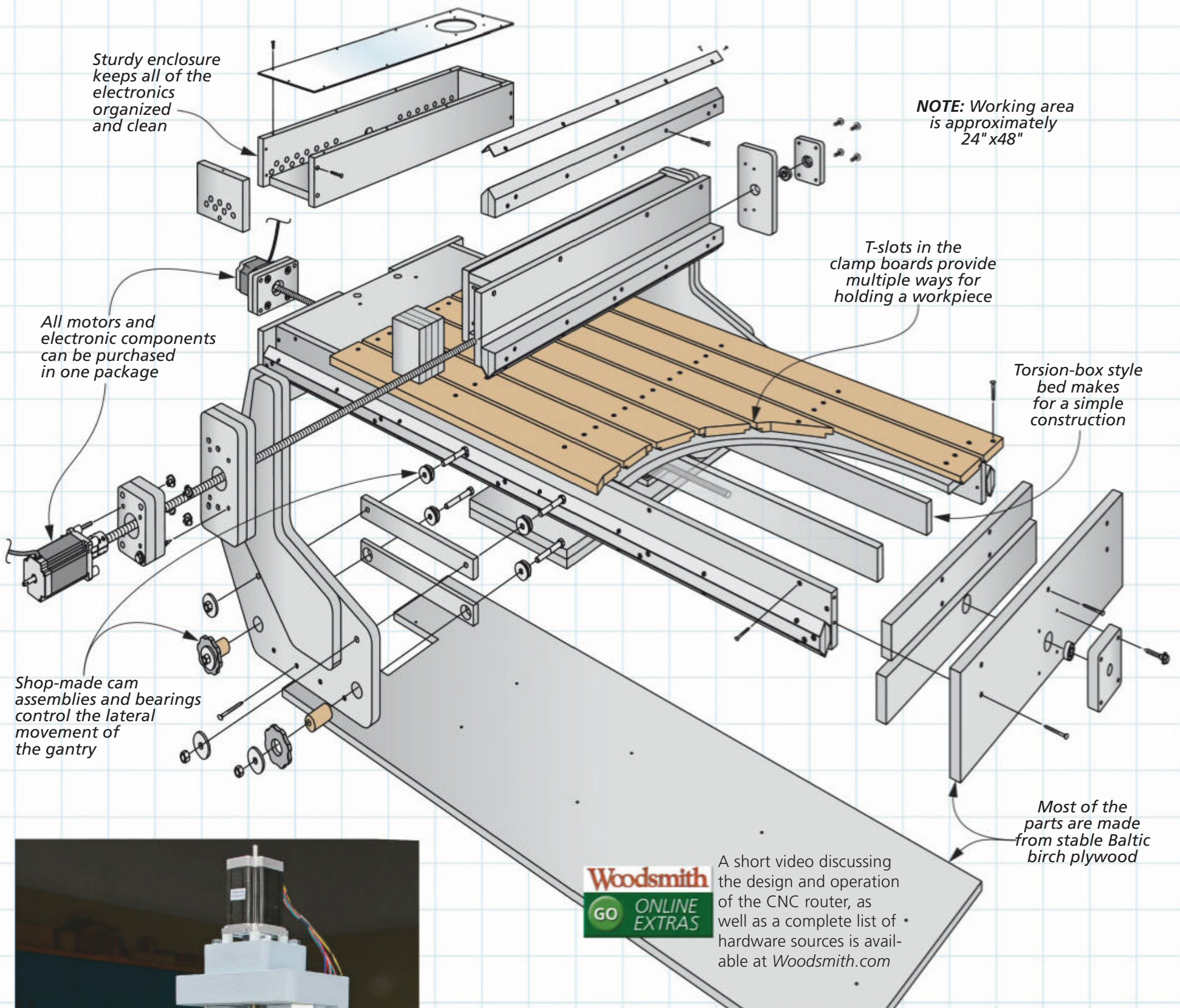
HOW DOES IT WORK? In the simplest terms, a CNC machine works by moving a rotating cutter (in our case, an off-the-shelf router) around a large table (the X and Y axes). The router is moved up and down on the Z axis. The ability to move in three directions allows the CNC to create 3D shapes and designs.

CLEVER DESIGN. As complex as this machine may look at first glance, most of the components are made from high-quality Baltic birch plywood. And they're held together with butt joints, glue, and screws. A package containing the motors and electronic components

is available from an online supplier (see Sources on page 67). In this issue, we'll tackle building the bed and the main gantry of the CNC router. Then in the next issue, we'll add the router mount as well as the wiring and electronics.

NEW SKILLS. Beyond the woodworking and electronics wiring, this project does require that you're willing to learn a couple of simple software programs — one to control the machine and the other to design projects. Although, some retailers sell predesigned projects. Whichever way you go, you're sure to find a host of uses for your new tool.

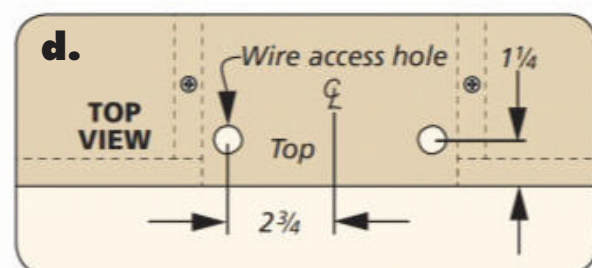
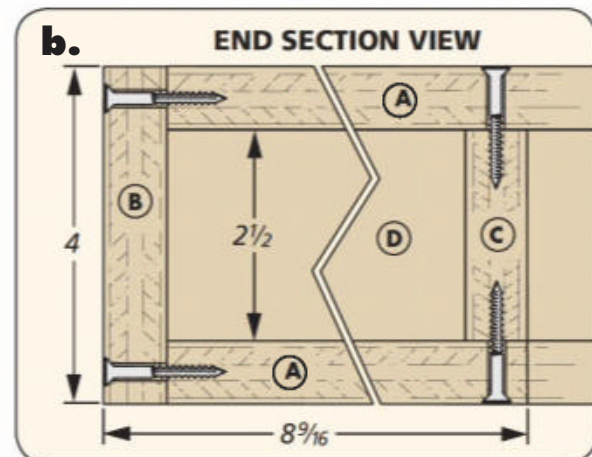
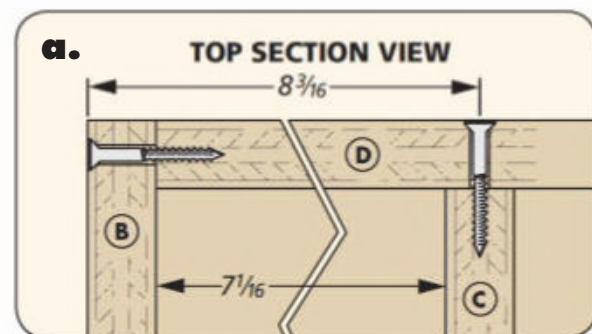
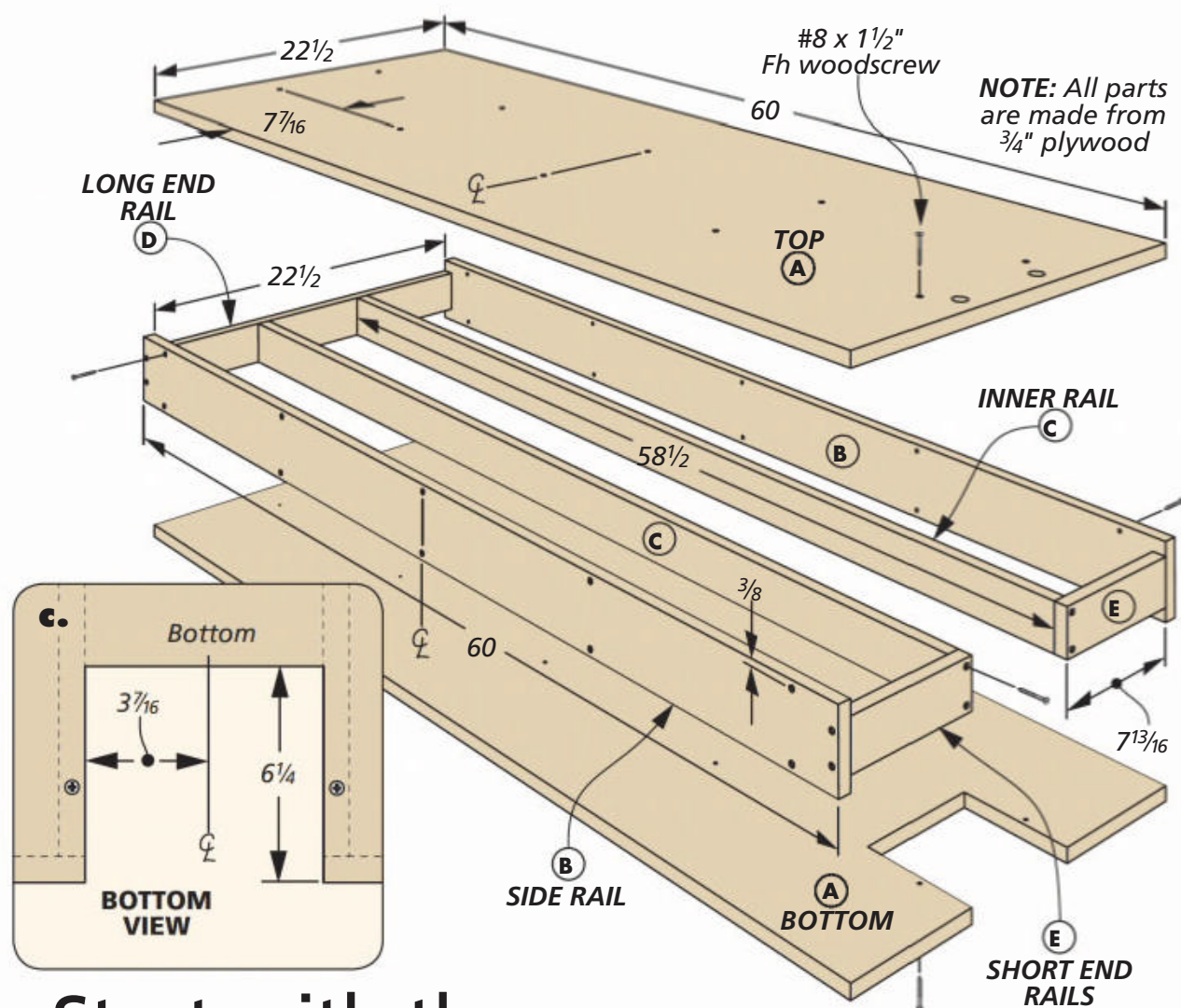
Construction Overview / **OVERALL DIMENSIONS: 62½"L x 41¼"W x 32⅞"H**



▲ The construction of the router mount (Z axis), as well as the addition of the electronics, will be covered in the next issue of *Woodsmith*.



▲ From intricately carved moldings to whimsical creations, a CNC router adds a new level of capability, precision, and speed to any shop. Several of these inexpensive project designs were purchased online at *makecnc.com*.



Start with the BED & RAILS

The bed for any CNC machine acts as the main surface where a workpiece is clamped in place. The cutter is controlled by software and is capable of moving around the bed to mill project parts. What size bed you build should be determined by the size and types of projects you'd like to make.

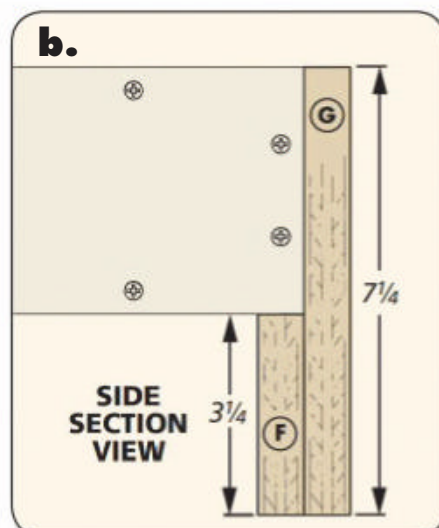
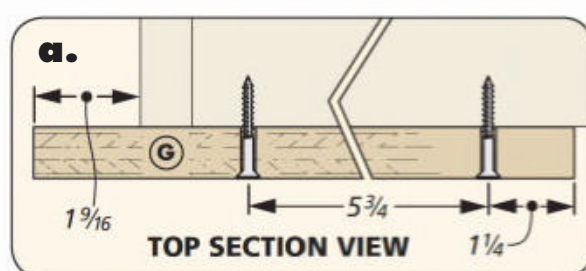
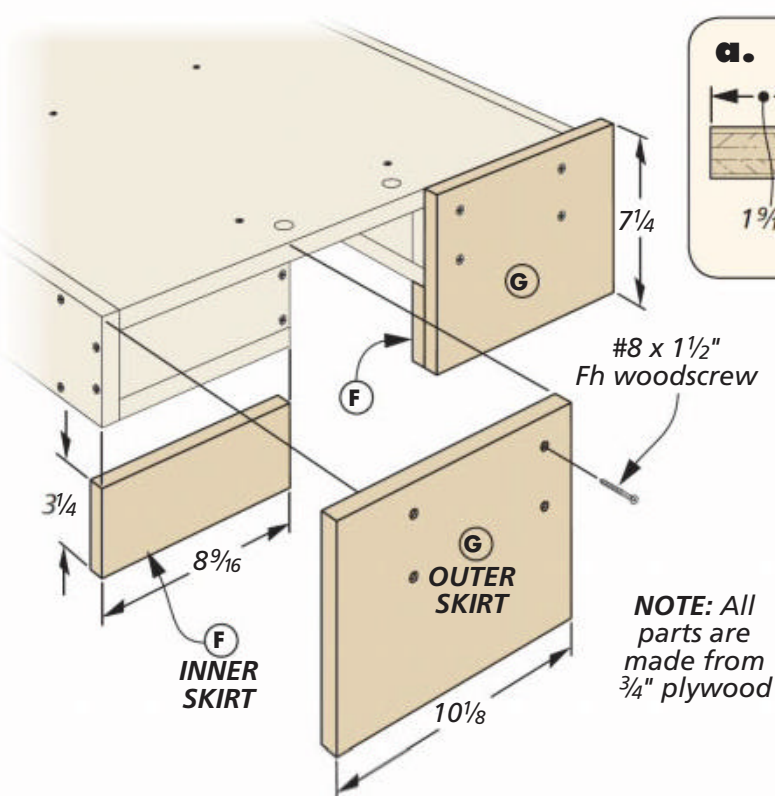
Since we were aiming for a machine that would comfortably fit in a home shop, we settled on the bed size you see above. Remember that one end of this bed also holds an electronics enclosure. That will be added a little bit later. There's also a little bit of dead space along both edges of the bed where the cutter can't reach. Keep these things in mind if you decide to customize the size of your CNC bed.

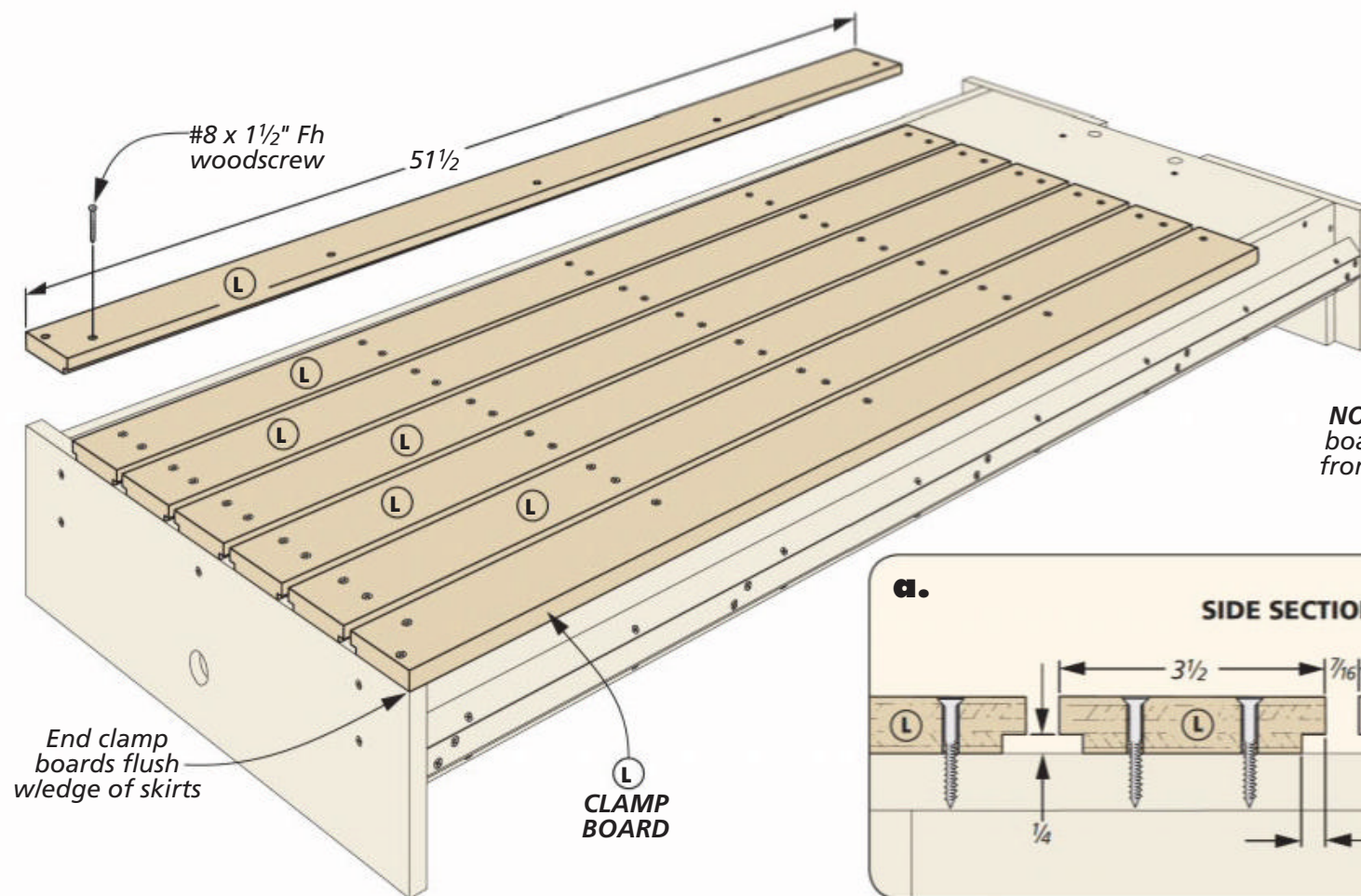
TORSION-BOX BED. As you see above, the main bones for the bed are nothing more than a torsion box assembly. The inner rails are sandwiched between two plywood panels. Screws with a little glue will hold everything together.

After cutting the parts to size, you'll want to cut a notch in the end of the bottom panel. This forms the opening for the X-axis motor. You'll also drill a couple of wire access holes near the same end of the top panel. Now, assemble the bed using the details above to help properly position each part.

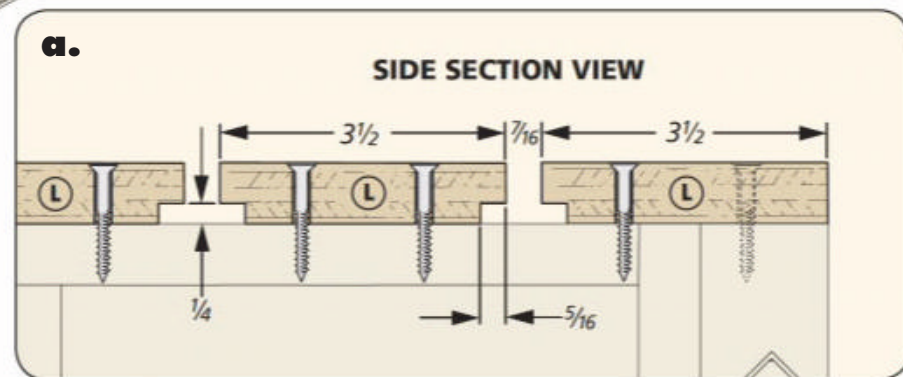
ADD MOTOR SKIRTS

With the torsion box bed completed, you can add a few skirt boards to the motor end of the assembly, as shown at left. These skirts help to beef up the bed structure around the motor housing and lift the bed off the surface of your workbench. The outer skirt also provides a positive stop for the rails that will be added shortly. I glued the parts for the inner and outer skirt together before attaching them to the bed. Be sure to note that the outer skirts protrude beyond the edges of the bed, as shown in detail 'a' at left.





NOTE: All clamp boards are made from $\frac{3}{4}$ " plywood



Finish Up THE BED

Before moving on to building the gantry, there are a couple more items that need to be taken care of on the bed. A series of clamp boards fastened to the top of the bed provides a place to secure a workpiece. And at one end of the bed, a simple plywood box serves as the electronics enclosure.

CLAMP BOARDS. As you can see in detail 'a' above and the photo below, the

clamp boards have rabbets along the bottom edges. These essentially create a shop-built "T-track" for use with standard T-bolts, or commercial clamps. This provides a flexible system for clamping a workpiece anywhere on the surface.

EASY PROCESS. The How-To box below shows the process for cutting the rabbets at the table saw. All of the clamp boards are the same size. You'll note, however, that the two outside clamp boards only have a rabbet on the inside facing edge (detail 'a').

I would recommend using just screws (no glue) to fasten the boards to the top

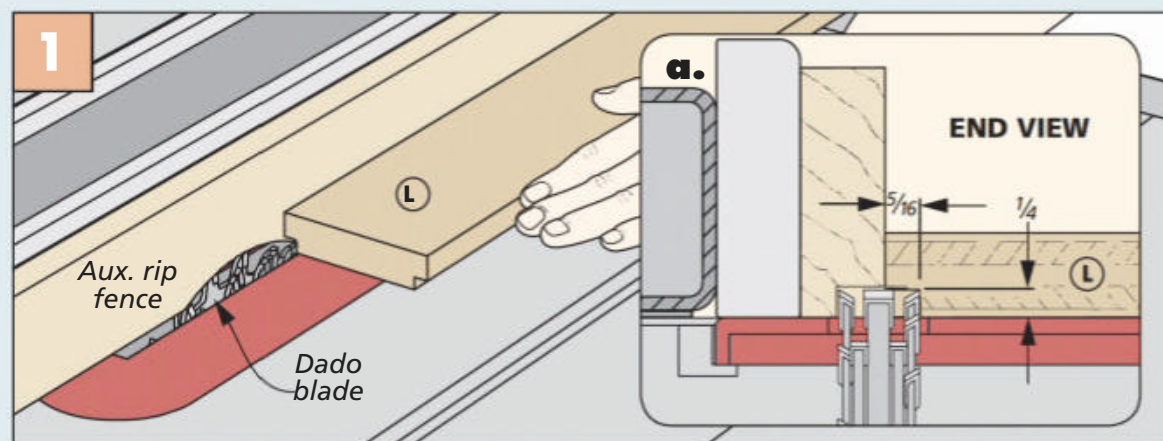
of the bed. That way, if they get a little nicked up or damaged over time, they'll be easy to replace.

SPOILBOARD. Of course, sometimes you'll need to cut completely through a workpiece. This is especially true when cutting out parts for a larger assembly. In this case, the damage to the clamp boards can get pretty severe rather quickly. (Not to mention the possibility of hitting a screw head with the cutter.) So for operations like this, it's a good idea to keep a large, sacrificial "spoilboard" on hand. I've used a large piece of $\frac{3}{4}$ " MDF clamped on top with good success.

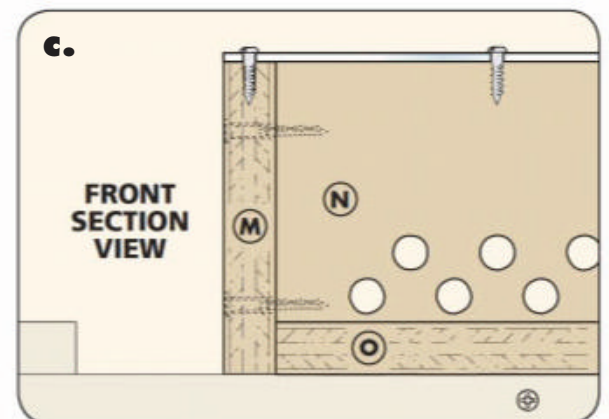
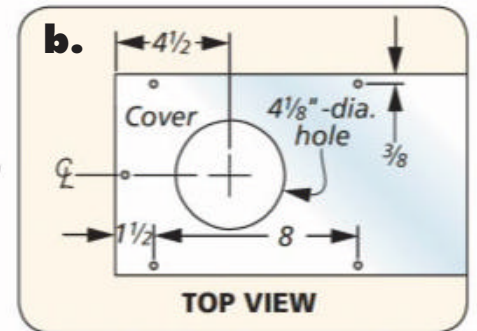
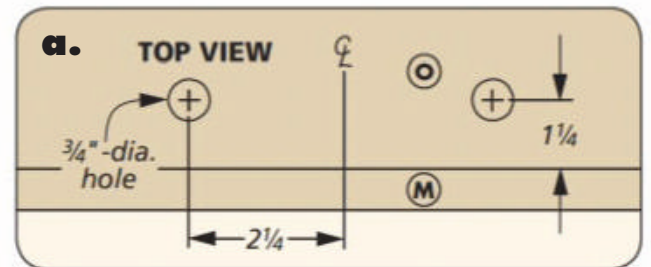
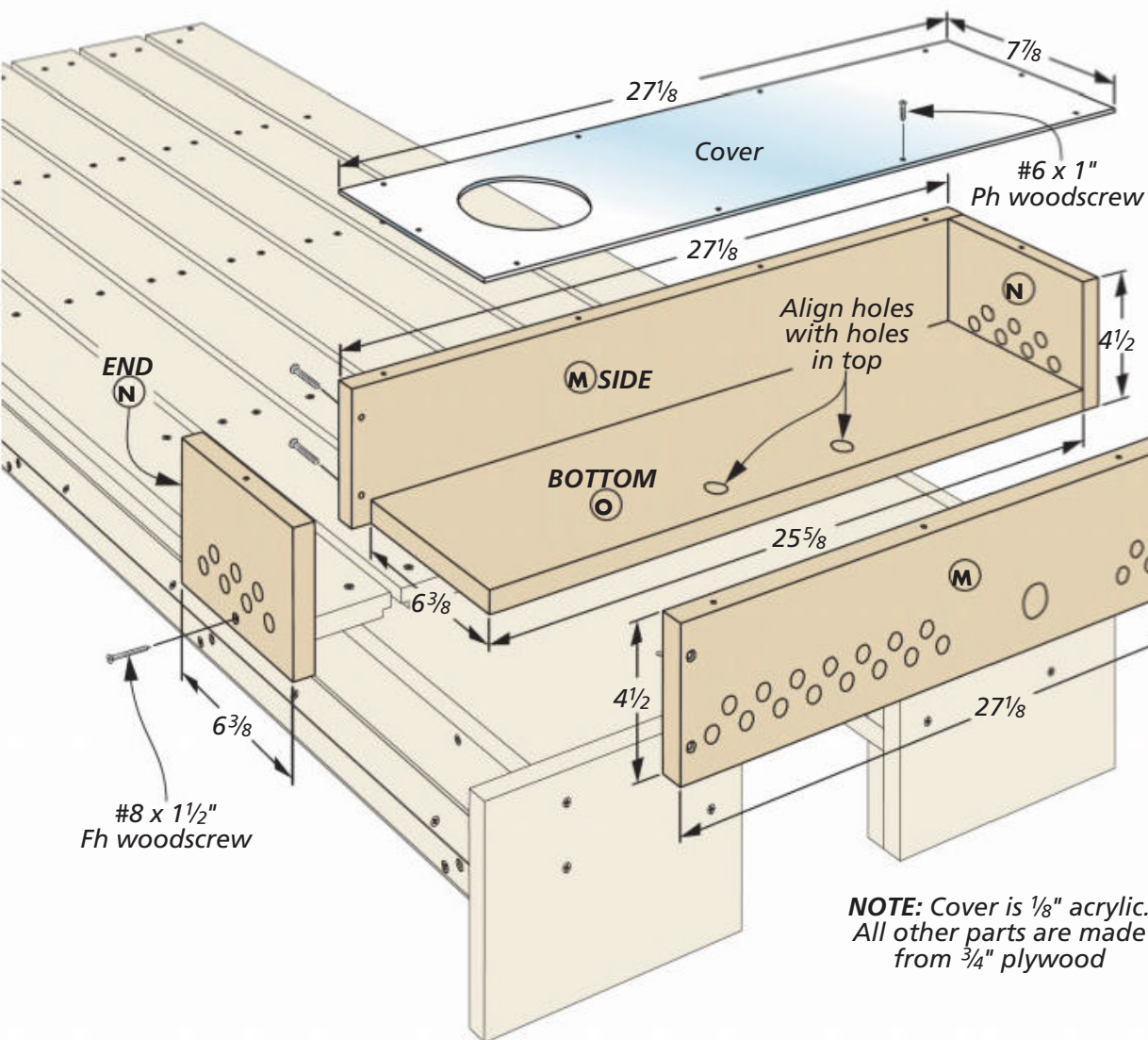


▲ The T-slots created under the edge of the clamp boards accommodate numerous types of T-bolt clamps & hold-downs.

How-To: CUT THE RABBETS



Clamp Board Rabbets. Use a dado blade buried in an auxiliary rip fence to cut the shallow rabbets on the bottom edge of the clamp boards. The two outside clamp boards only receive a rabbet on their inside edge.



ELECTRONICS ENCLOSURE

All of the electrical components for the CNC machine can be purchased in one package from an online retailer. (See Sources on page 67 for more information.) Although built for heavy use, it's still a good idea to house these parts in a protected place.

The plywood box shown above meets this need nicely. It's sized to fit all of the components that came in our kit and fill the empty spot left on the end of the table. The acrylic cover allows a full view of everything inside and even has a large hole near one end to accommodate a cooling fan.

COOL IT DOWN. Of course, a cooling fan isn't going to do much good unless there's a way for air to flow into the enclosure. For this, I added a series of

holes in both end pieces, as well as the side that faces away from the bed. This is to minimize drawing dust into the box during use.

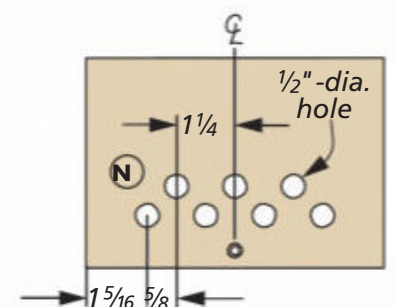
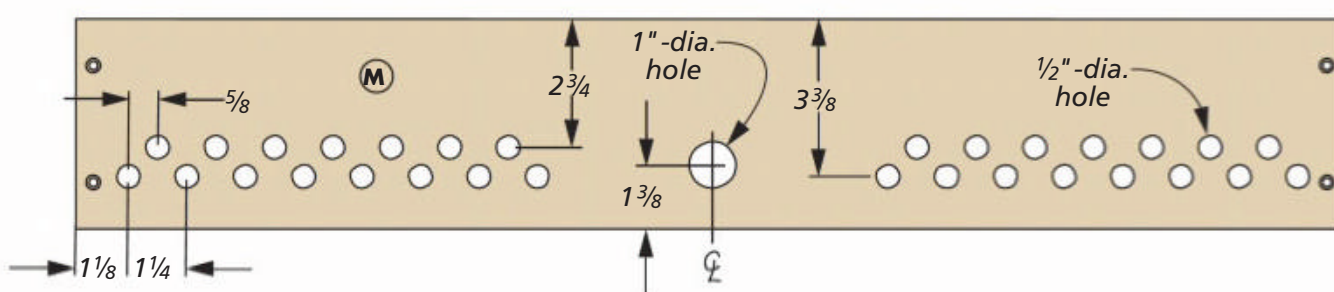
AIR HOLES. The locations of the air holes aren't critical. At the same time, I didn't want random holes all over the enclosure. The drawings below show the spacing and pattern I used to make the holes at the drill press.

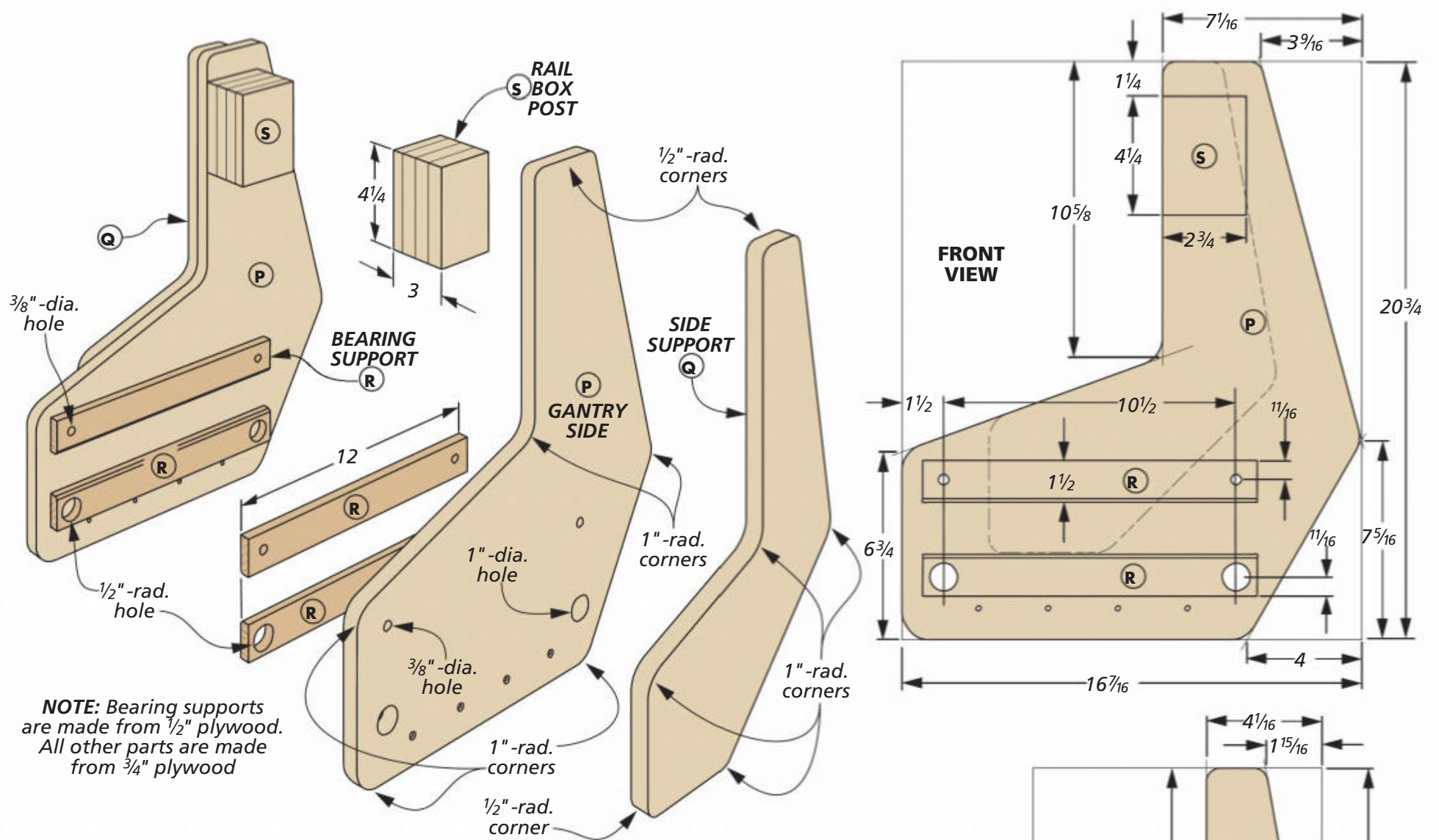
While you're still at the drill press, go ahead and drill the three wire access holes — one in the rear-facing side piece and two in the bottom (detail 'a' above). The holes in the bottom need to line up with the two holes in the top of the bed. Use the holes in the bed to transfer the position to the enclosure bottom. Now, assemble the box and glue it to the bed.

ACRYLIC COVER. As I mentioned earlier, the cover for the electronics enclosure is made from a piece of acrylic. I would recommend waiting until after purchasing the cooling fan before drilling the large hole for it.

Once you have the fan in hand, a circle cutter in the drill press works well to make the hole. Be sure to run the drill press at a slow speed to avoid melting the acrylic. And also be sure to properly secure the workpiece to the drill press table. If the circle cutter were to catch on an unsecured piece, it could create a dangerous situation.

Drill the mounting holes in the cover at this time, also. But hold off installing it until all of the electronics have been installed in the enclosure and the wiring is complete.

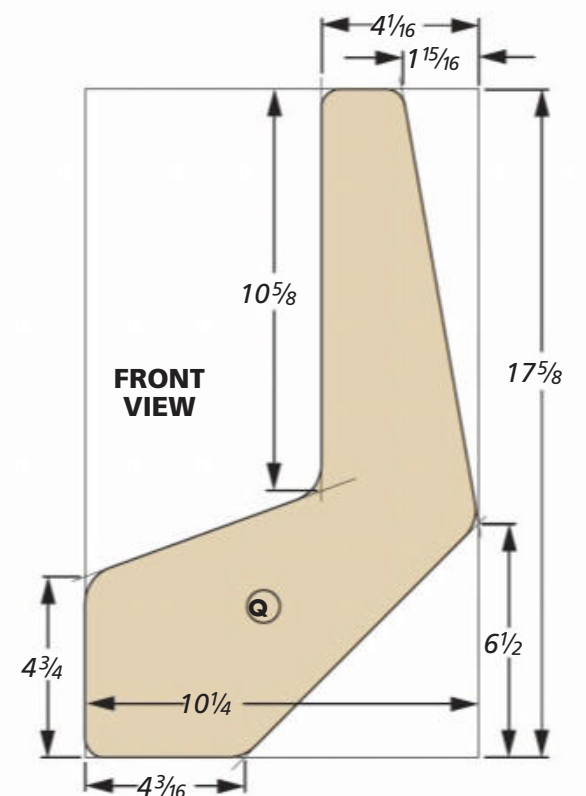
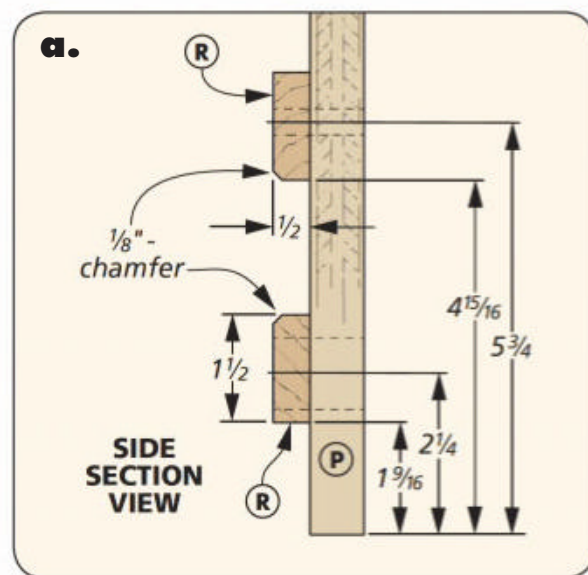




Building the GANTRY

Now that the bed of the CNC router is mostly complete (there are still a few finishing touches that need to be done later on), it's time to turn your attention to the gantry. The gantry moves the motor mount along the length of the bed (X-axis). It rides on the two rails along the edges of the bed. It also provides the foundation for the bridge that spans across the bed and gives the machine its side-to-side movement (Y-axis).

DOUBLE-LAYER SIDES. I began construction on the gantry by making the two sides and the side supports. The supports provide added rigidity to the sides. The best way to make these parts is to cut rectangular blanks to size using the dimensions shown in the two front views above. Note: To speed up the layout process, I sandwished the two side blanks together, as well as the two side support blanks, with double-sided tape.



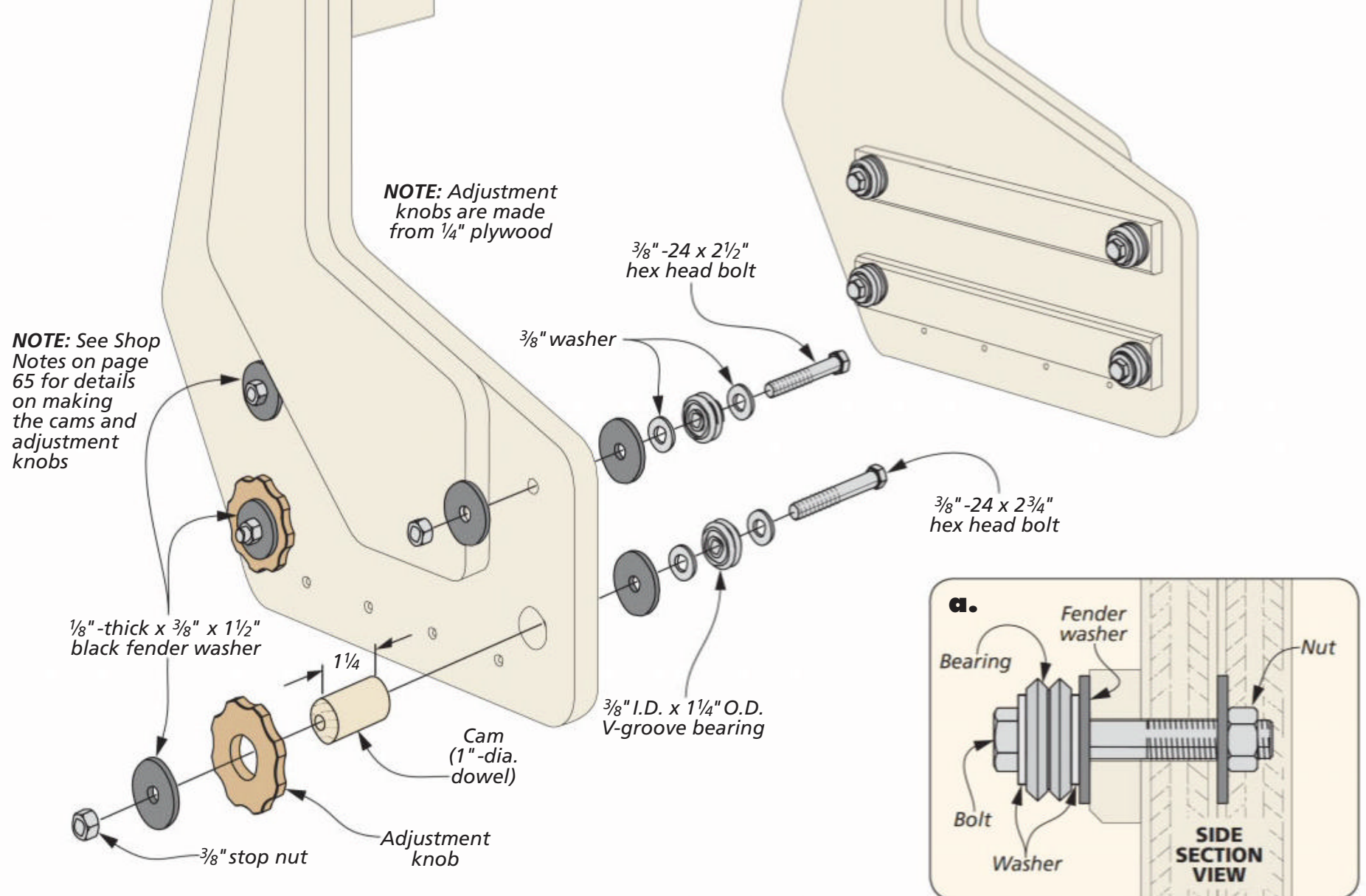
With the blanks taped together, head to the band saw to cut them to shape. After that, spend some time at the disc sander to round the corners and smooth out the cut marks. A spindle or drum sander works well for the inside corners. I also took a minute to drill the four pilot holes along the lower edge of the sides while they were still attached.

ADD BEARING SUPPORTS. Before gluing the supports to the sides, I decided to make the four bearing supports. Since several of the holes in the sides and bearing supports need to line up, I wanted the bearing supports in place before drilling these holes. Be sure to

note that the bearing supports have one inside edge chamfered to provide added clearance. You can see this in detail 'a'. The bearing supports are then glued in place.

When the glue dries, drill the large holes in the lower bearing support and side, and the smaller holes in the upper bearing support and side. The side supports can then be glued in position to the outside face of the sides. Simply line up the top and front edges before clamping them in place.

THICK POSTS. Before moving on, I added one more component to each side assembly — the rail box posts.



These posts are glued up pieces of plywood cut to final size. Each post is glued to the inside face of the sides (upper front view) and provides a mounting point for the bridge that is added shortly.

ADDING HARDWARE

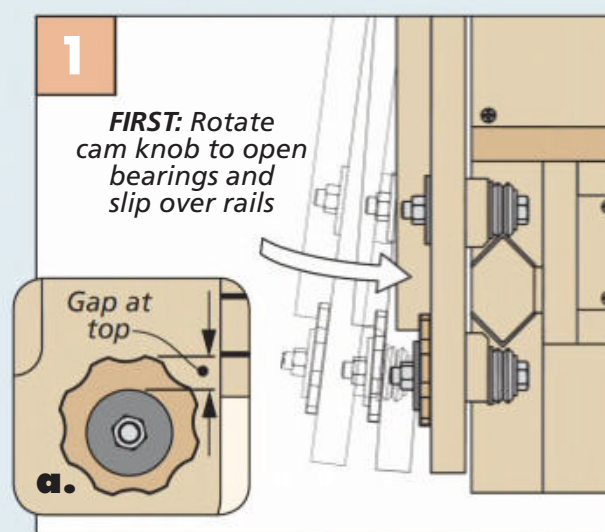
As I mentioned earlier, the gantry moves along the rails via a series of V-groove bearings attached to the bearing supports. A clever, shop-made cam assembly allows you to fine-tune the gantry position for smooth movement along the rails. Making the knob for this mechanism is up first.

OFFSET, LOBED CAM. There are two parts that make up each cam assembly — the adjustment knob and the cam. The adjustment knob is a piece of 1/4" plywood with a hole in the center and a "lobed" perimeter that makes it easy to grip. The cam is simply a short piece of dowel with an offset hole drilled through it. When complete, the cam is glued in the hole in the knob. The drawings on this page give you an idea of what these look like. For more information on making the cam assemblies, turn to Shop Notes on page 65.

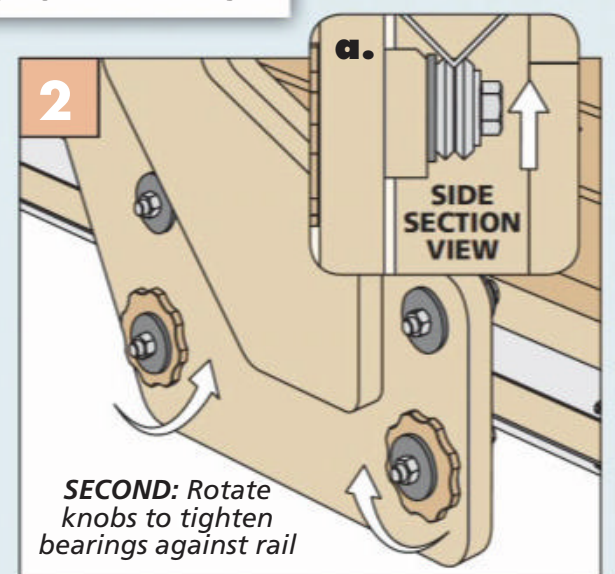
MORE HARDWARE. With the four cam assemblies done, take a look at the

drawing above to see how to add them to the sides in conjunction with the V-groove bearings and the rest of the hardware. You'll notice that the two upper bearings are fixed in position and only the two lower bearings on each side need to be adjusted to fit the rails. With the hardware in place, the How-To box below shows how to slip the sides on the rails and lock them in place using the cam knobs.

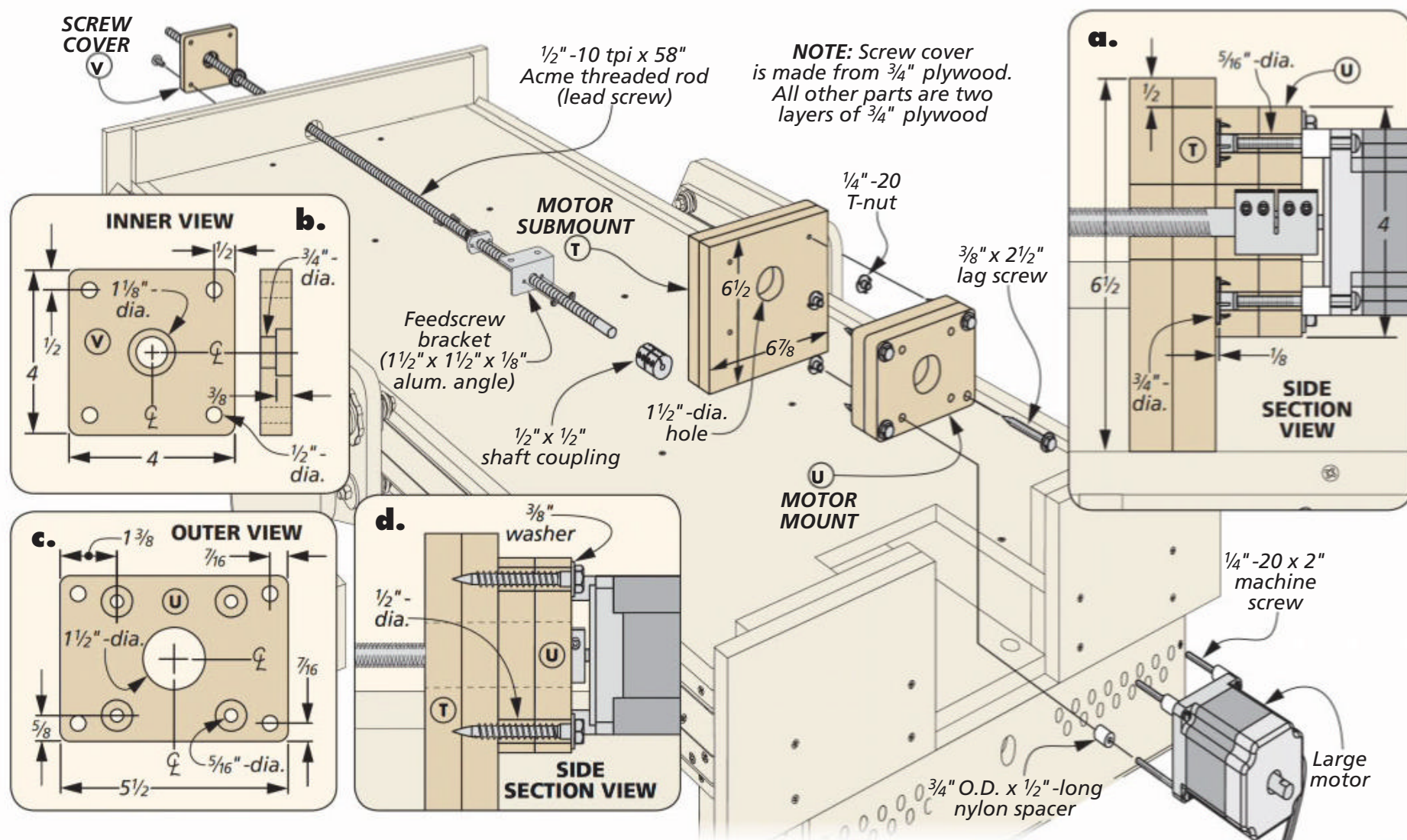
How-To: POSITION SIDES ON RAILS



Tilt in Place. With the cam assemblies in their lowest position (detail 'a'), tilt the sides onto the rails.



Lock in Position. Rotate the cam knobs to hold the sides tight on the rails. Then, tighten the bolts to lock it in place.



Add the UNDERCARRIAGE

At this point, the gantry sides are locked in position on the rails using the cams. For the next steps, you'll want to flip the table upside-down on a set of sawhorses. Just take care of the gantry sides. Now, you'll add components to the undercarriage of the machine. These parts include the lead screw, main motor, and accompanying hardware, as well as the parts that span the gantry sides to connect them together.

LEAD SCREW & MOTOR. The drawings above show an overview of the parts

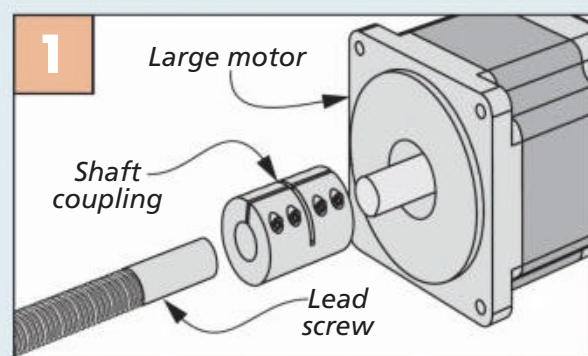
you'll need to add the lead screw and main motor. The woodworking isn't complicated by any means. Both the motor mount and submount are two layers of plywood and the screw cover is a single layer. Each piece has several holes that need to be drilled.

The hole locations and sizes are found in the details, above. You'll want to note that the motor mount has recessed T-nuts on the face that mates with the motor submount (detail 'a'). Likewise, the screw cover has a counterbored

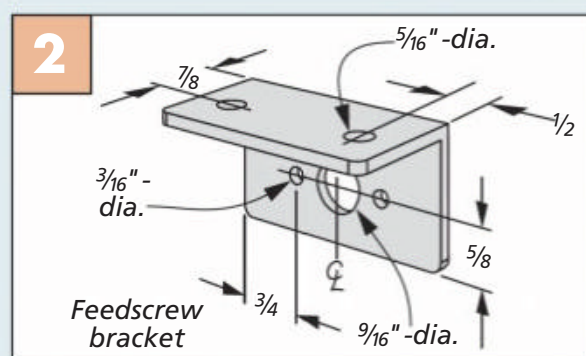
hole on its inside face to house a bearing (detail 'e').

You'll also notice that the mounting holes in the motor mount and screw cover are slightly oversized. This lets you fine-tune the gantry position later on, when the construction is completed.

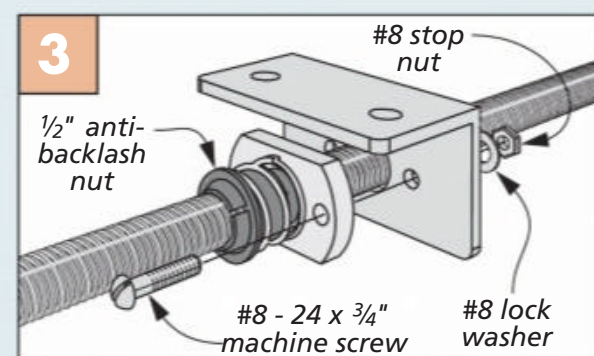
How-To: MAKE THE LEAD SCREW HARDWARE



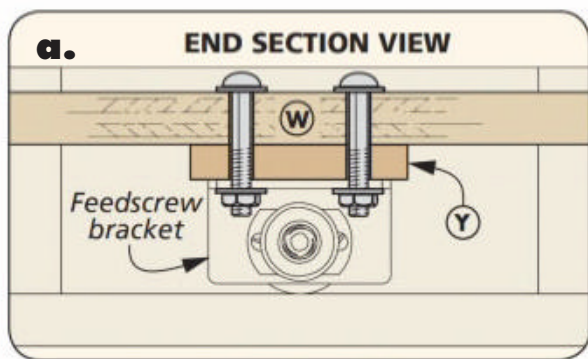
Add Shaft Coupling. Install the shaft coupling between the lead screw and motor shaft and tighten the set screws.



Make the Bracket. The feedscrew bracket is made from a piece of aluminum angle.



Anti-Backlash. Thread the anti-backlash nut onto the lead screw and secure it to the feedscrew bracket.



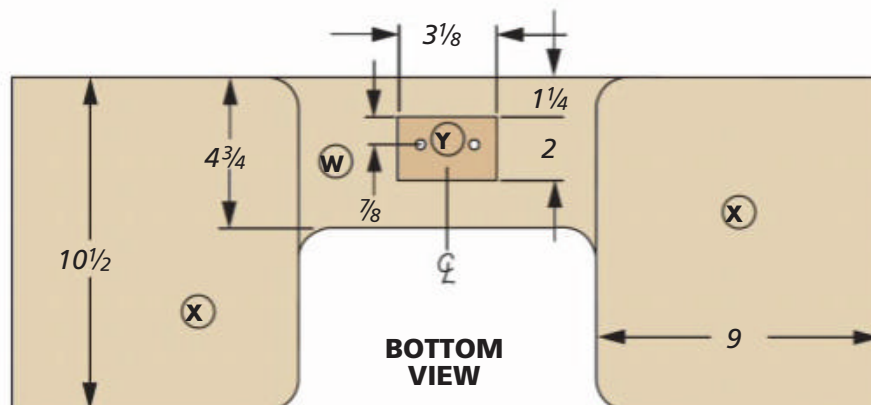
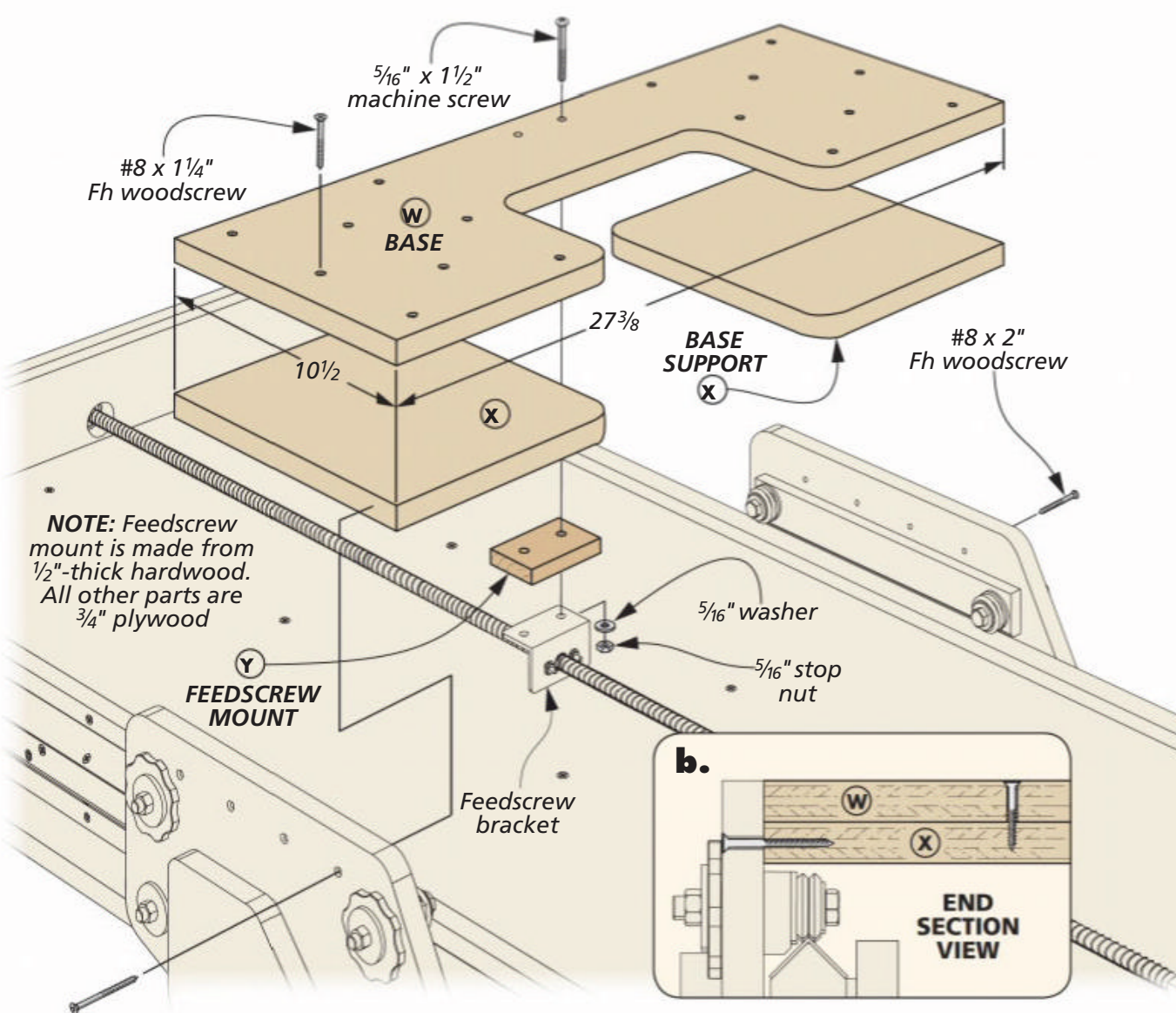
ADD HARDWARE. The motor submount is attached directly to the underside of the table with glue. For now, you can loosely attach the screw cover to the end of the table. The How-To box at the bottom of the previous page shows the process for making and installing the rest of the lead screw hardware and the main motor. You'll attach the motor to the mount, but just loosely snug the mounting bolts for now.

COMPLETE THE GANTRY BRIDGE

Now, you'll switch back to a little wood-working to span the gap between the gantry sides. The key here is to ensure that both sides remain square to the table while you measure the distance between the sides near the lower edge. The gantry base should be cut to this length. Then, add the base supports and the feed screw mount before attaching the entire assembly to the sides with screws (detail 'b').

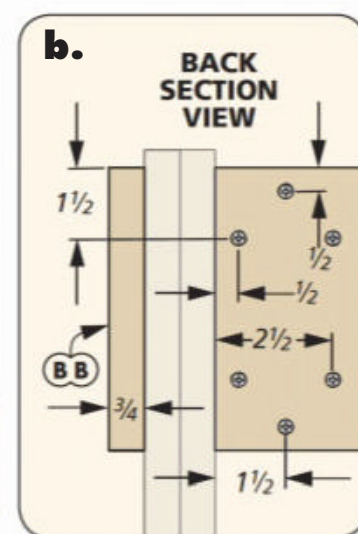
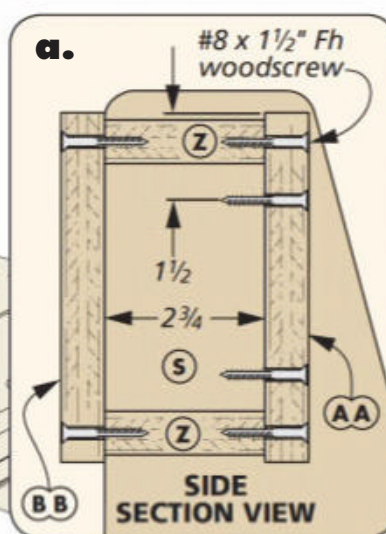
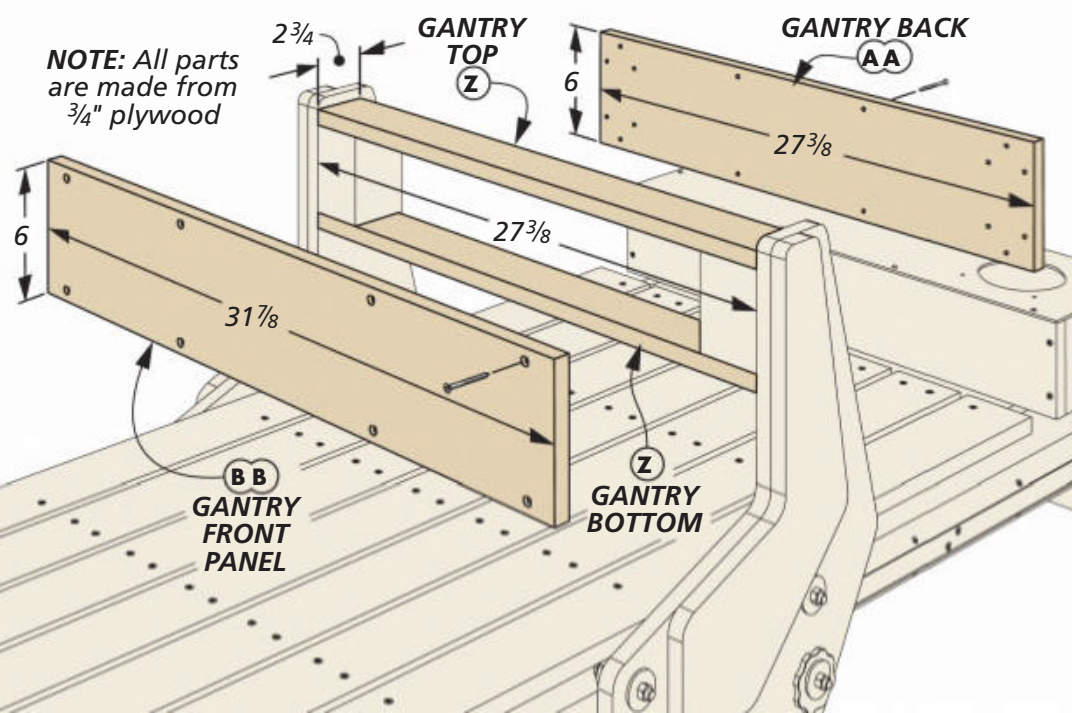
You can also tie the base assembly to the feed screw bracket with bolts, washers, and nuts (detail 'a'). With the work on the undercarriage wrapped up, have a helper assist you in flipping the table upright again before moving on to the upper section of the gantry.

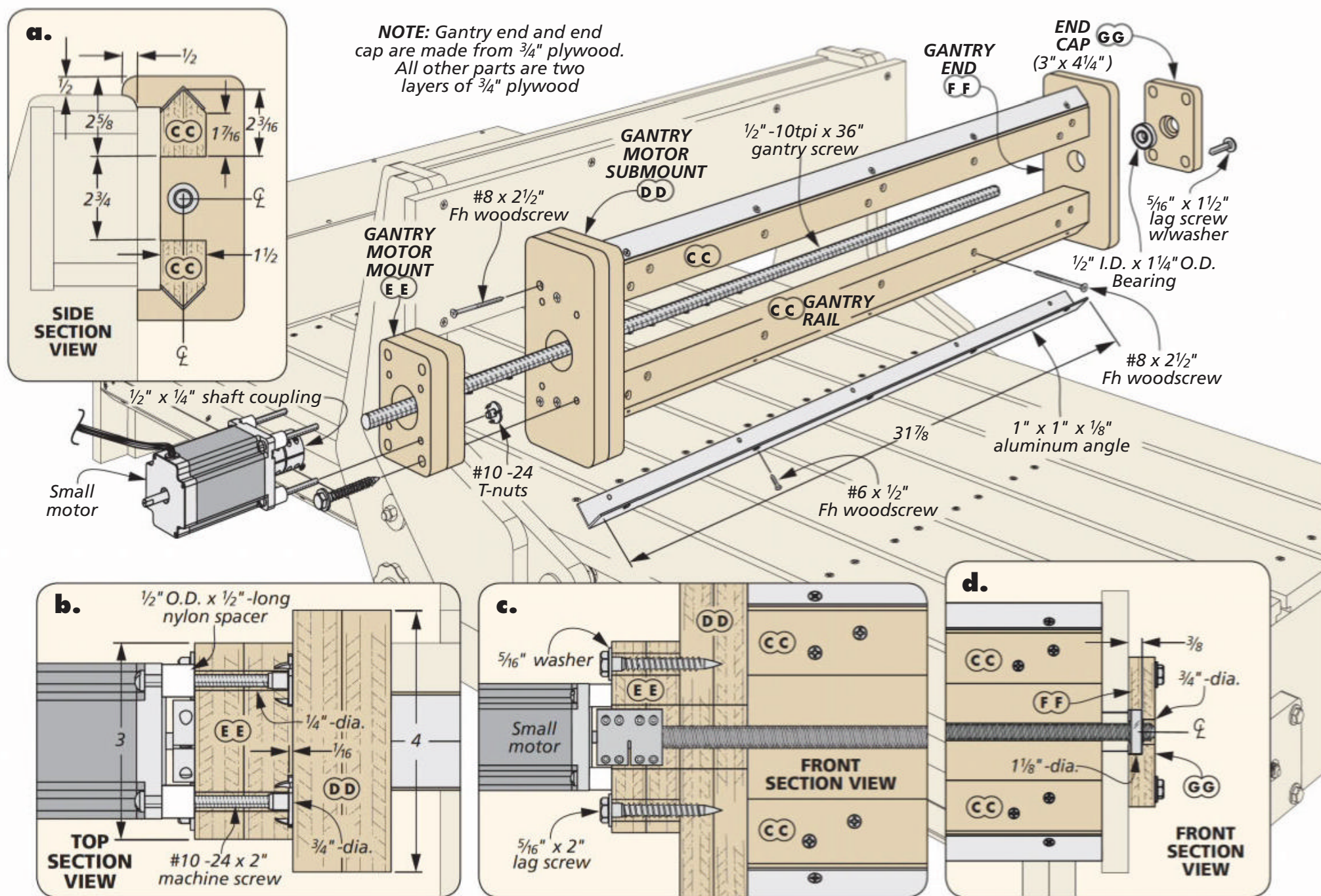
GANTRY BRIDGE. To complete the top side of the gantry, you'll again take the measurement between the sides



near the top edge. If the sides are still square to the table, this dimension should be the same as the length of the gantry base. Now cut the top, bottom, and back to this length and fasten them in place (drawings below).

The top and bottom are glued to the rail box posts and the back is attached to all three parts. The front panel extends out past the edge of the gantry side supports (detail 'b'). Cut this part to size and add it to the assembly, as well.





Completing the GANTRY

With the sides of the gantry connected over the top and underneath the bed, there are just a few more parts to add to wrap up this portion of the CNC machine. And the remaining wood-working should look pretty familiar

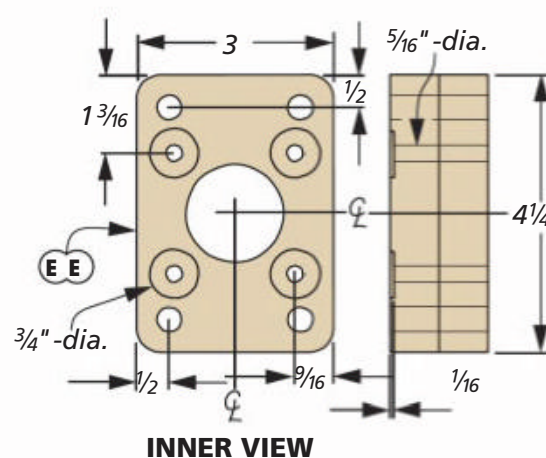
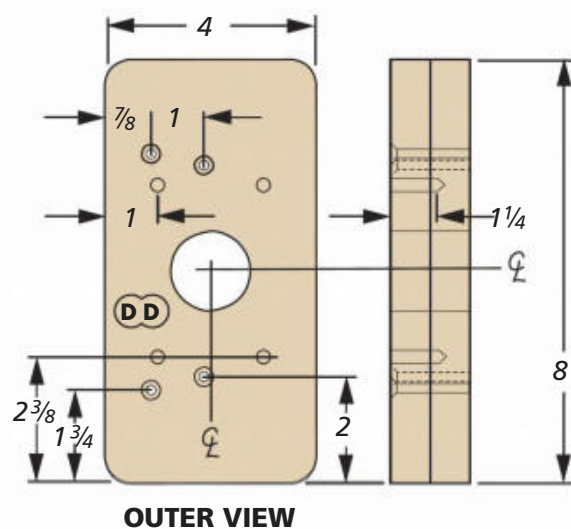
at this point. Here you'll be adding the mounts and rails to the gantry that control the Y-axis movement of the machine. After that, I'll walk you through the process for aligning the gantry at both ends of the bed and tightening the motor mount bolts.

SHORT RAILS. But first, start by making another set of rails. The only difference from the rails along the side of the bed is that we've separated these rails so the gantry screw can run between them (illustrations above). But the process for cutting the miters on the

edges and adding the aluminum angle runners is the same as before. When completed, set the rails aside.

MOUNTS AND CAPS. On the motor side of the gantry, the submount and motor mount are next. The two drawings at lower left provide the information you'll need to make these parts. They're made in a similar fashion as those for the main motor using two layers of plywood for each. The main difference here is that the Y-axis motor that these parts support is slightly smaller than the main motor.

At the other end of the gantry, the cap has a bearing recessed in the face and secured between the end piece (detail 'd'). With all of the parts done, use detail 'a' to position and attach them to the front panel of the gantry. Be sure to install the T-nuts in the motor mount before securing it to the submount. And also, as before, leave the lag screws for the motor mount and end cap loose. You'll align and tighten them up after



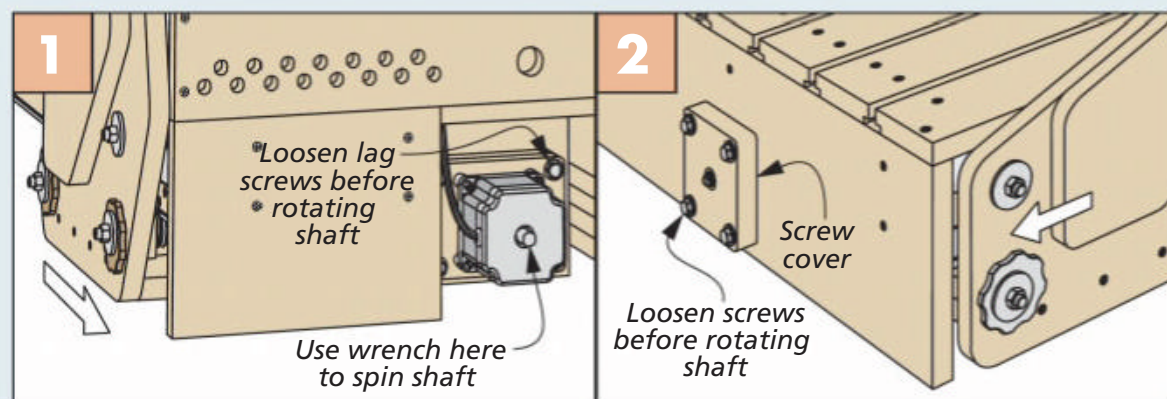
How-To: ALIGN THE GANTRY

the router mount is built in the next issue. Finish up the work on the gantry by adding the motor and gantry screw.

GANTRY ALIGNMENT. It's critical that the gantry doesn't bind as it travels along the rails. The How-To box at right shows the process to align the gantry for smooth operation.

First, loosen the cam knobs and adjust them so they're just snug. You want the gantry to be able to move in the next step. The back end of the motor shaft has a flat that allows for a small wrench or vise grips, as seen in Figure 1.

Turn this shaft until the gantry has moved all the way to the motor end of the bed. This will align the lead screw and the motor. Now you can tighten the motor mount lag screws, locking it in place. Next, move the gantry to the other end (Figure 2) and do the same process to align the end of the screw with the screw cover.



Align & Tighten Mounts. First, move the gantry to the motor end of the bed by turning the end of the motor shaft with a wrench. Tighten the motor mount lag screws. Move the gantry to the other end and tighten the screw cover bolts.

MORE TO COME. With that, you're well on your way to adding a 3-axis CNC router to your shop. In the next issue, we'll wrap up the CNC. This will start by building the router holder. Then, we'll add the electronic controllers, and walk you through the wiring.

Below, you'll find the hardware needed to build the entire CNC router. For a detailed sources list, head over to Woodsmith.com. There, you'll find an online extra that contains vendor information, along with links to the vendors websites for ordering parts. **W**

Materials & Supplies

- A** Top/Bottom (2) $\frac{3}{4}$ ply. - 22 $\frac{1}{2}$ x 60
- B** Side Rails (2) $\frac{3}{4}$ ply. - 4 x 60
- C** Inner Rails (2) $\frac{3}{4}$ ply. - 2 $\frac{1}{2}$ x 58 $\frac{1}{2}$
- D** Long End Rail (1) $\frac{3}{4}$ ply. - 2 $\frac{1}{2}$ x 22 $\frac{1}{2}$
- E** Short End Rails (2) $\frac{3}{4}$ ply. - 2 $\frac{1}{2}$ x 7 $\frac{13}{16}$
- F** Inner Skirts (2) $\frac{3}{4}$ ply. - 3 $\frac{1}{4}$ x 8 $\frac{9}{16}$
- G** Outer Skirts (2) $\frac{3}{4}$ ply. - 7 $\frac{1}{4}$ x 10 $\frac{1}{8}$
- H** Long Inner Skirt (1) $\frac{3}{4}$ ply. - 3 $\frac{1}{4}$ x 24
- I** Long Outer Skirt (1) $\frac{3}{4}$ ply. - 7 $\frac{1}{4}$ x 27 $\frac{1}{8}$
- J** Rail Spacers (2) $\frac{3}{16}$ x 1 - 60
- K** Rails (2) 1 $\frac{1}{2}$ ply. - 2 $\frac{3}{8}$ x 60
- L** Clamp Boards (7) $\frac{3}{4}$ ply. - 3 $\frac{1}{2}$ x 51 $\frac{1}{2}$
- M** Sides (2) $\frac{3}{4}$ ply. - 4 $\frac{1}{2}$ x 27 $\frac{1}{8}$
- N** Ends (2) $\frac{3}{4}$ ply. - 4 $\frac{1}{2}$ x 6 $\frac{3}{8}$
- O** Bottom (1) $\frac{3}{4}$ ply. - 6 $\frac{3}{8}$ x 25 $\frac{5}{8}$
- P** Gantry Sides (2) $\frac{3}{4}$ ply. - 16 $\frac{7}{16}$ x 20 $\frac{3}{4}$
- Q** Side Supports (2) $\frac{3}{4}$ ply. - 10 $\frac{1}{4}$ x 17 $\frac{5}{8}$
- R** Bearing Supports (4) $\frac{1}{2}$ ply. x 1 $\frac{1}{2}$ - 12
- S** Rail Box Posts (2) 2 $\frac{3}{4}$ ply. - 3 x 4 $\frac{1}{4}$
- T** Motor Submount (1) 1 $\frac{1}{2}$ ply. - 6 $\frac{1}{2}$ x 6 $\frac{7}{8}$
- U** Motor Mount (1) 1 $\frac{1}{2}$ ply. - 4 x 5 $\frac{1}{2}$
- V** Screw Cover (1) $\frac{3}{4}$ ply. - 4 x 4
- W** Base (1) $\frac{3}{4}$ ply. - 10 $\frac{1}{2}$ x 27 $\frac{3}{8}$
- X** Base Supports (2) $\frac{3}{4}$ ply. - 10 $\frac{1}{2}$ x 9
- Y** Feedscrew Mount (1) $\frac{1}{2}$ x 2 - 3 $\frac{1}{8}$
- Z** Gtry. Top/Bottom (2) $\frac{3}{4}$ ply. - 2 $\frac{3}{4}$ x 27 $\frac{3}{8}$
- AA** Gantry Back (1) $\frac{3}{4}$ ply. - 6 x 27 $\frac{3}{8}$
- BB** Gantry Front Panel (1) $\frac{3}{4}$ ply. - 6 x 31 $\frac{7}{8}$
- CC** Gantry Rails (2) 1 $\frac{1}{2}$ ply. - 2 $\frac{3}{16}$ x 31 $\frac{7}{8}$

- DD** Gantry Mtr. Submount (1) 1 $\frac{1}{2}$ ply. - 4 x 8
- EE** Gantry Mtr. Mount (1) 1 $\frac{1}{2}$ ply. - 3 x 4 $\frac{1}{4}$
- FF** Gantry End (1) $\frac{3}{4}$ ply. - 4 x 8
- GG** End Cap (1) $\frac{3}{4}$ ply. - 3 x 4 $\frac{1}{4}$
- (165) #8 x 1 $\frac{1}{2}$ " Fh Woodscrews
- (34) #8 x 2 $\frac{1}{2}$ " Fh Woodscrews
- (104) #6 x $\frac{1}{2}$ " Fh Woodscrews
- (3) 1" x 1" x 96" 6061 Aluminum Angle
- (10) #6 x 1" Rh Woodscrews
- (1) $\frac{1}{8}$ " x 28" x 32" Acrylic Sheet
- (8) $\frac{3}{8}$ "-24 x 2 $\frac{3}{4}$ " Hex Head Bolts
- (8) $\frac{3}{8}$ "-24 x 2 $\frac{1}{2}$ " Hex Head Bolts
- (24) $\frac{3}{8}$ " Washers
- (16) $\frac{3}{8}$ " I.D. V-Groove Bearings
- (16) $\frac{1}{8}$ "-thick x $\frac{3}{8}$ " x 1 $\frac{1}{2}$ " Fndr. Washers
- (16) $\frac{3}{8}$ " Stop Nuts
- (1) 1"-dia. x 12" rgh. Dowel
- (1) 3 Axis Elec. Combo for Heavy Gantry
- (4) $\frac{1}{4}$ "-20 x 2" Machine Screws
- (4) $\frac{3}{4}$ " O.D. x $\frac{1}{2}$ "-long Nylon Spacers
- (4) $\frac{1}{4}$ "-20 T-Nuts
- (4) $\frac{3}{8}$ " x 2 $\frac{1}{2}$ " Lag Screws
- (1) $\frac{1}{2}$ " x $\frac{1}{2}$ " Shaft Coupling
- (1) 1 $\frac{1}{2}$ " x 1 $\frac{1}{2}$ " x 24" 6061 Alum. Angle
- (2) $\frac{1}{2}$ "-10tpi x 60" Lead Screws
- (2) $\frac{1}{2}$ " I.D. x 1 $\frac{1}{4}$ " O.D. Bearings
- (8) $\frac{5}{16}$ " x 2" Lag Screws
- (24) $\frac{5}{16}$ " Washers

- (3) $\frac{1}{2}$ " Anti-Backlash Nut
- (6) #8 -24 x $\frac{3}{4}$ " Machine Screws
- (6) #8 Lock Washers
- (6) #8 Stop Nuts
- (8) $\frac{5}{16}$ " x 1 $\frac{1}{2}$ " Machine Screws
- (8) $\frac{5}{16}$ " Stop Nuts
- (16) #8 x 1 $\frac{1}{4}$ " Fh Woodscrews
- (8) #8 x 2" Fh Woodscrews
- (4) $\frac{5}{16}$ " x 1 $\frac{1}{2}$ " Lag Screws
- (8) #10-24 x 2" Machine Screws
- (8) #10-24 T-Nuts
- (2) $\frac{1}{2}$ " x $\frac{1}{4}$ " Shaft Coupling
- (8) $\frac{1}{2}$ " O.D. x $\frac{1}{2}$ "-long Nylon Spacers

Additional Materials for Router Mount

- (1) Mach3 Software
- (1) ArtCam or Vectric CAD/CAM Software
- (1) 24" Dust Skirt
- (1) Cooling Fan
- (1) Grounded Cord Set
- Variety of 14 ga. Electrical Wire
- Variety of 14 ga. Wire Nuts
- (1) High Cycle 4 Lead Elec. Cable -10ft.
- Variety of Cable Clamps
- (1) $\frac{5}{16}$ "-18 x 12" Threaded Rod
- (2) $\frac{5}{16}$ "-18 Star Knobs
- (20) #8 x $\frac{1}{2}$ " Ph Sheet Metal Screws

Also needed: Three 60" x 60" sheets of $\frac{3}{4}$ " Baltic birch plywood



Modular Patio Seating

With deep, inviting seats, this modular outdoor furniture can be arranged to fit any outdoor space. It will become your favorite lounging spot.

When summertime is on the horizon, I start daydreaming of boating, get-togethers, and barbecues. But one of my favorite things is those summer nights that are nice and cool after a warm day. These are the nights that we often find ourselves lounging around the fire pit. And when I first saw the

design for this seating, I knew the deep seats were the perfect place to curl up on and enjoy one of those nights.

MODULAR DESIGN. One of the things that I like about this seating is it's modular. The chairs are designed to fit together to create sofa-type seating, as you can see above. The combination of corner

and side chairs means you can build as many as you like to fit anywhere.

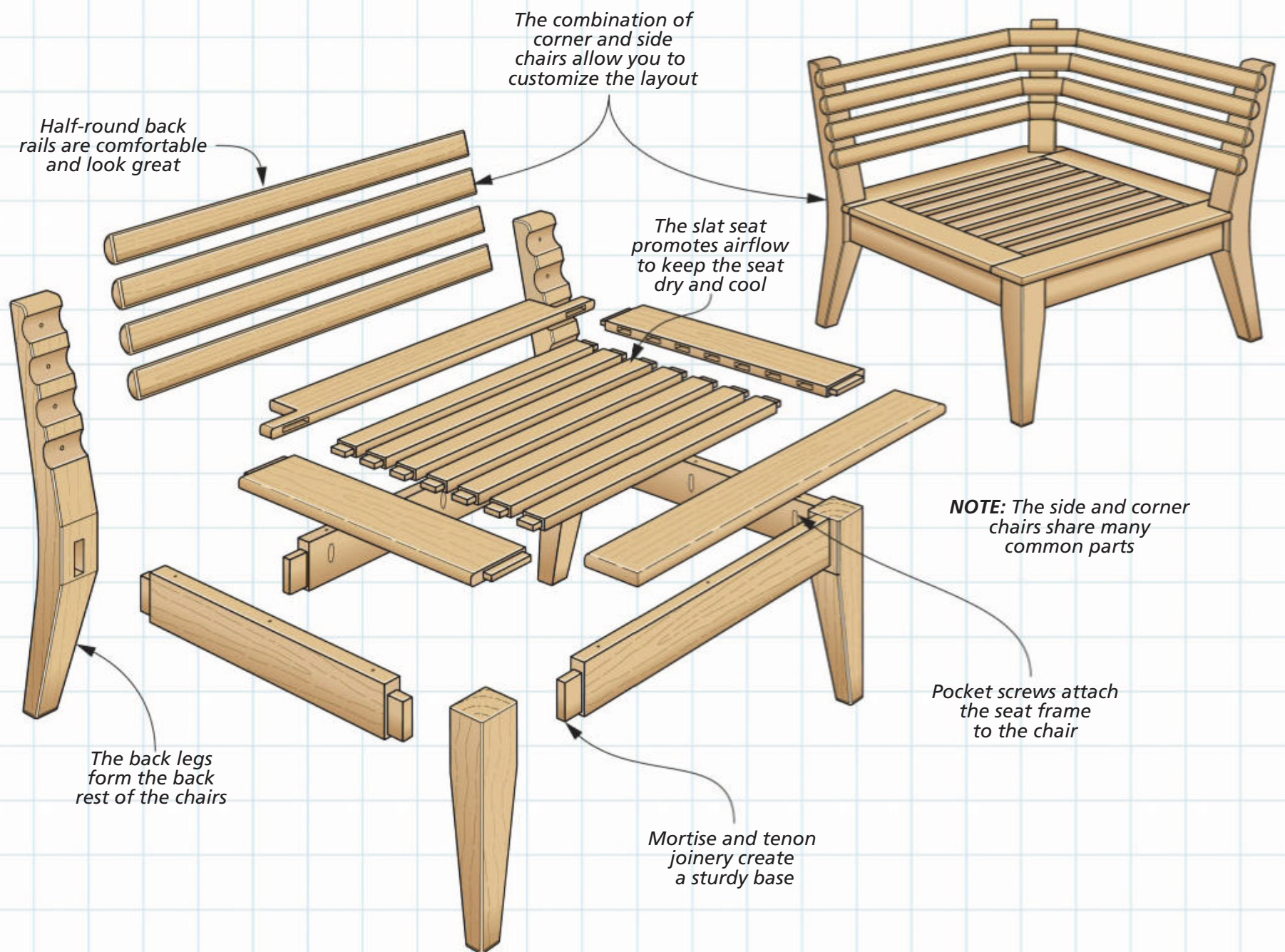
Beyond the modular design, the hardwood construction offers some great and unique woodworking challenges as well. So turn the page to get started, because you'll want to have them ready for that first cool summer night.



▲ The deep seat of the chairs creates the perfect platform for a cushion. There's plenty of room to curl your legs up and lounge.



▲ The gentle angle of the backrest makes the chair a comfortable place to relax. The miters are reinforced with a pair of splines.

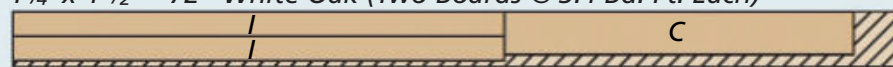


Materials, Supplies & Cutting Diagram (1 Side Chair & 1 Corner Chair)

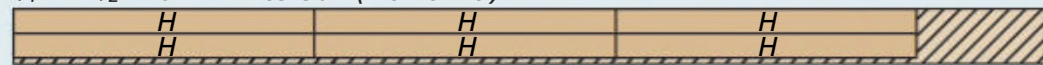
A	Front Legs (3)	3 x 3 - 14¼"
B	Back Legs (4)	3 x 6⅜ - 30"
C	Chair Rails (6)	1¼ x 3½ - 28½"
D	Rear Corner Leg (1)	3 x 5 - 30"
E	Corner Rails (2)	1¼ x 3½ - 27½"
F	Seat Fronts/Backs (4)	¾ x 4½ - 32"
G	Seat Sides (4)	¾ x 4½ - 24½"
H	Seat Slats (14)	¾ x 2 - 24½"
I	Back Rails (13)	1¼ x 2 - 32 (rgh)

- (24) #8 x 1¾" Pocket Screws
- (20) #8 x 1¾" Rh Woodscrews

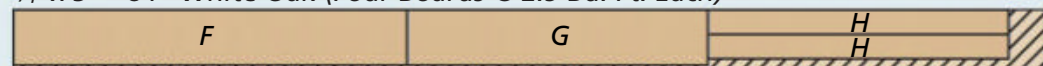
1¼" x 4½" - 72" White Oak (Two Boards @ 3.4 Bd. Ft. Each)



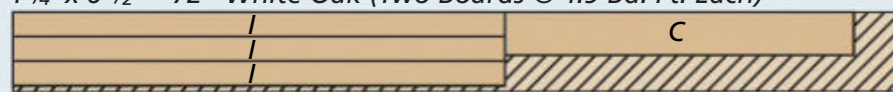
¾" x 4½" - 84" White Oak (2.6 Bd. Ft.)



¾" x 5" - 84" White Oak (Four Boards @ 2.9 Bd. Ft. Each)



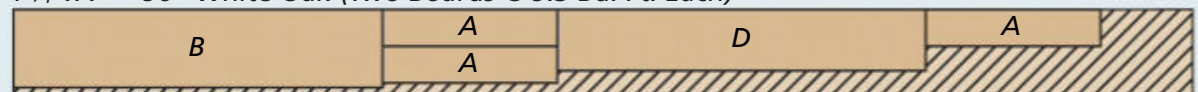
1¼" x 6½" - 72" White Oak (Two Boards @ 4.9 Bd. Ft. Each)



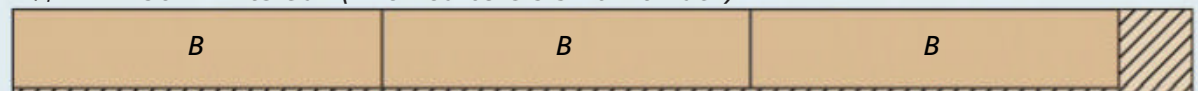
1¼" x 7½" - 96" White Oak (Two Boards @ 7.5 Bd. Ft. Each)

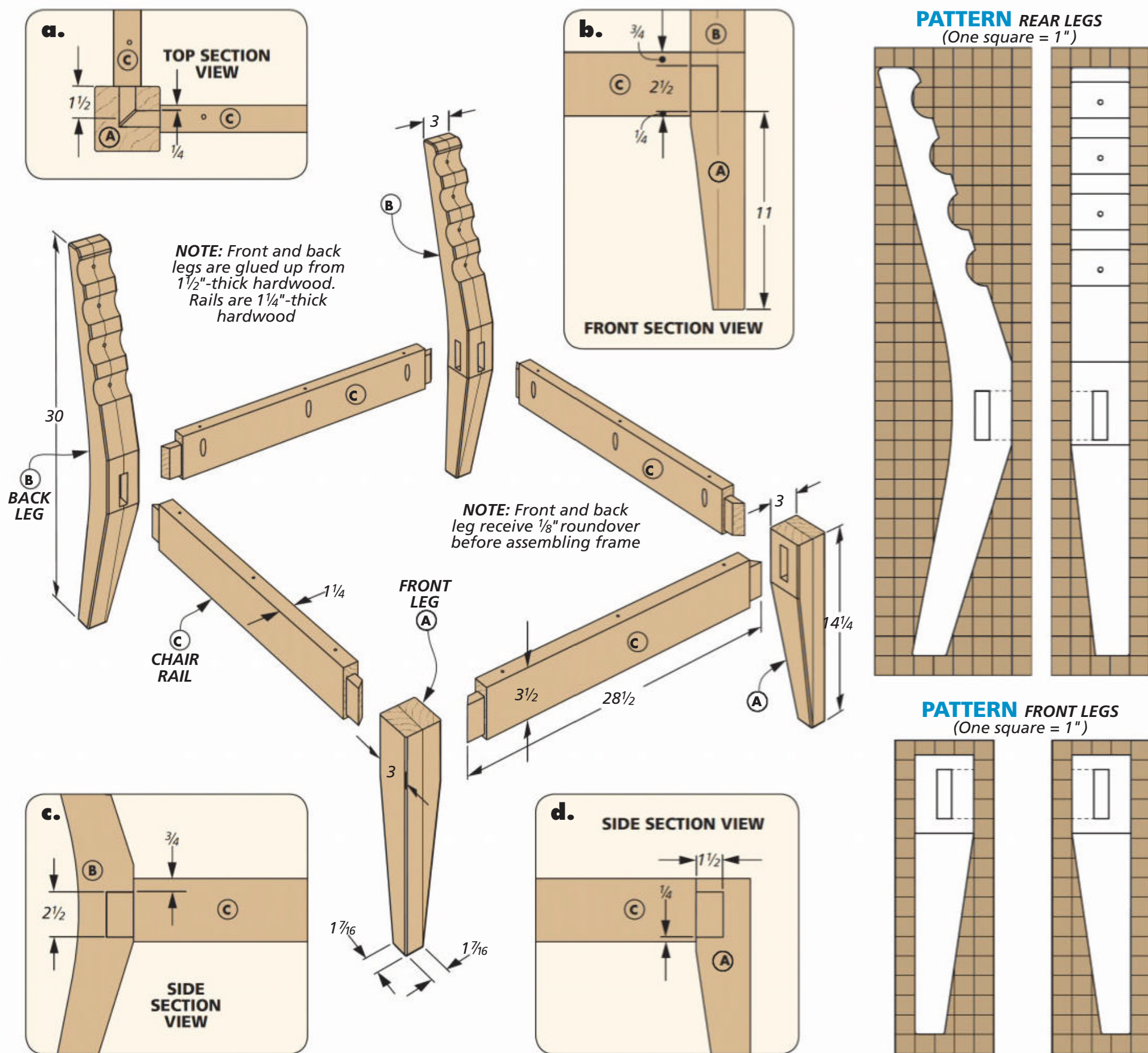


1¾" x 7" - 96" White Oak (Two Boards @ 9.3 Bd. Ft. Each)



1¾" x 7" - 96" White Oak (Two Boards @ 9.3 Bd. Ft. Each)





Start with the **SIDE CHAIR FRAME**

For the outdoor seating I built, I decided on two side and two corner chairs. The chairs share many of the same frame parts, but the side chair is a little more straightforward, so I started with that frame. Before you head out to the lumberyard, give a little thought to your material selection. Outdoor projects are exposed to the elements, so the material selection is extremely important. Here, I used durable white oak. For some tips on material and

building for the outdoors in general, see the article on page 10.

BEEFY FRAME. As you can see in the drawing above, the frame consists of three different parts — front and rear legs connected by rails. The legs are made of glued up blanks that are tapered on the inside faces. The rails are joined to the legs with mortise and tenon joinery, and will later be used to attach the seat frame to the chair. Up first are the front legs.

SQUARE BLANKS. After gluing up the stock for the front legs, I planed them to final size and cut them to length. I held off on cutting any tapers yet. Laying out and cutting the mortises is easier with everything still square. After marking the mortise locations, I cut the mortises using a mortising machine (Figure 1, next page). If you don't have a mortising machine, you can drill out the mortises and square them up with a chisel.

At this point, I want to mention that the front legs are common to both chairs. The corner chairs each require one front leg, and the side chairs require two each. So while I was making one set of front legs, I went ahead and made all six legs that were needed for my configuration.

FREEHAND TAPERS. With the mortises cut on the inside faces of each front leg, you can now convert the square blank into the tapered leg. The pattern on the previous page acts as a guide. After laying out the pattern on the leg, I cut the tapers at the band saw, as seen in Figure 2. A few quick swipes with a hand plane removes the band saw marks. After routing a small roundover on the edges of the front legs, you can set them aside and turn your focus to the rear legs.

A GOOD ANGLE. The back legs form the back of the seat frame and also the support for the back of the chair. Round notches on the upper portion of the legs will hold the back slats that are added later. As with the front legs, the back legs are common between the chairs. The side and corner chairs each require two of these legs, so I made eight total.

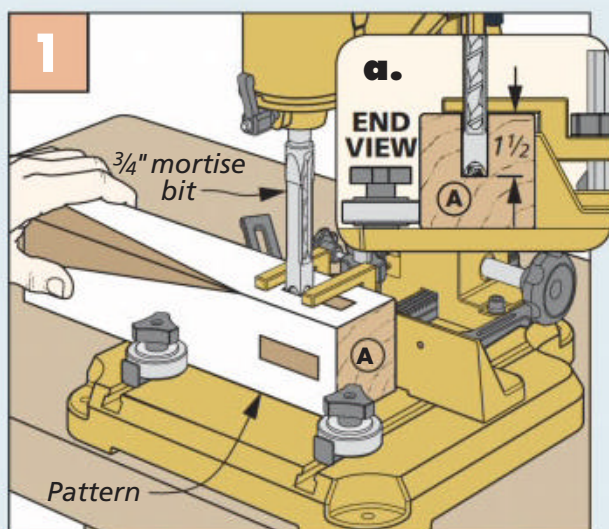
Like the front legs, the back legs start as glued up stock to make the blanks. After laying out the pattern on the blank, you'll want to drill the notches for the back slats. I did this with a Forstner bit at the drill press, as seen in Figure 3.

The leg can now be cut to shape at the band saw. I followed the pattern closely, but made sure to leave a little material so I could sand right up to the line. The leg blanks are large, so take your time here.

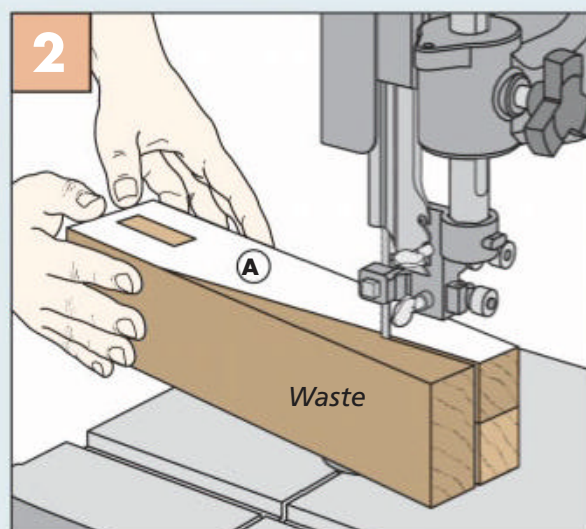
MORTISES NEXT. Now, it's back over to the mortising machine (or drill press) to cut the mortises. Cutting the mortise on the inside face is straightforward — just remember that you need left and right legs (four of each in my case). These require the inside mortise on opposing faces. The mortise on the front is a little trickier due to the curved back not allowing the leg to lay flat. But a little blocking will have you on your way. You can see how I set this up in Figure 4 below.

FINALLY, RAILS. With the legs complete, making the rails for the frame is straightforward. With the rails cut to size, I cut a tenon at the table saw, as seen in Figure 5. Just note the tenon is offset. After mitering the ends of the tenons, finish up the rails by drilling three pocket screw holes in each one (Figure 6).

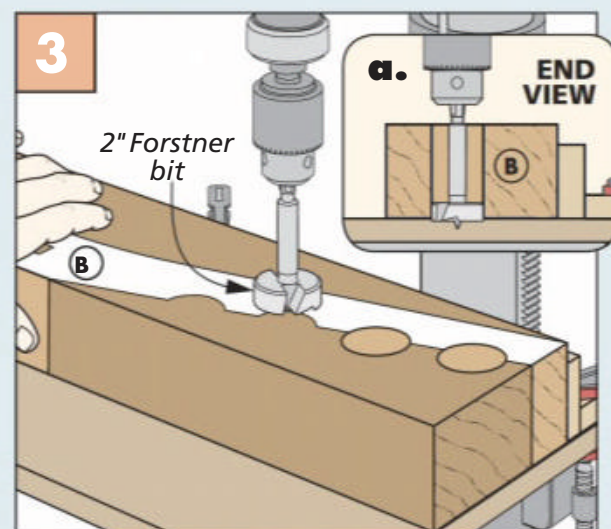
How-To: CUT & SHAPE THE CHAIR LEGS & RAILS



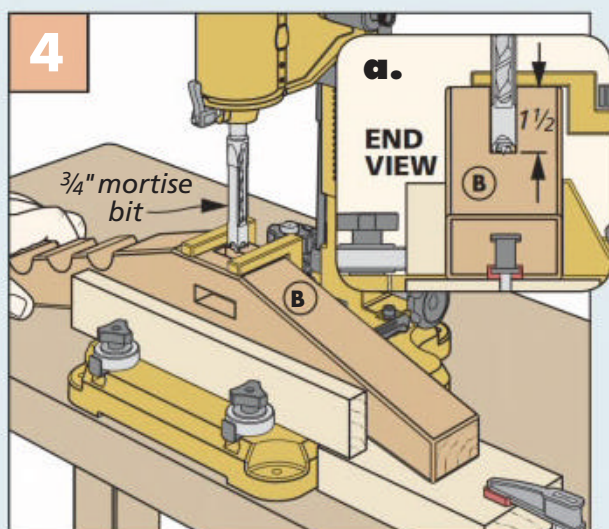
Front Leg Mortises. Use a mortising machine to cut the mortises in both adjoining faces of the front legs.



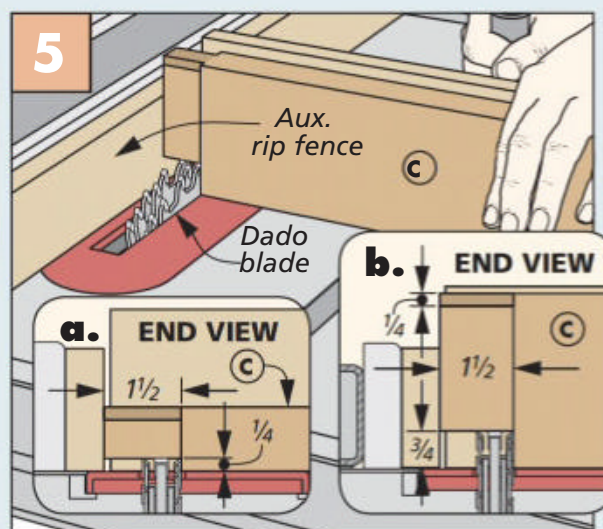
Taper the Legs. At the band saw, taper the legs, staying to the waste side of the line. Then sand or plane to the line.



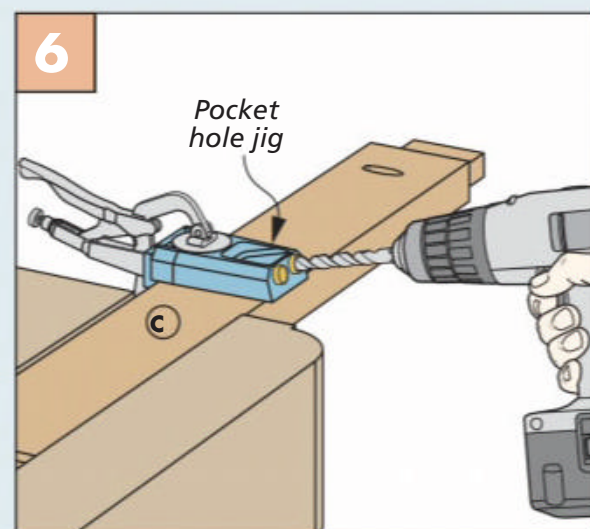
Drill the Back Legs. After laying out the back legs, use a Forstner bit to drill the notches. Then cut the leg to shape.



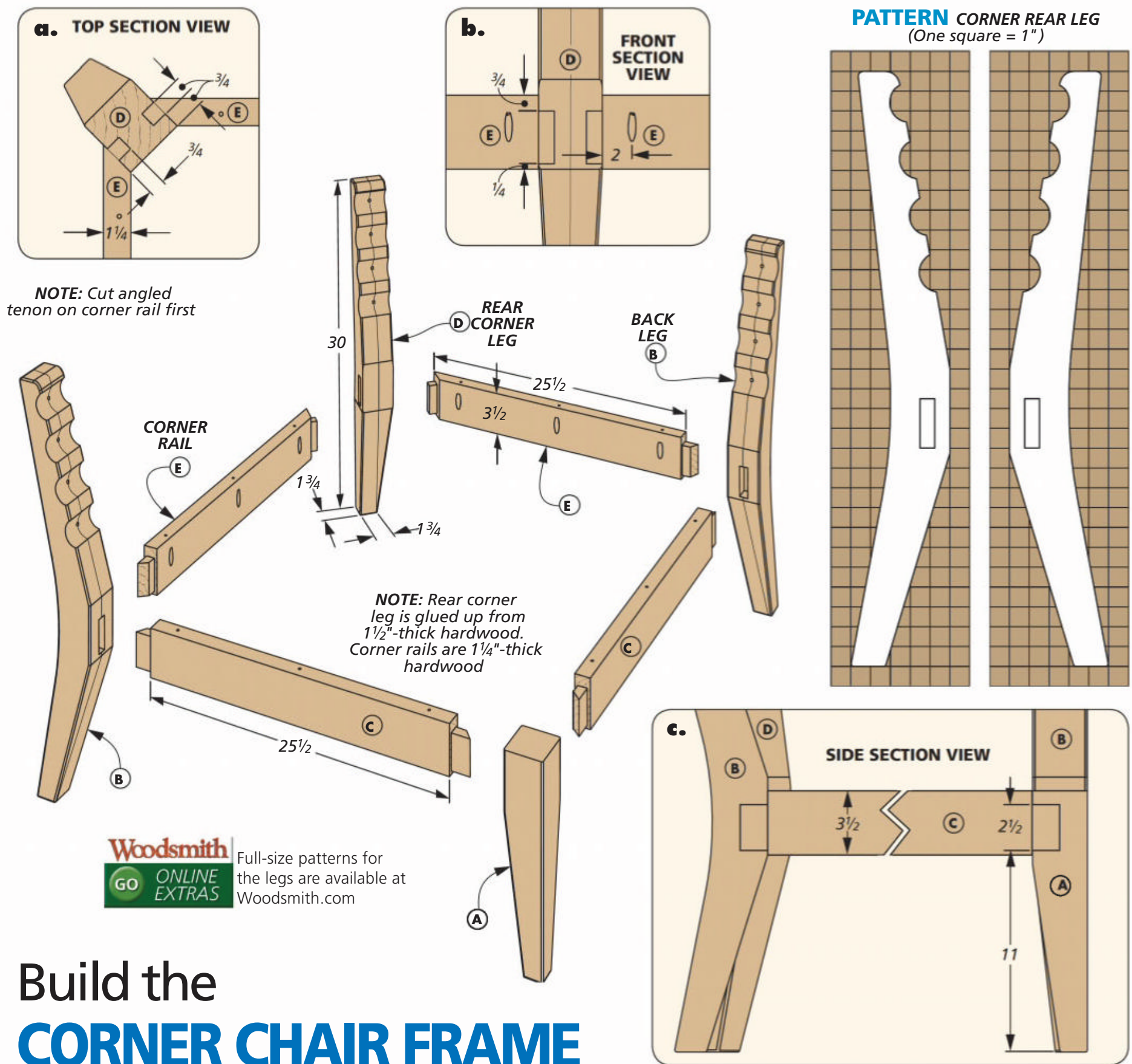
Rear Leg Mortises. Back at the mortising machine, square the leg to the bit before cutting the mortises.



Rail Tenons. A dado blade and auxiliary rip fence can be used to cut the tenons on the ends of the rails.



Pocket Screw Holes. Before assembling the chair frames, drill the pocket screw holes in the chair rails.



Build the CORNER CHAIR FRAME

After building the side chair frame, you'll find many of the same parts on the corner chairs. Both chairs share common front legs, back legs, and front rails. To build the corner chairs, you'll add a rear corner leg and a pair of rails with angled tenons.

REAR LEG POSITIONING. The process of making and adding a rear corner leg will look quite familiar. It follows the same steps that are used in the rear legs that you already built. There are two differences, however. The first is the angle of the back support. This leg is slightly more upright. This allows

the back slats that you add later to flow at the same angle as they turn around the corner of the chair.

The second difference is the orientation that the leg sits in relation to the rest of the frame. Instead of the rails meeting this leg at a right angle, they meet it at a 45° angle. You can see what I mean in detail 'a' above. To accept those rails, the mortises on this leg gets cut on opposite faces rather than adjoining faces. Finally, the orientation of the leg allows you to add short back rails in the corner, and avoid a backrest that pinches in the corner.

BLANKS AGAIN. Now that you understand the difference between the rear and corner legs, the rest of the process should be pretty clear. It starts by laying out the pattern onto the blanks and drilling the back slat locations. You can see this in Figure 1 on the next page. Cutting the leg to shape is next. Once you have everything smooth and matching the pattern, it's time to cut the mortises. I started by cutting the left side mortise, as seen in Figure 2. With that done, you can flip the blank over to cut the mortise on the opposite face (Figure 3).

ANGLED RAILS

The two front rails that make up the corner chair frame are the same as the ones you made previously. The rear rails however, have a standard tenon on one end, and an angled tenon and shoulder on the other. The angled tenon matches the mortise on the rear corner leg, and allows that leg to sit at a 45° angle in relation to the chair frame.

ANGLED TENONS. When you're sizing your stock for the rear rails, leave the blank a couple of inches long. I cut the angled tenon first, and then trimmed the rail to final length and cut the opposing tenon.

The key to cutting the angled tenons here is to sneak up on the fit. This is done over at the table saw. I set the rip fence to act like a stop block, and

used a miter gauge and a dado blade to define the top and bottom shoulders of the tenon first (Figure 4). After the shoulders are cut, you can tilt the dado blade 45° and cut the cheeks of the tenon (Figure 5). You'll have to make two passes, cutting the inner cheek first and then flipping the piece over and raising the saw blade.

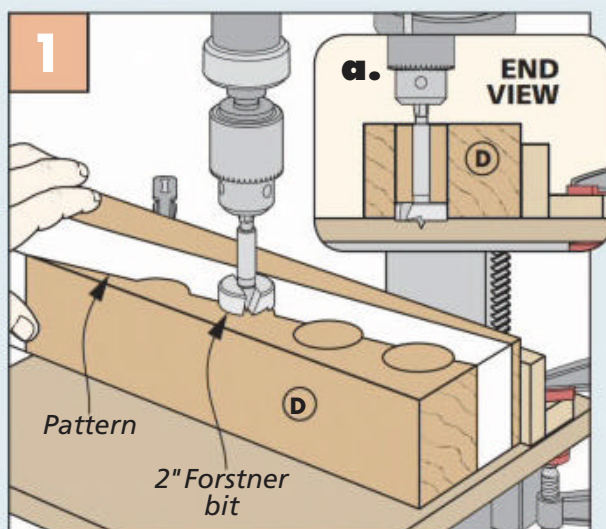
With the angled tenons cut, you can cut the rail to final length and cut the final tenon (Figure 6). A quick miter on the straight tenon and a series of pocket holes finish out the rails.

BASE ASSEMBLY. Now that you have a pile of various parts, it's time to assemble the chair frames. A quick note on glue, however. As with any outdoor furniture project, make sure to use a quality waterproof glue, such as *Titebond III* or epoxy.

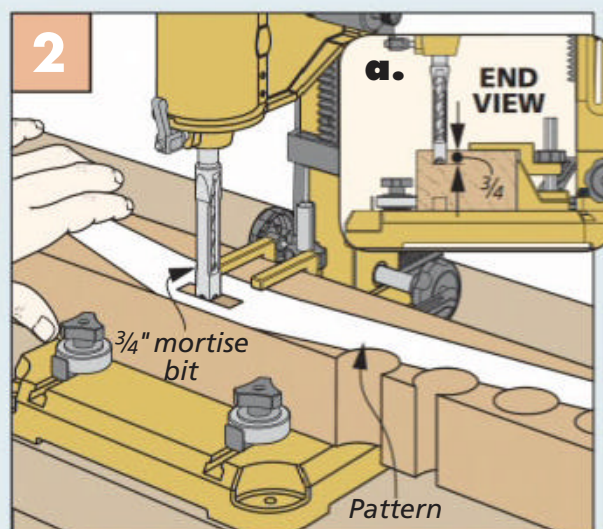
I started assembling the side chair frames first. I applied glue to both the inside of the mortise, and on the surfaces of the tenons. Four clamps across the corners of the chairs hold everything tight while the glue dries.

After assembling the side chairs, the assembly of the corner chair follows suit. Here however, I glued the angled tenon on the rear rails into the rear corner leg first. A couple of wedge-shaped cauls will help keep the clamp in place on the angled surfaces of the rails. Then, you can work your way around the chair until you have all of the rails and legs in place. Now that the chair frames are assembled, up next is tackling the slatted seat frames. Finally, we'll finish out the chairs by making and installing the back rails.

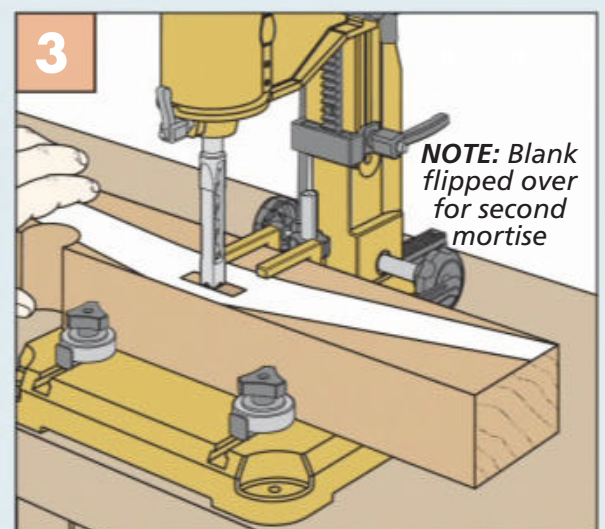
How-To: CUT & SHAPE THE REAR CORNER LEG & RAILS



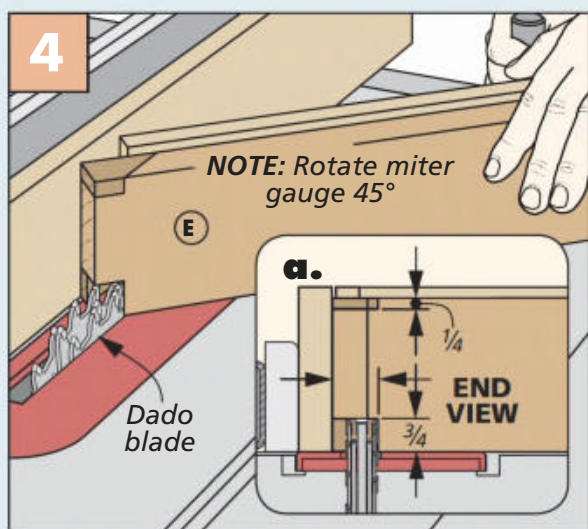
Drill Rail Recesses. At the drill press, drill the notches in the rear corner leg blank using a Forstner bit.



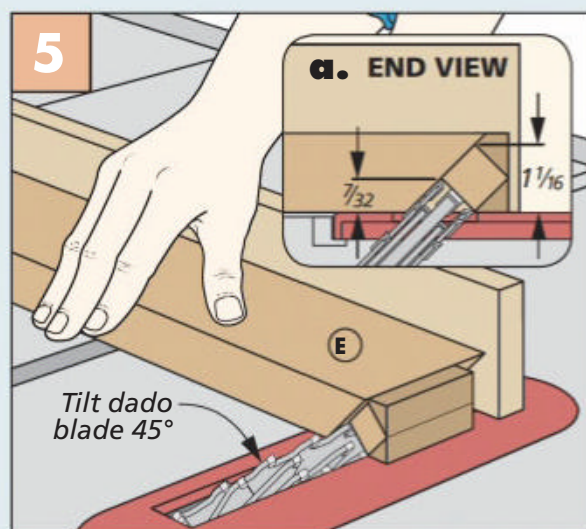
Left Side Mortise. Use the mortising machine to cut the mortise in the left side of the rear corner leg blank.



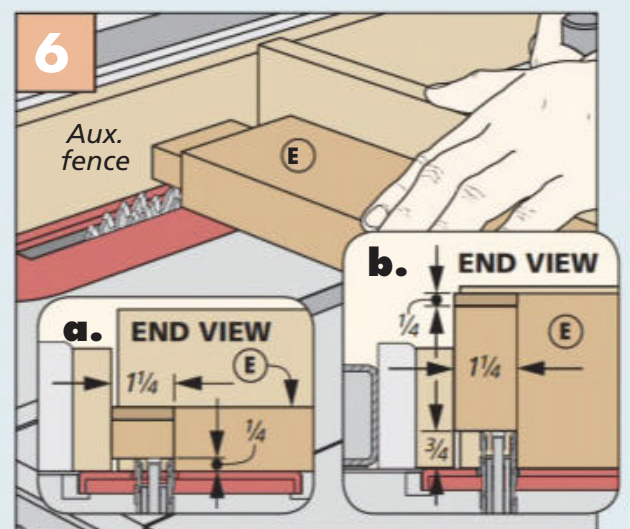
Right Side Mortise. Flip the blank over and cut the mortise in the right hand side of the rear corner leg.



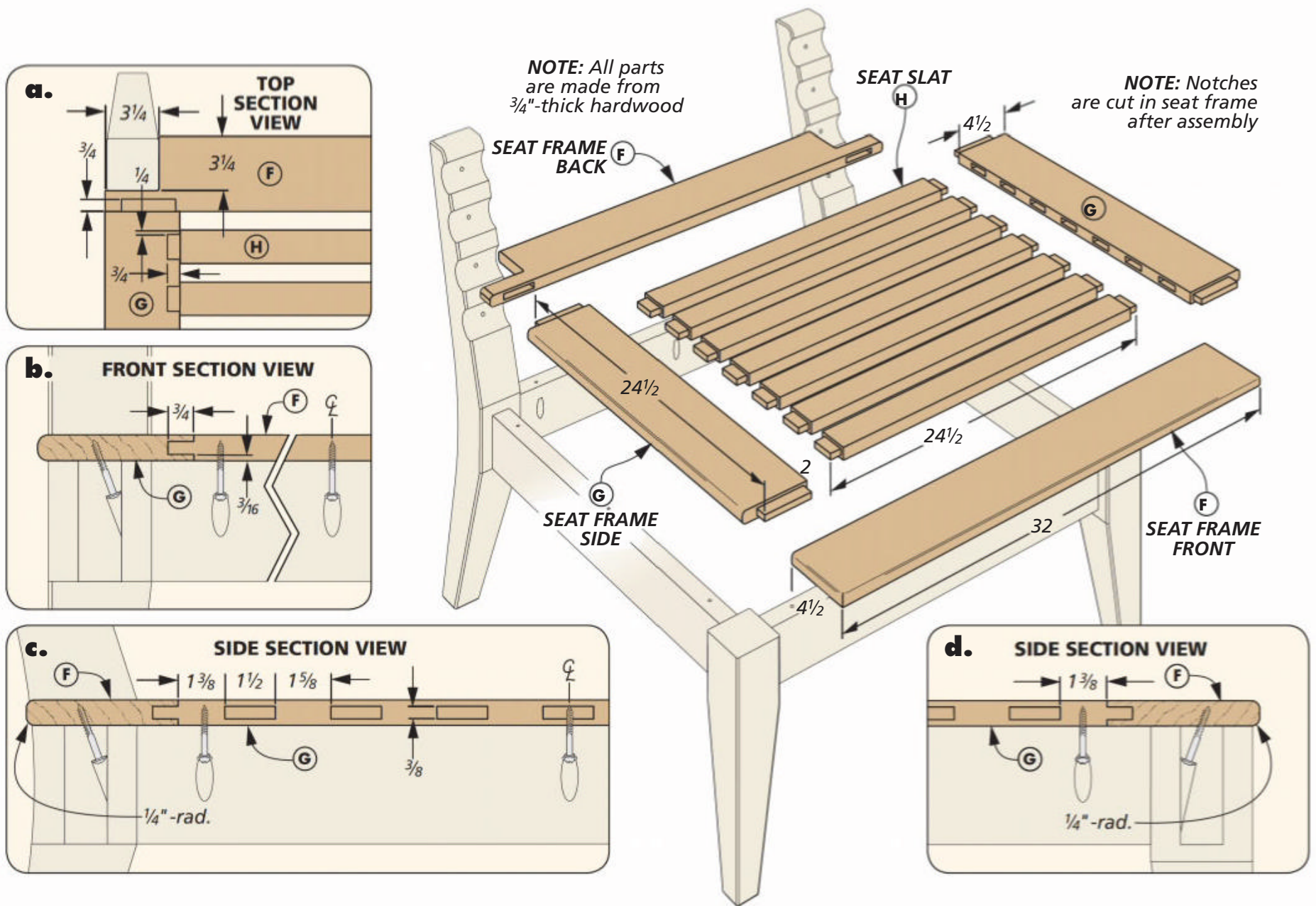
Define Shoulders. Using a dado blade in the table saw, define the shoulders of the angled tenon.



Cut Cheeks. Tilt the dado blade and cut the cheeks of the tenon. Sneak up on the cut until the cheeks meet the shoulders.



Straight Tenons. After trimming the rail to length, cut the straight tenon on the end of the rear rails.



Making the SEAT

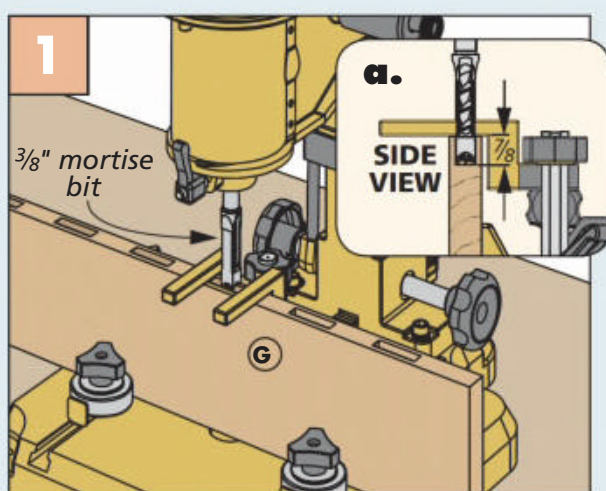
For outdoor seating, a slatted seat works well. Even with a cushion, it allows water to drain off and also promotes air flow to help things dry out after getting wet. For the seats on my chairs, I made a frame using mortise and tenon joints. Inside this frame, mortises will be used to capture

the tenons on the end of the seat slats. Then, the entire seat assembly is attached to the chair frame.

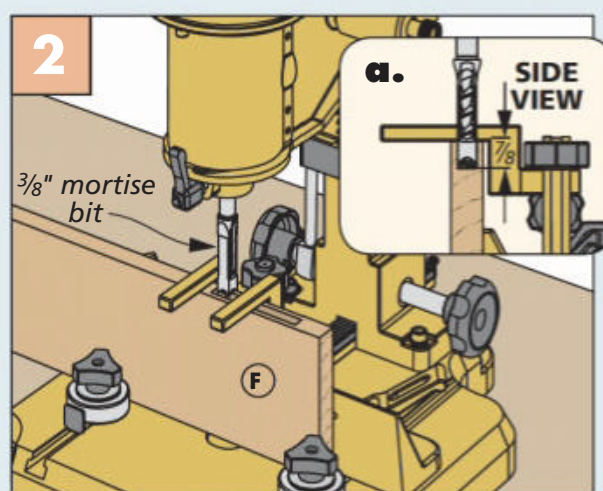
FRAMES FIRST. As you'll notice in the drawing above and the main drawing on the next page, the seat frames have notches cut in them to wrap around the legs. The seat frames for the chairs are identical, but the notches are different between the side and corner chairs.

After cutting the frame parts to size, I laid out the mortises for both the seat slats and the frame assembly. Then, I used the mortising machine to cut the mortises in both frame sides (Figure 1 below). While you're there, go ahead and take care of mortises in the seat front and back, as seen in Figure 2. Finally, the tenons can be cut on the ends of the slats and the frame sides (Figure 3).

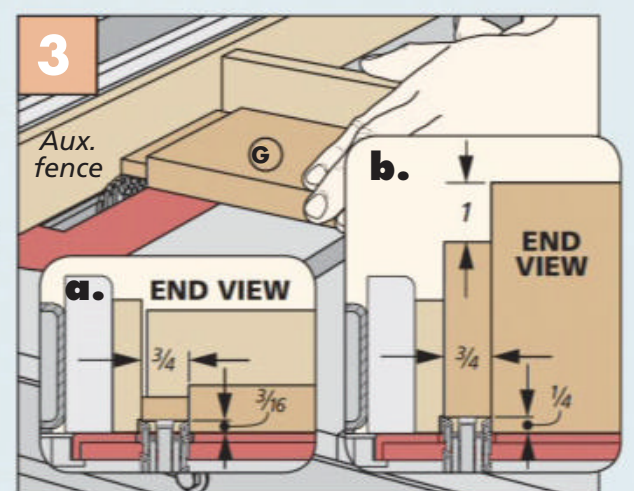
How-To: BUILD & ATTACH THE SEAT



Slat Mortises. Use the mortising machine to cut the series of mortises on the inside of the seat frame sides.



Frame Mortises. While still at the mortising machine, cut the mortises in the seat frame fronts and backs.



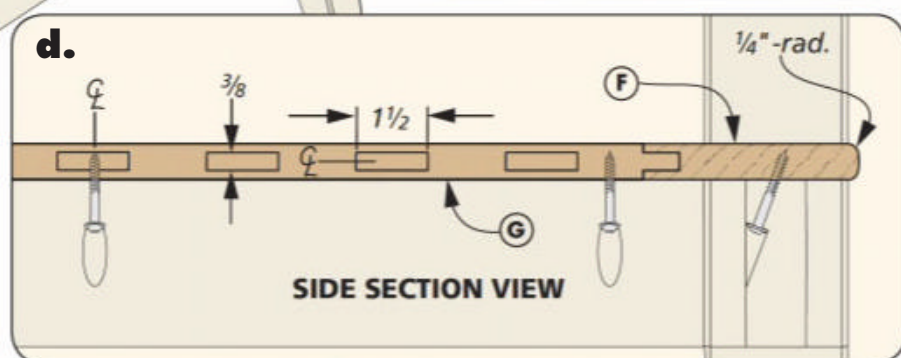
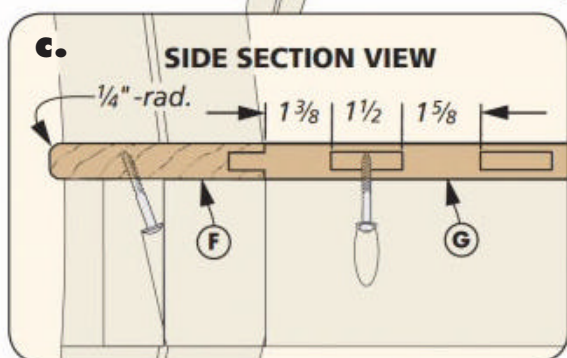
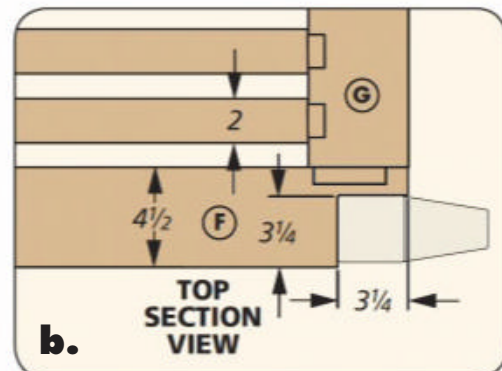
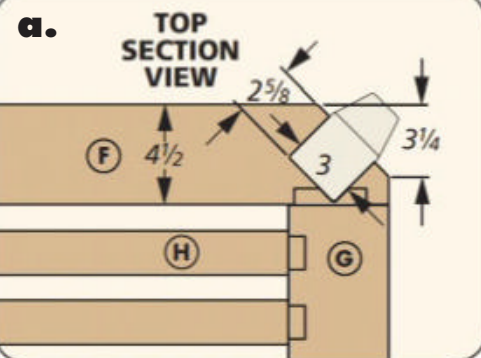
Frame Tenons. Use a dado blade in the table saw to form the tenons on the ends of the seat frame sides and slats.

NOTE: Seat frame has 1/4" roundover on all outside edges

Notch cut after assembly

SEAT SLAT

NOTE: All parts are made from 3/4"-thick hardwood



ASSEMBLE THE SEAT. With the joinery cut on the parts, you can assemble the seats. You'll cut the notches after the glue is dry. The process I used to glue up the seat is as follows. I first assembled the seat slats into the rails. After the slats are in place, I used a couple of clamps to hold the rails and slats together. Then, the tenons on the rails can be glued into the seat front and back.

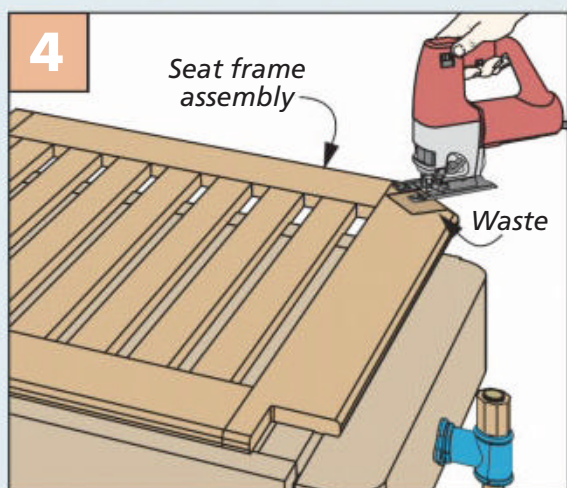
CUT THE NOTCHES. Once the glue on the frames is dry, you can tackle cutting the notches. I used a jig saw with a fine-toothed blade to cut these (Figure 4), but a hand saw and coping saw would work just as well. No matter which method you choose, take your time and stay as close to your layout line as you can. That way, the seat will fit with little fuss. For the side chair, the two

notches are square into the frame, as seen in detail 'a' on the previous page.

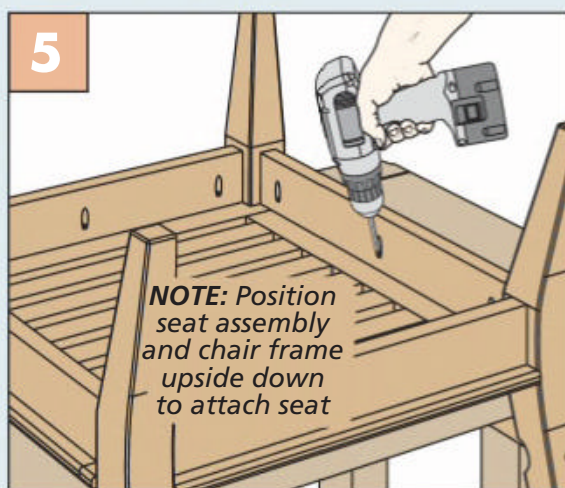
The corner seat frame is a little different. Two of the notches are cut square into the frame, as seen in detail 'b' above. The notch for the rear corner leg is a little different. First, the corner is cut off at 45°. That angle then becomes the base for cutting the notch (detail 'a').

One thing to mention is the seat slat orientation. You can see how I have the slats oriented in the drawing above. To keep the slats traveling in a consistent direction, one of the corner chair seats simply needs to be flipped over. Now, this isn't a big deal if you put cushions on the chairs, as shown in the photo on page 34. But for uniformity, I made sure the slats were all in the same direction in my finished layout.

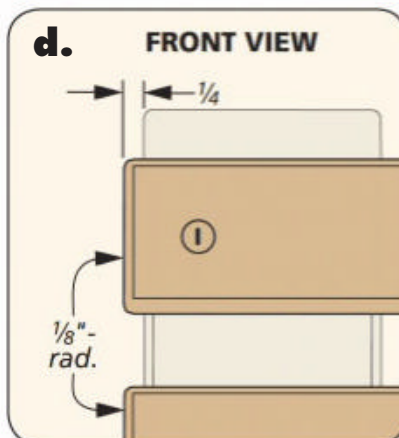
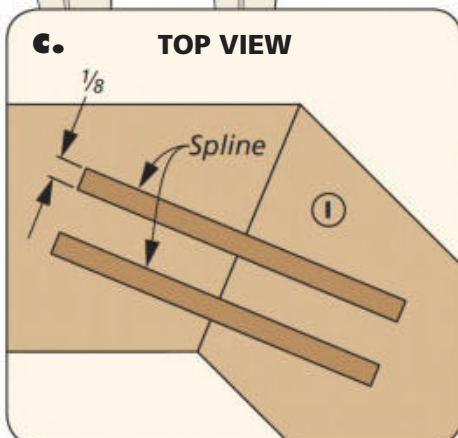
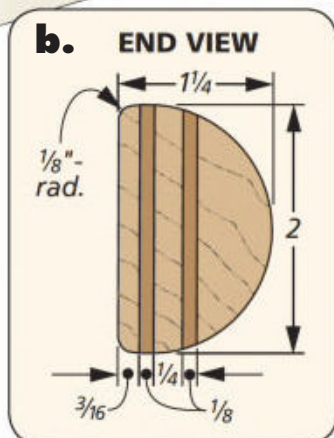
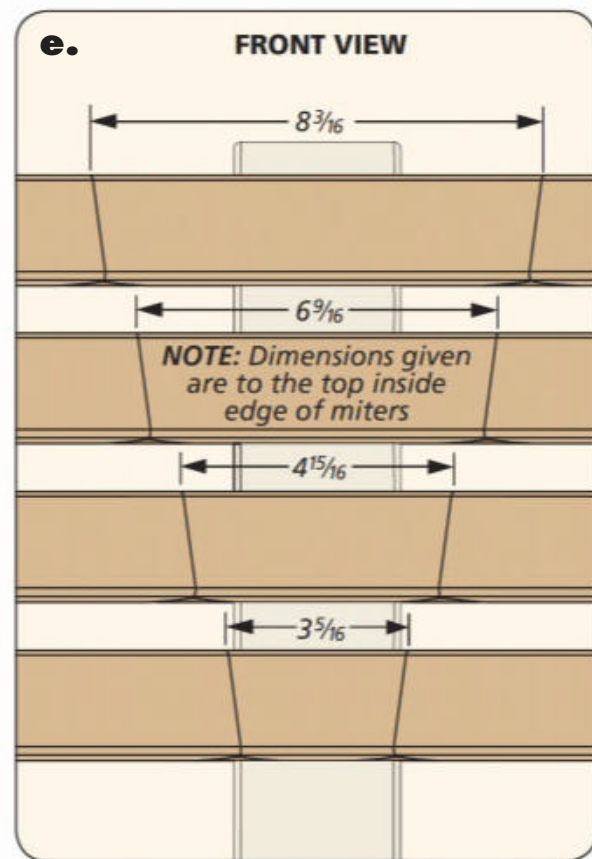
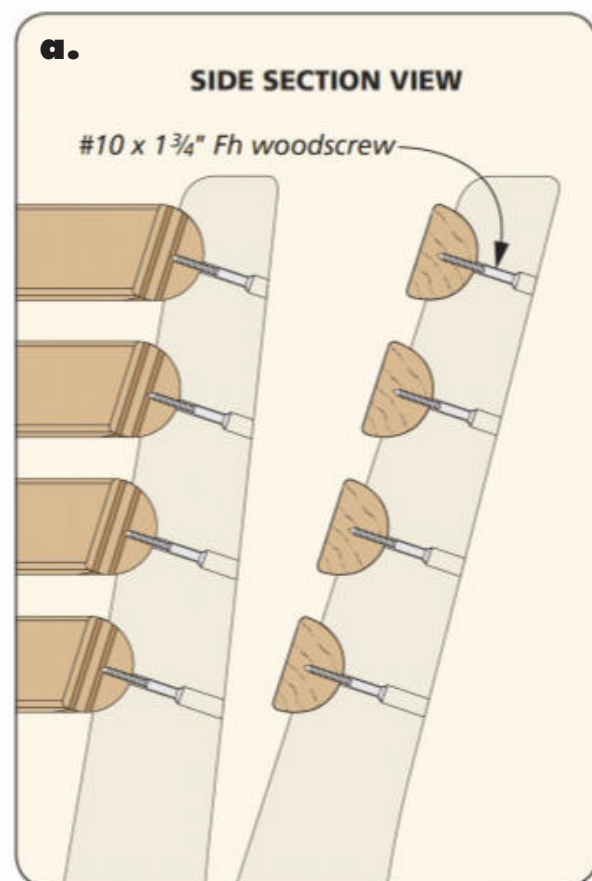
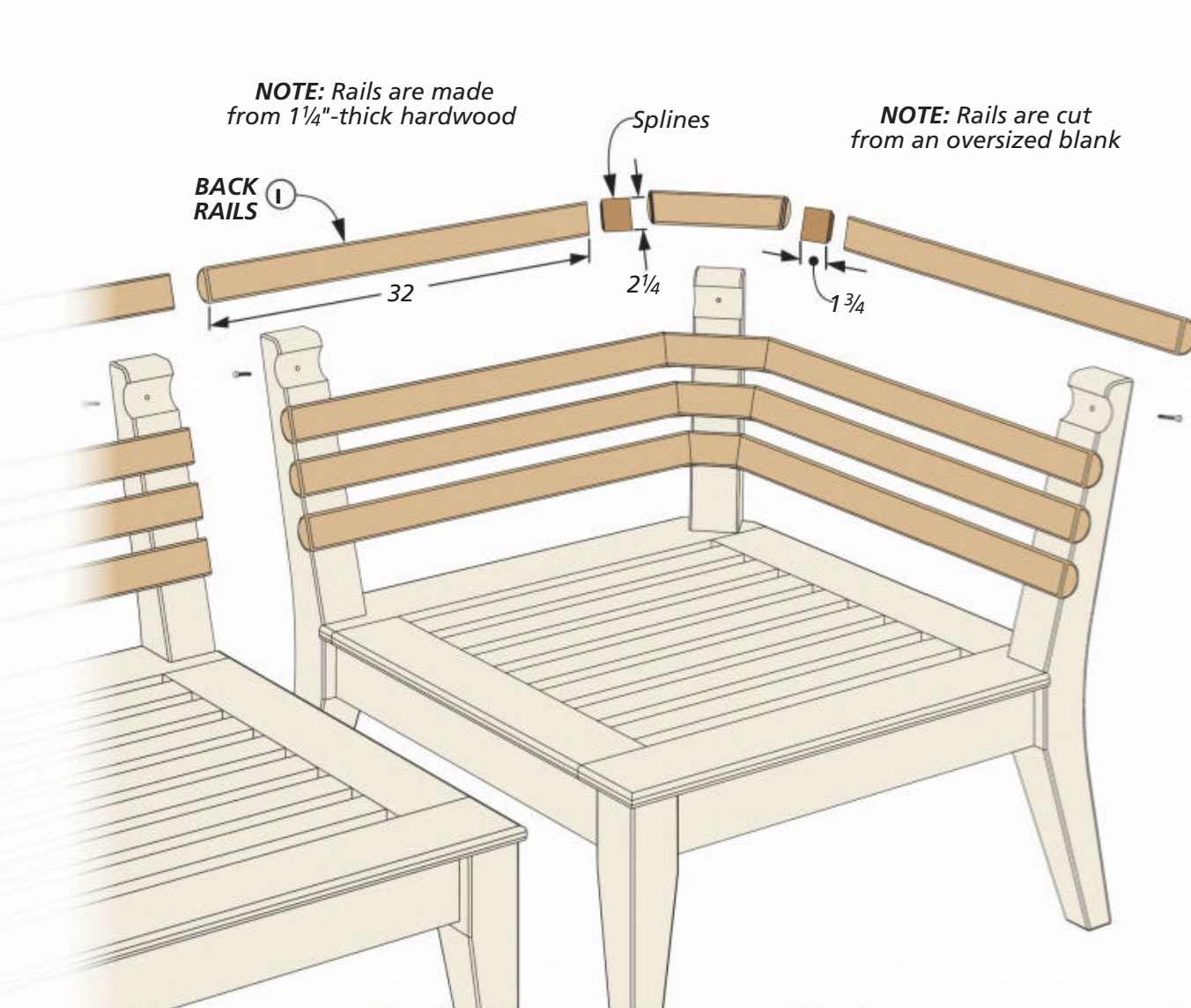
ATTACH 'EM. Now that the notches are cut, the seats are ready to be attached to the chair frame. The seats simply fit around the legs and are attached with screws through the pocket holes (Fig 5). If you need to, a pair of clamps can lend a helping hand to hold the seat down to the frame as you drive the screws home. The final thing to add is the back rails.



Notch the Seats. Use a jig saw with a fine-toothed blade to cut the leg notches in the seat frame.



Attach the Seat. Position the seat onto the chair frame and attach it with screws through the rails.



Add the **BACK RAILS**

To add comfort to the chairs, a series of rails are installed into the notches of the back legs. As you can see in the drawing above, the rails are shaped into a half-round profile and stand slightly proud of the legs.

STOCK FIRST. Because each chair has four rows of rails, you'll need quite a bit of stock for these. I started making the rails by cutting blanks that were twice as long as the finished rails and more than twice as wide. This yields four rails from each blank. After rounding over the edges of the blank (Figure 1), the rails can be ripped free at the table

saw, as seen in Figure 2. I then trimmed the side chair rails to length. The corner chair rails were left extra long. More on that later. Then, I routed a small roundover on all the edges of the rails (Figure 3). You can then set the side chair rails aside for now.

CORNER CHAIR. The back rails for the corner chair require a little more finessing than just screwing them in place. The recesses in the rear corner leg create a spot to attach the shorter back rails. This gives the corner chair a backrest that's comfortable all the way around. As you can see in the drawing above and in

detail 'e', the corner rails also flare out towards the top. The bottom is the shortest and the top is the longest.

COMPOUND MITERS. Upon first looking at the rails on the rear corner leg, you might think the joint is a simple 22.5° miter. That's true, but you also need to take into account that the legs (and rails) tilt back. That turns the miter into a compound miter. This isn't as bad as it sounds, and Figure 4 shows how I did this. It's a simple matter of setting the miter gauge and tilting your saw blade to the correct angle. The first thing I cut here was the rear corner rails.

How-To: CREATE THE BACK RAILS

I trimmed them all to final length with the appropriate miters on each end. Then, I trimmed the matching miters on the long rails the same way. Remember, the opposite end of these rails are left long for now.

A PAIR OF SPLINES. Because miter joints are relatively weak, each one gets a pair of splines. You can see the spline locations in details 'b' and 'c'. The spline slots are easy to cut at the table saw using a jig, as seen in Figure 6. Shop Notes on page 64 explains the details of the jig and how it works. The splines are cut from a small piece of scrap.

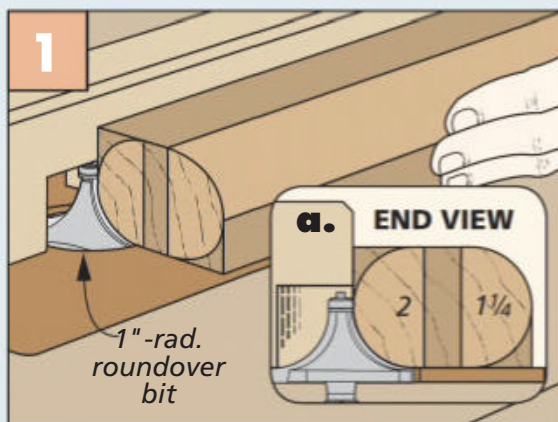
CLAMPING FIXTURE. Clamping the sections of back rail together with the splines poses a small challenge. With the length and the angles, it's almost impossible to get a clamp on them. That is, unless you clamp them together using a fixture like I did. You can see my setup in Figure 7.

The fixture consists of a corner brace and a couple of fences clamped to my workbench. You can reposition the corner brace depending on which length of corner rail you're gluing up. The combination of braces and fences allows good clamping pressure. Glue up all of the corner back rails and make sure to get good glue coverage on the spline and slots.

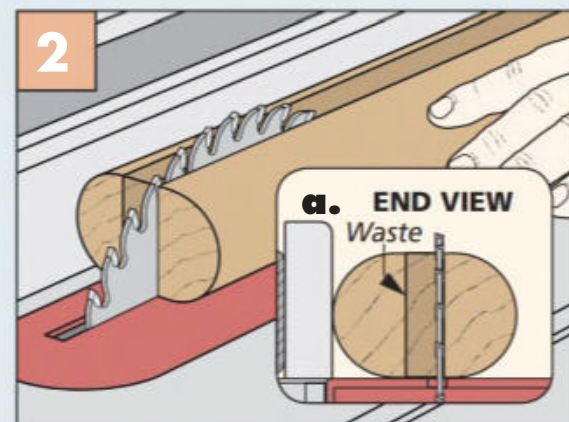
INSTALL THE BACKS. To install the back rails on the side chairs, I clamped all of the rails in place using a caul. Then, after drilling some counterbores, they can be installed with screws (Figure 8). Just make sure the faces of the rails are parallel to the face of the legs (detail 'a').

For the corner chair, you'll want to install the rail assemblies one at a time. I started with the bottom rail. First, loosely position and clamp the corner section in place. Then position the long rails, flexing them if needed, and clamp them in place so the face is parallel with the leg. The corner rail will not be parallel to the rear corner leg (detail 'a'). After tightening the clamps, drill and install the screws as before. Rinse and repeat for all the back rails. Finally, trim the ends of the long rails using a hand saw, and sand a small roundover (detail 'd').

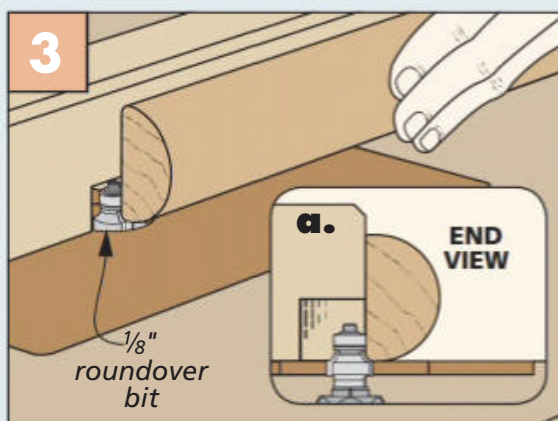
After applying a couple of coats of outdoor finish, you can toss on a set of cushions and pillows. Then sit back, relax, and enjoy the summer. **W**



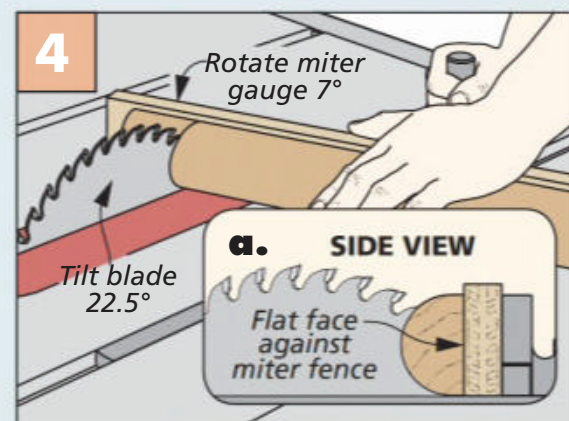
Large Roundovers. Use a large roundover bit in the router table to round all corners of an oversized blank



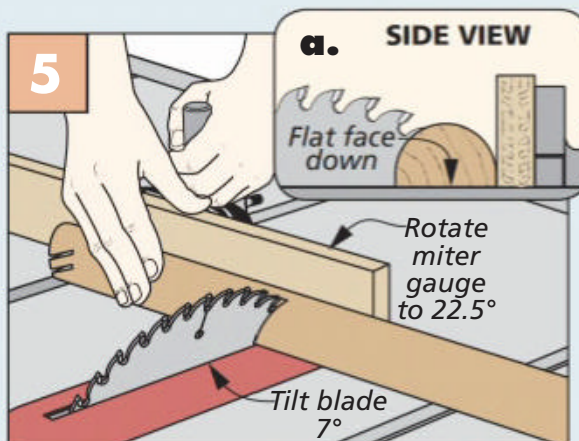
Rip to Size. At the table saw, cut the back rails apart, keeping the flat waste firmly against the table.



Small Roundovers. Back at the router table, use a small roundover bit to ease all the edges of the rails.



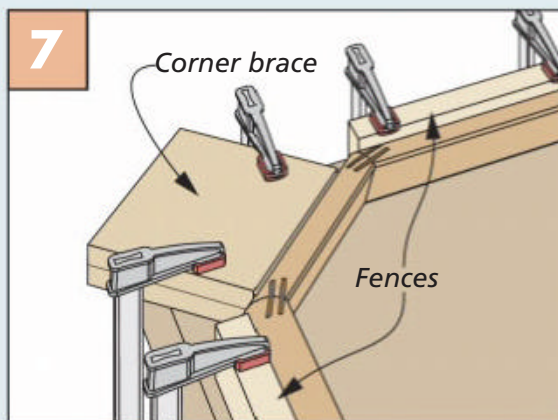
Compound Miter. Rotate miter gauge 7° and tilt blade to cut the miter. Keep the flat face against the miter gauge.



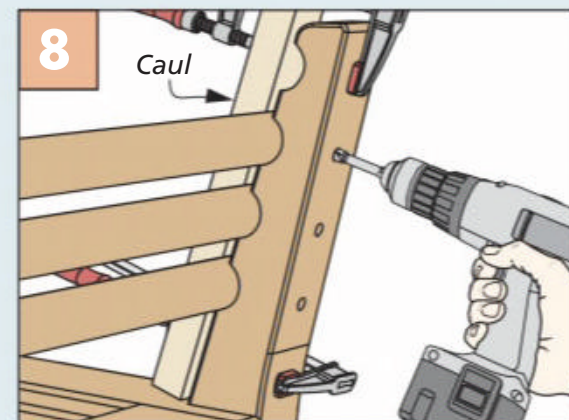
Second Miter. Reset the miter gauge to 22.5° and tilt blade 7°. Make the cut with the flat face down.



Spline Slots. Cut a pair of spline slots in the mitered ends of each back rail using the spline jig at the table saw.



Glue Up Miters. Use a pair of fences and a corner brace to clamp the miters and splines in place as the glue dries.



Fit & Drill Holes. Clamp the rails in place to the legs and drill the holes before attaching them with screws.



Kentucky Sugar Chest

Expanding on a historically sweet project, this version of a sugar chest lets you sink your woodworking teeth into it without fear of cavities.

I had never heard of a sugar chest until I teamed up with our creative director, Chris Fitch, to work on this project. The function of a sugar chest was to protect and parse out the valuable commodity that sugar was in the nineteenth century.

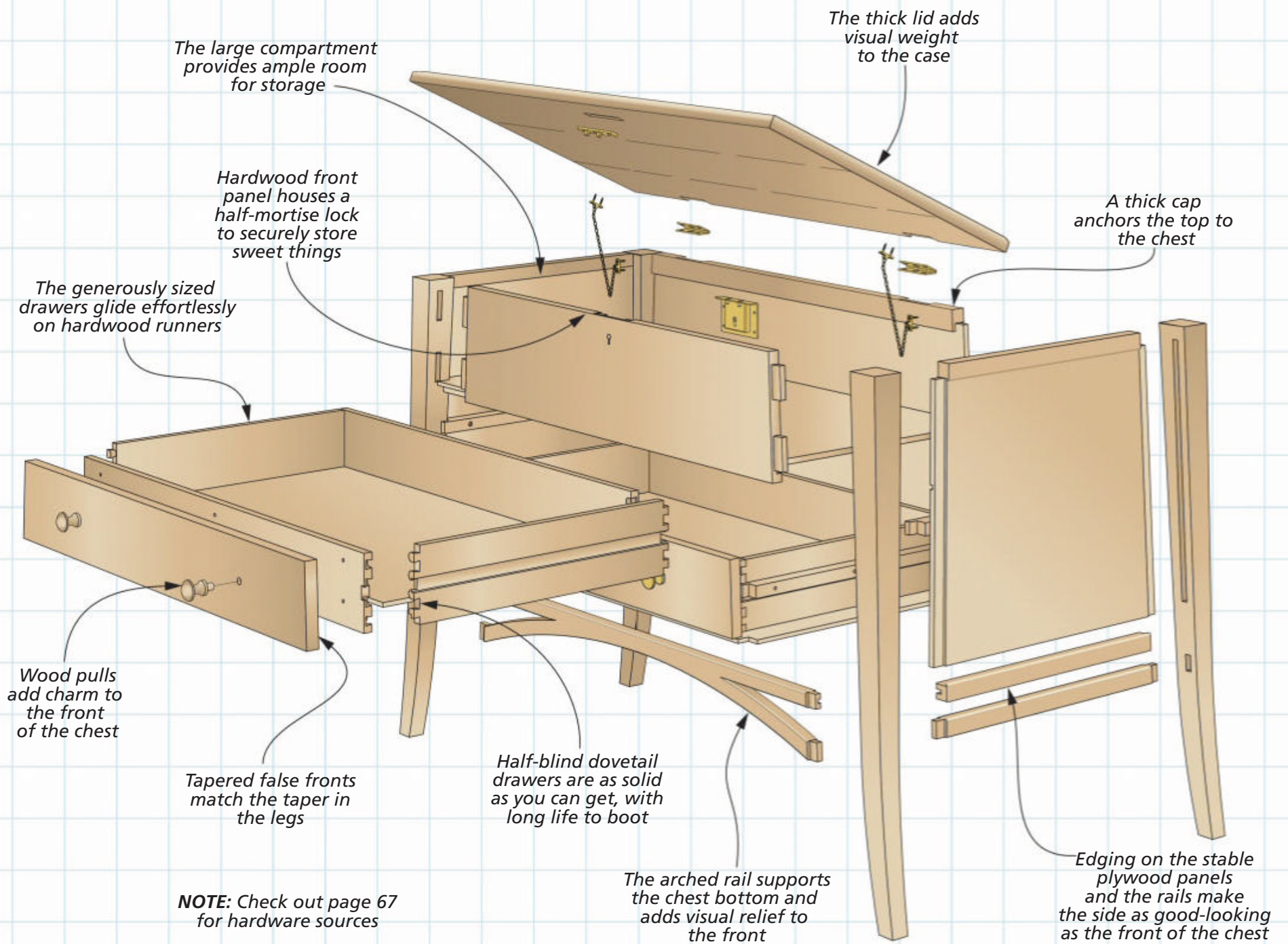
The earliest sugar chests most likely were modified blanket chests. Our version expands on the modest examples that came out of Kentucky, the same place Chris hails from. Go figure.

The upgrades start with the tapered and splayed cherry legs that set the tempo for something more than the square boxes of the past. The legs are wed to plywood sides and back. A solid hardwood front holds an elegant half-mortise lock. Combined with the thick cherry lid, lets you securely store your cones of sugar (or anything else you'd like to store) in the large storage compartment at the top of the chest.

Carving and cutting cones of sugar required a set of tools that were kept close at hand. To that end, there are the two long drawers beneath the chamber.

One more step taken to relieve this project from being strictly a utility piece is a lace-like, arched rail that runs across the front and flows into the gentle curve on the legs. These details will give your woodworking skills a challenge that's sure to last longer than any sugar high.

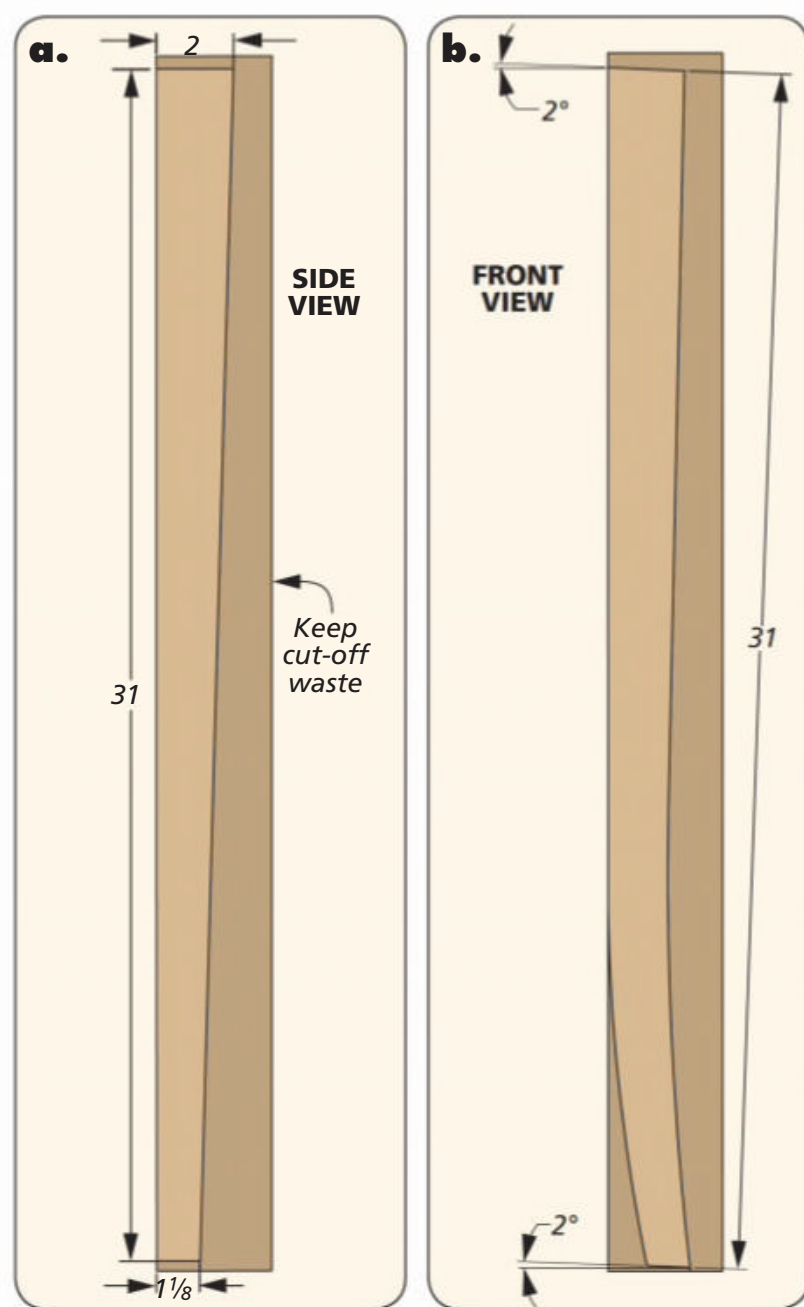
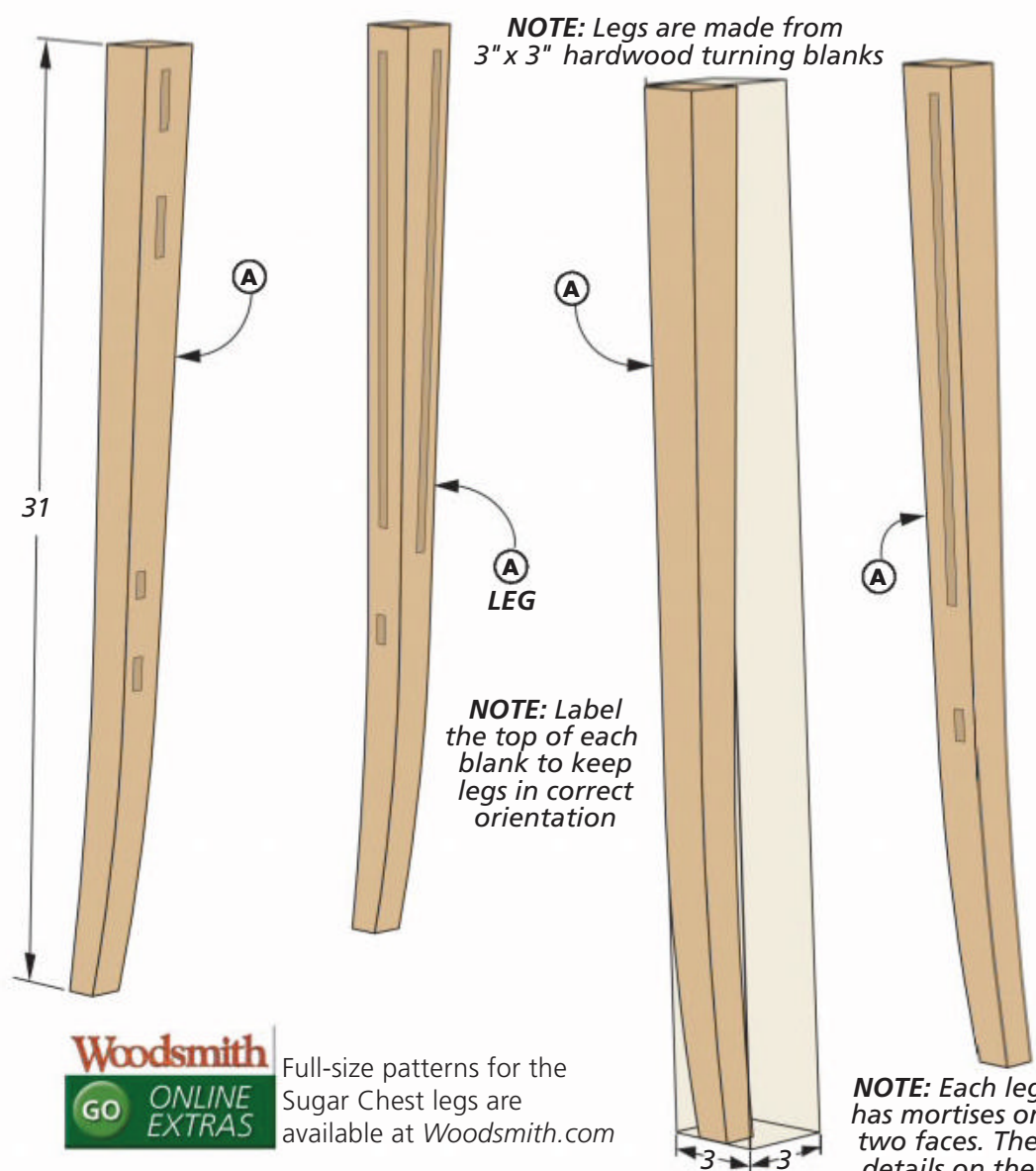
Construction Overview / OVERALL DIMENSIONS: 37"W x 32"H x 21½"D



▲ The large chamber in the top of the chest is where cones of sugar (and a few bottles of gin) were traditionally stored. Your belongings will find a safe home there, as well.



▲ The arched rail is a nice accent below the drawers and storage compartment. It's also a welcome change in tasks from the woodworking challenge of large tapered workpieces.



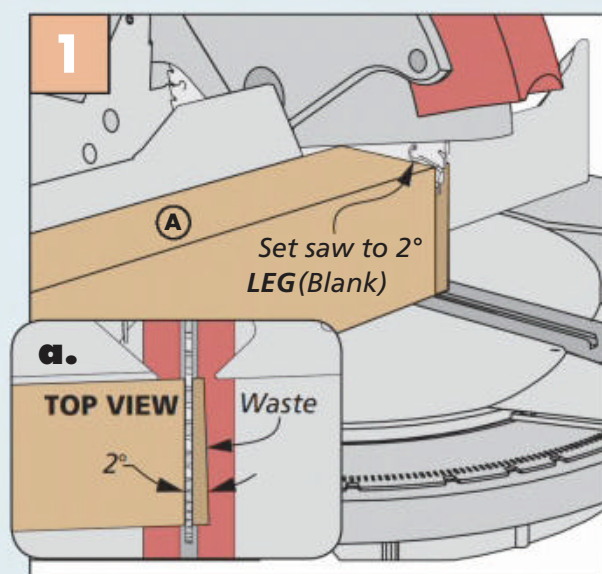
Start with the LEGS

The subtle flow that separates this chest from its boxy predecessors starts with the curved, tapered legs. Looking closely at the drawing above and the details of the face profiles, you'll get an idea of what's involved in making these legs.

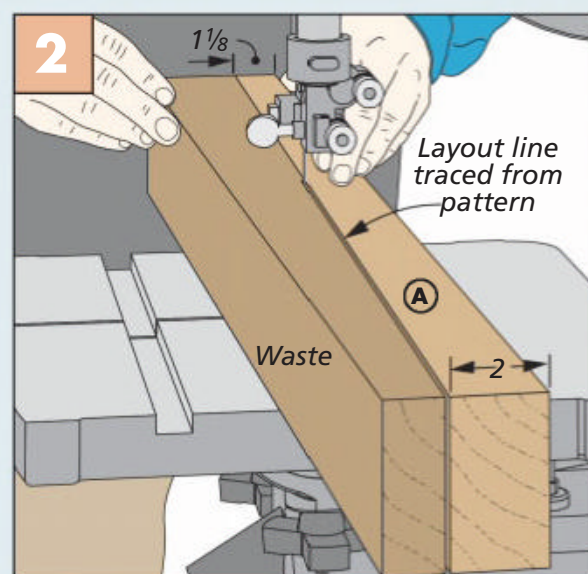
Laying out the profile and joinery of each leg is a challenge in itself. To make the process easier, I used cherry turning blanks. This let me focus on the tapers and mortises without concern for how glue lines might affect the look of the leg.

TWO TEMPLATES. To maintain a consistent profile on all the legs, I relied on templates. Because the legs are tapered in two different directions, two templates are required. You can find full-size patterns for both at *Woodsmith.com*.

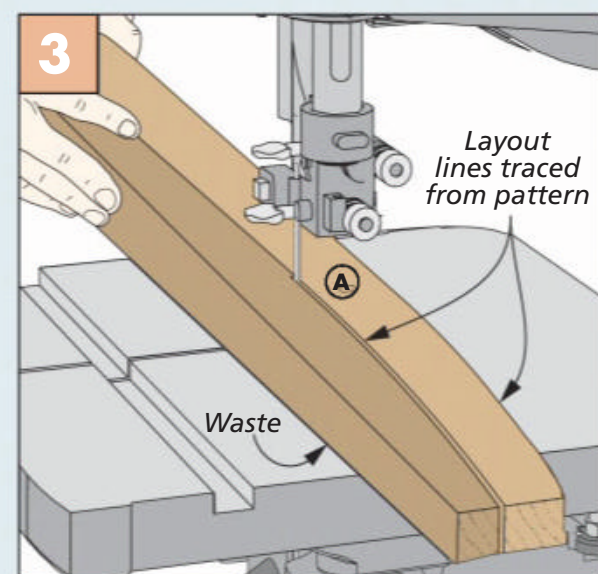
How-To: CUT THE LEG BLANKS TO SHAPE



Tapered Ends. Your miter saw is the ideal tool to cut the beveled ends of each thick leg blank.



Straight Tapers First. At the band saw, cut the long straight taper on each leg blank. Stay on the waste side of the line.



Curves Next. After sanding the tapered sides, cut the curved profile on the opposite face of the leg blanks.

How-To: MORTISE THE LEGS

The first template (detail 'a' on the previous page) is a straightforward taper that has square ends. The other template is for the front of the legs (detail 'b'). This template runs flush against the edge of the blank. To create the "splay" in the legs, a 2° angled cut is made at both ends of the template.

A GOOD START. With the templates in hand, start by orienting the leg blanks and tracing both template profiles on the appropriate faces. Due to the thickness of the turning blanks, I made the beveled end cuts on each leg at the miter saw (Figure 1 on the previous page).

SIDE PROFILE FIRST. Cutting the long, straight taper is the next step. This is best done at the band saw (Figure 2). Leave the layout line so you can sand the taper accurately. Take the best one of the waste pieces from this step and sand it smooth, as well. You're going to use this piece later with your crosscut sled to cut the tapered panels.

FRONT PROFILE. After sanding all the cut faces smooth, you can focus on the curved profile back at the band saw (Figure 3). Once you've sanded those faces, it's on to the mortises.

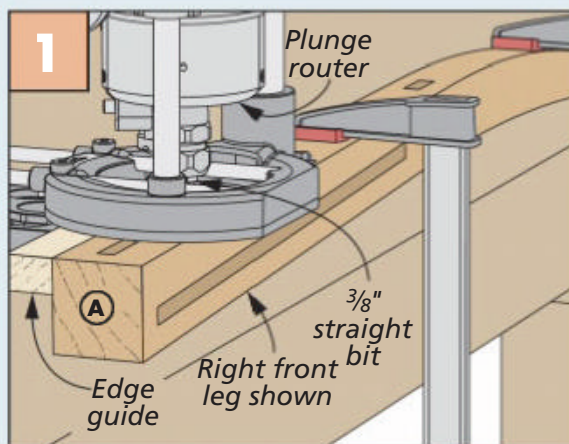
MORTISES

There are mortises on the inside faces of all the legs. To avoid confusion, it's best to lay out the location of all the mortises before routing them. All of these mortises (except the last) were done with a plunge router, an edge guide, and a straight bit.

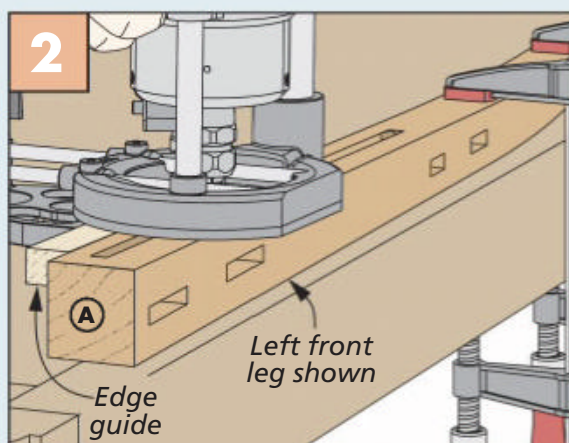
I started with the four short mortises on the inside face of the front legs. These are for the front panel and arched rail. Detail 'a' shows the locations, while Figure 1 shows the setup used.

LONG MORTISES. Next up are the long mortises (detail 'b') for the side panels (Figure 2). All four legs get this mortise. Its location varies depending on which leg you're working on. Also, the back legs receive a second long mortise for the back panel (Figure 3 and detail 'c').

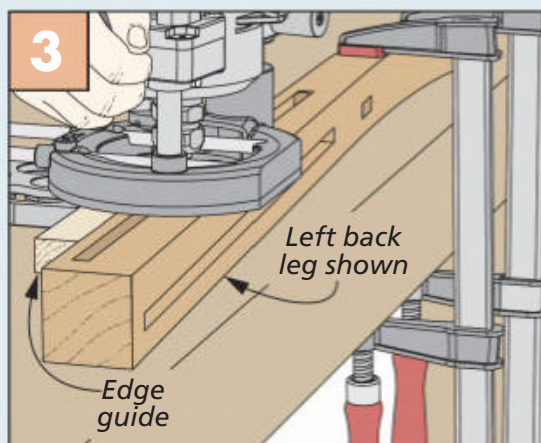
Since the curve of the leg interferes with the travel of the edge guide, I made the short mortises (detail 'd') for the side rails over at the drill press (Figure 4). With that, it's time to square up all the mortises with a chisel. Then, it's on to making some side panels.



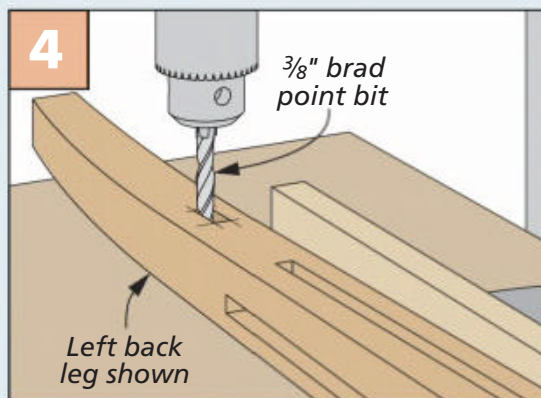
Front Face Mortises. Rout the four mortises that hold the front panel and arched rail (detail 'a').



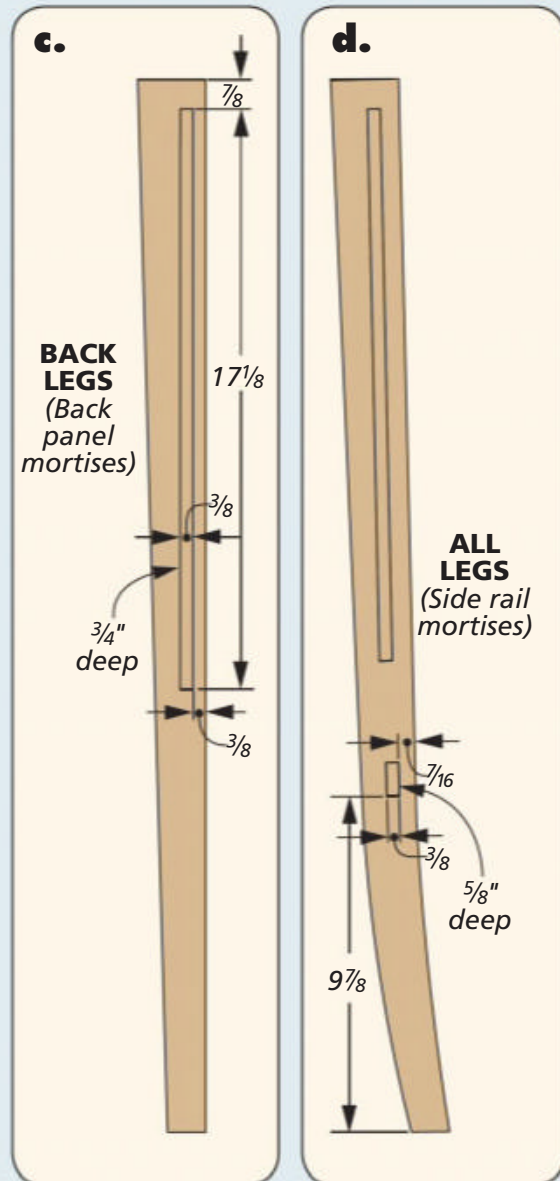
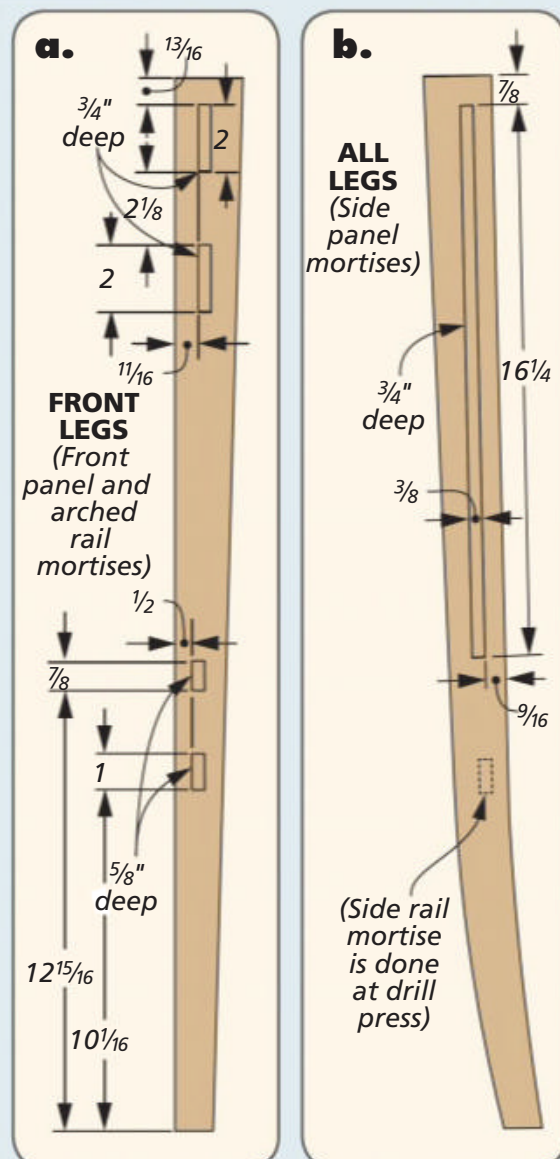
Side Panel Mortise. Flip the leg and rout the long mortise that's needed for the side panels (detail 'b').

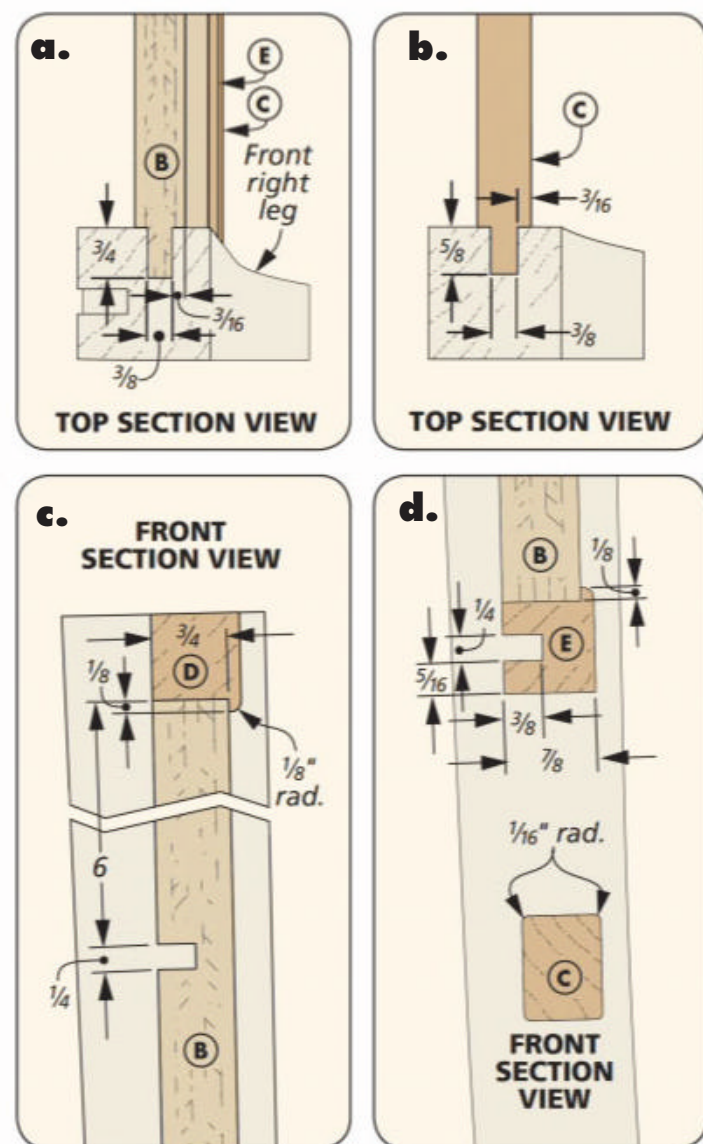
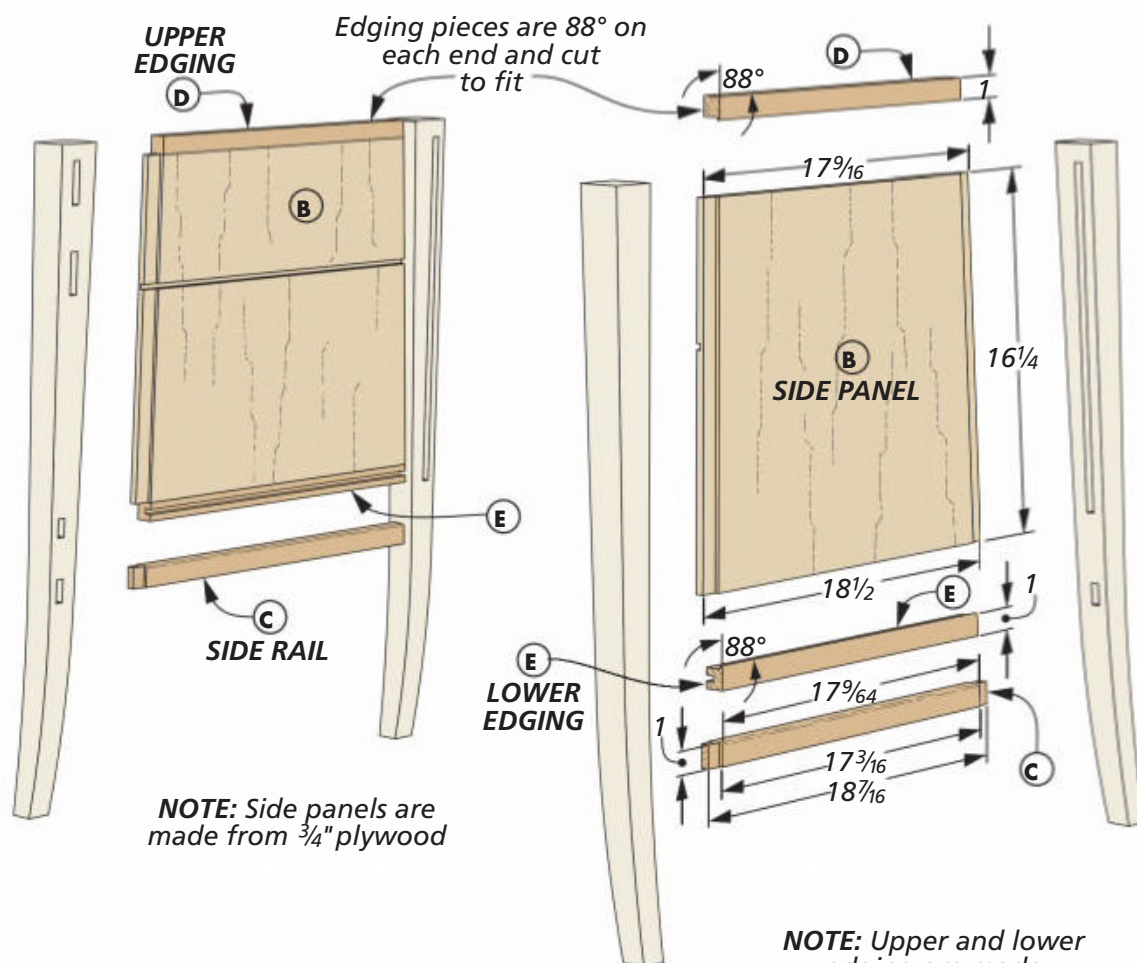


Back Panel Mortise. Another long mortise is needed to hold the back panel in place (detail 'c').



Side Rail Mortise. The drill press is the easiest way to tackle the short mortise for the side rail (detail 'd').





Build the SIDES

I'm not going to sugar-coat it, working with tapers can be a real challenge. But all the work you put into the legs will pay off as you start making the side panels and their supporting parts — the edging and rails.

As the drawing above reveals, the tapered side panels are $\frac{3}{4}$ " plywood. You'll also notice that this taper, when viewed from the side, brings the front and back of the case back to 90°.

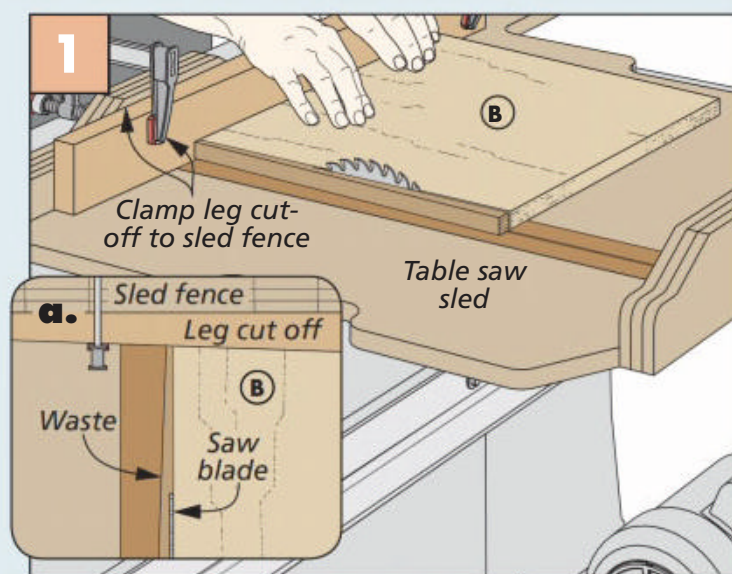
That's because the taper you're cutting here is a flipped version of the ones you did on the side of the legs.

There are no fancy calculations needed to do this. You're going to make these taper cuts (and many of the rest in this project) with the aid of that waste piece you saved and sanded smooth back when you made the legs. All you

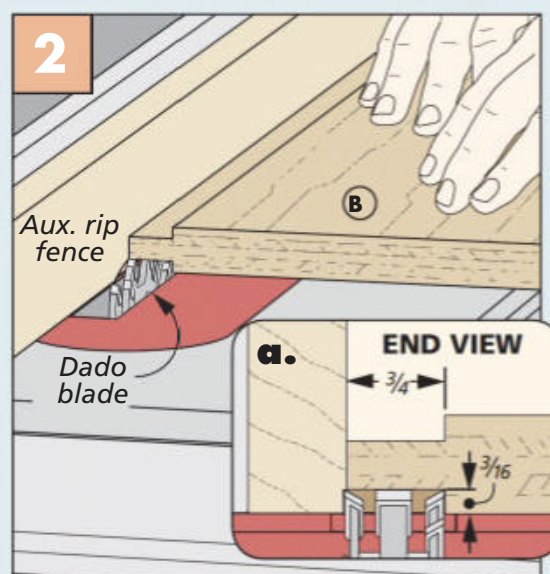
have to do is attach it to your crosscut sled with a couple of clamps. Figure 1 below shows this setup as it's being used to cut the taper in the side panels.

TONGUES NEXT. The tongues that join the front and back legs together are made at the table saw as well. Just change over to a dado blade, add an auxiliary fence, and you're ready to rumble — well,

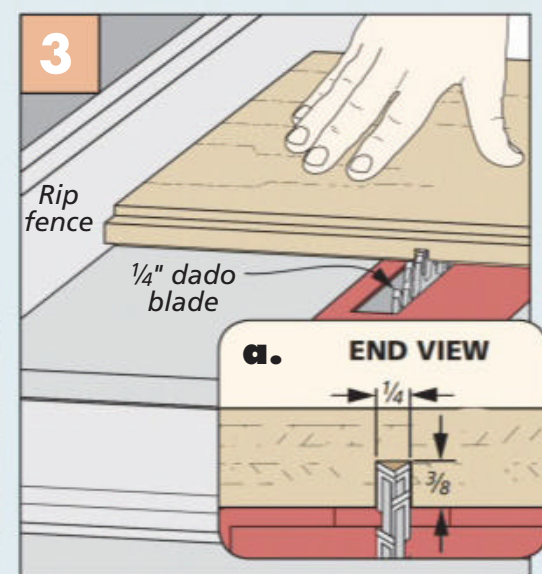
How-To: MAKE THE SIDE PANELS



Tapering the Panels. Combine your crosscut sled with a waste piece from one of the leg blanks to taper the side panels.



Rabbits. A dado blade and an auxiliary fence is used to make the tongues on the side panels.



Dado for Divider. A dado in the side panel holds the tongue that's in the edge of the divider.

How-To: COMPLETE THE SIDE ASSEMBLIES

at least ready to cut the rabbets on the sides of the panel. You can see this being done in Figure 2. There's also a dado in the upper section of the panel. This is to hold the divider that separates the drawers from the upper storage compartment (Figure 3).

RAILS & EDGING

Beneath the side panels and the lower edging are the side rails. The side rails have tenons that tie them to the legs. The shoulders of these tenons are tapered as well. To make quick work of this, I used a dado blade and miter gauge adjusted for the taper (Figure 1). This is faster than using the crosscut sled and nibbling the tenons with a standard blade.

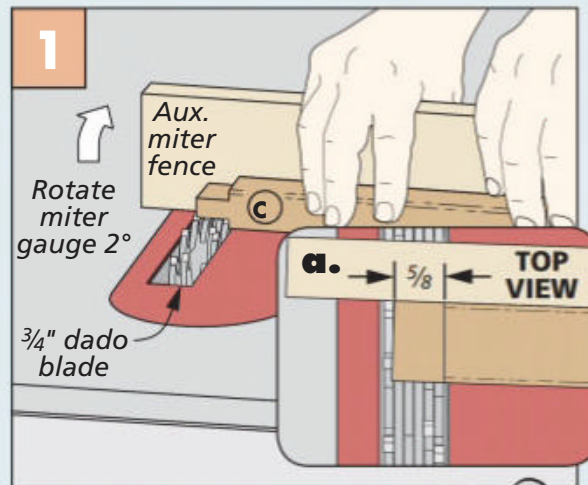
GLUEUP. Figure 2 shows how the legs, side panels, and side rails come together. Do this on a flat surface to ensure the assembly stays flat. While those assemblies are drying, you can turn your attention to the edging.

EDGING. The side panel is capped, top and bottom, with hardwood pieces. The upper edging lines up with the top of the legs and hides the ends of the plywood panels. The lower edging also hides the end of the side panel and has a groove that will hold the bottom panel of the chest. Both of these pieces have a wide rabbet that fits over the side panel.

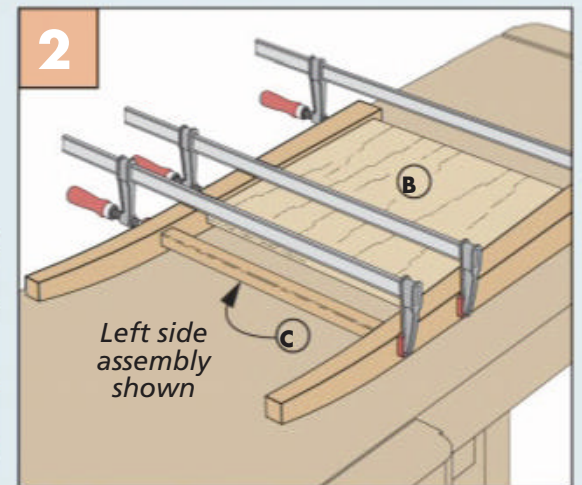
One more thing about the upper edging piece that might seem contrary at first. I didn't bevel the top to match the taper on the top of the legs. On such short pieces (as well as the grooves for the divider and bottom) the 2° of taper is so slight that it doesn't really show up.

The upper and lower edging are identical in profile. So after cutting some extra-long blanks, I headed to the router table with all the pieces to rout the round over that you see in details 'c' and 'd' on the previous page.

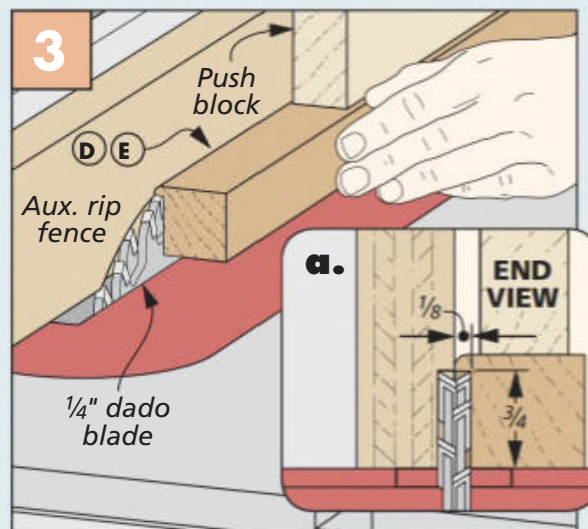
Next is the rabbet that's shown being made in Figure 3. This rabbet will nest against the edges of the plywood panel. That step completes the milling on the upper edging so you can set those two pieces aside for the moment. There's one more process to do on the lower edging, and that's cutting a groove with a dado blade at the table saw for the plywood bottom of the chest (Figure 4).



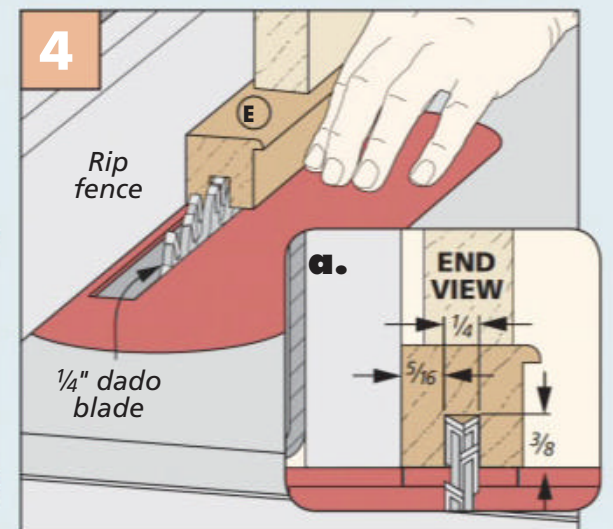
Shoulders for the Side Rails. An auxiliary fence attached to your miter gauge creates clean shoulders.



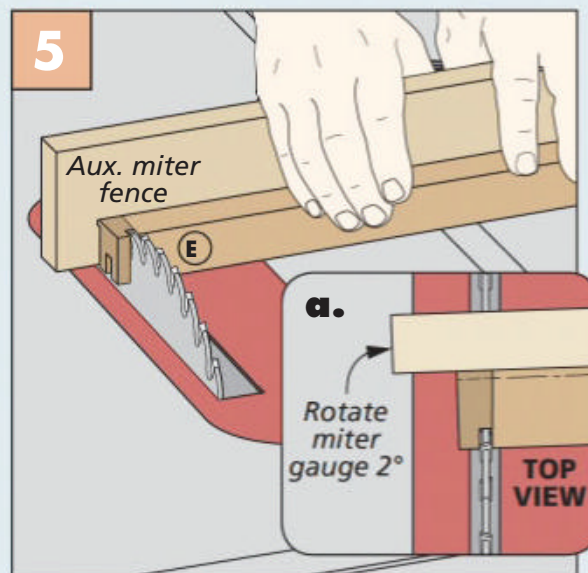
Glue Up Side. Glue up the side panels, side rails, and legs. The edging is custom fit afterwards.



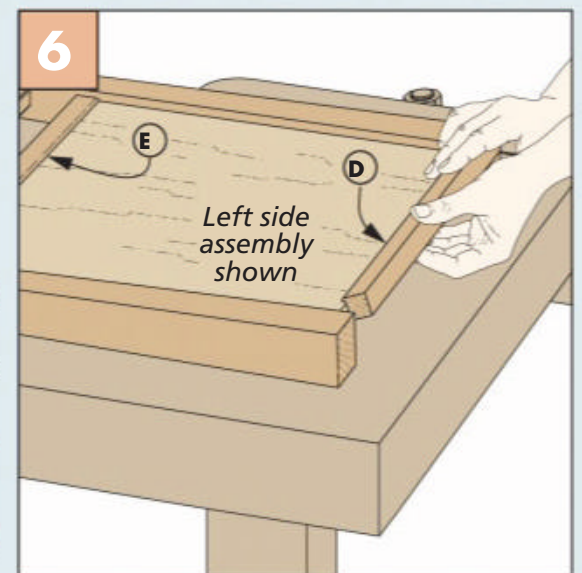
Rabbets Next. A dado blade in your table saw makes quick work of the rabbets needed in the edge pieces.



Groove in Bottom Edging. Use the dado blade to make the groove for the bottom in the lower edging.



Trim the Edging to Fit. With the miter gauge set at the proper angle, trim the ends of all the edging pieces.



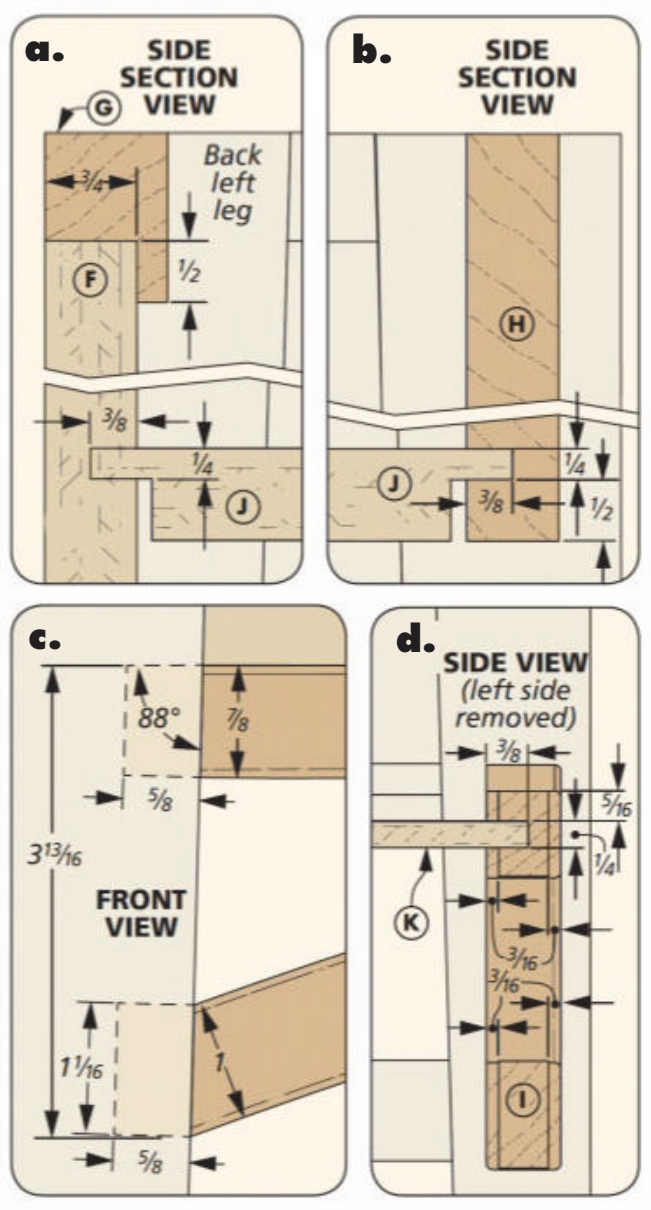
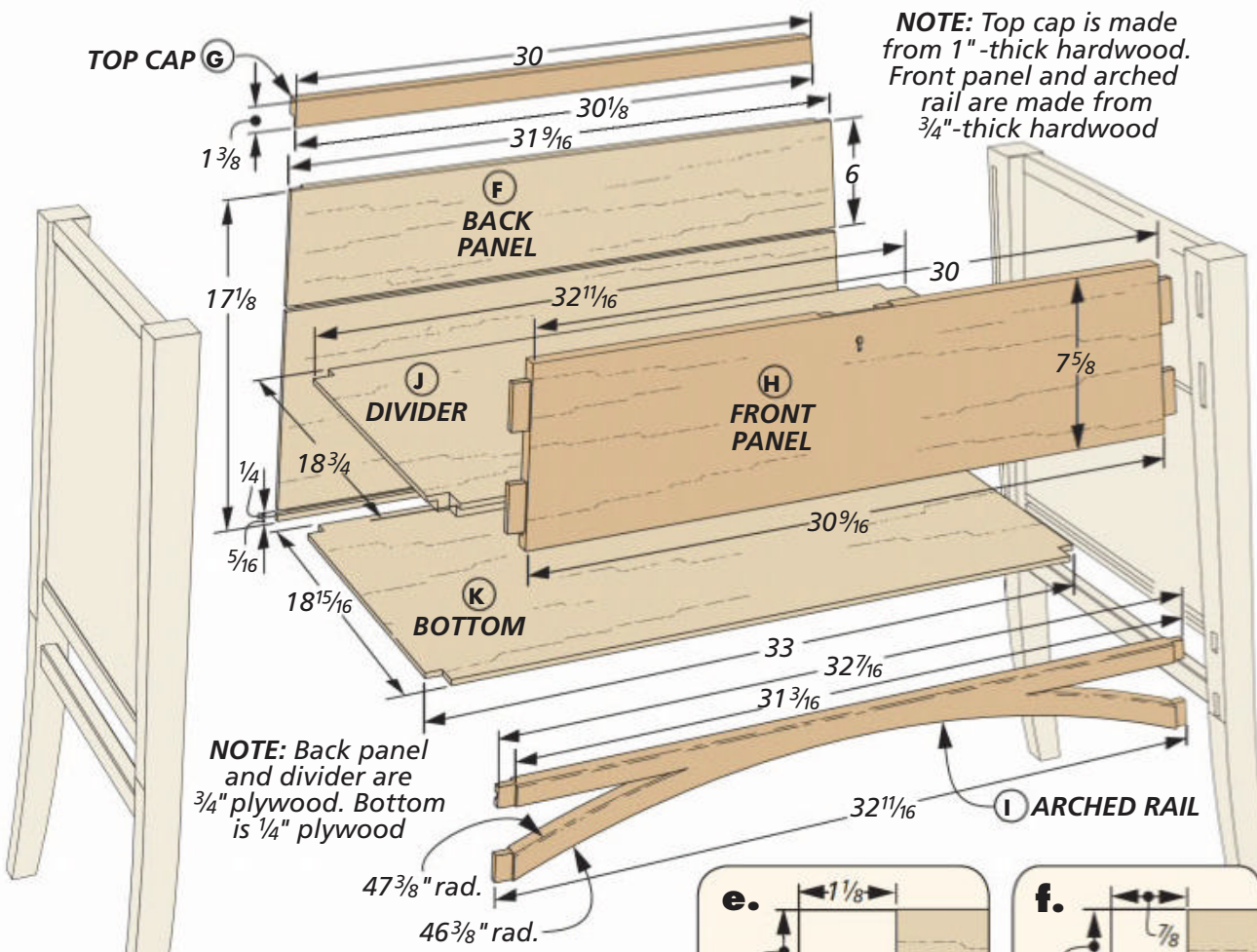
Glue Upper Edging in Place. After trimming the upper and lower edging to a tight fit, glue them in place.

Trimming the edging pieces to final length involves marking and cutting to fit like you see in Figures 5 and 6.

To get a feel for this, I started the cutting and fitting routine on the lower edge pieces. Since they're out of sight, I

wasn't as concerned with a perfect fit. Then I fit the upper pieces.

With those glued in place, you can start cranking up to make all the parts that bring the two sides together. Turn the page and get after it.



Complete the CASE

Now that you've got past the hurdle of the tapered legs and side panels, finishing the case parts for the chest should be a breeze. The parts here are longer than the previous ones, but the same methods are used to make them.

The biggest of the parts is the back panel. Take a look at it in the main drawing above and you'll notice it's a tapered

piece of 3/4" plywood like the side panels. Here though, the grain runs horizontally. After tapering the panel with the cross-cut sled, you can move on to making tongues on the ends to join the panel to the chest (Figure 1).

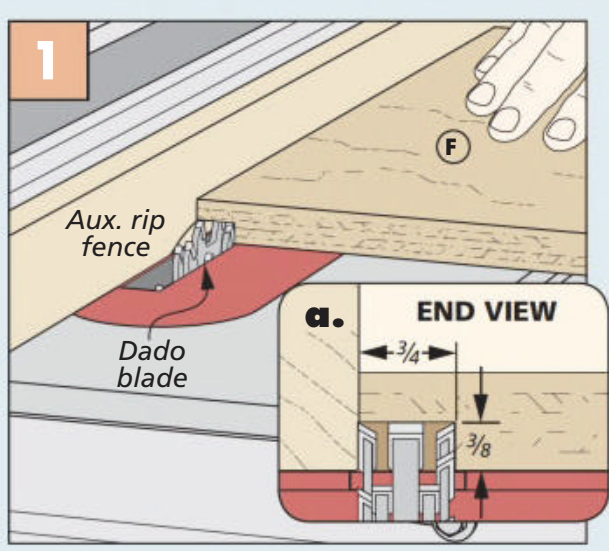
You have two grooves to deal with on the back panel — one for the divider and one for the chest bottom (Figure 2).

You also need to make a hardwood top cap (Figure 3). The top cap is extra wide to provide a solid surface for the hinges. With that done, you can set it aside and focus on the front panel.

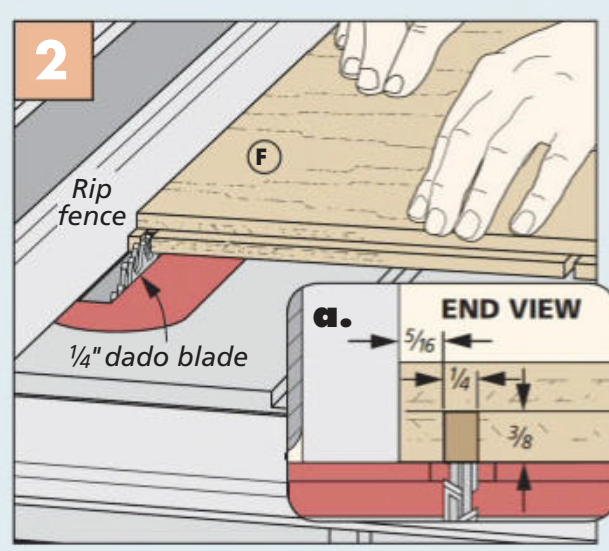
FRONT PANEL

The front of the chest is comprised of two hardwood pieces. The first is

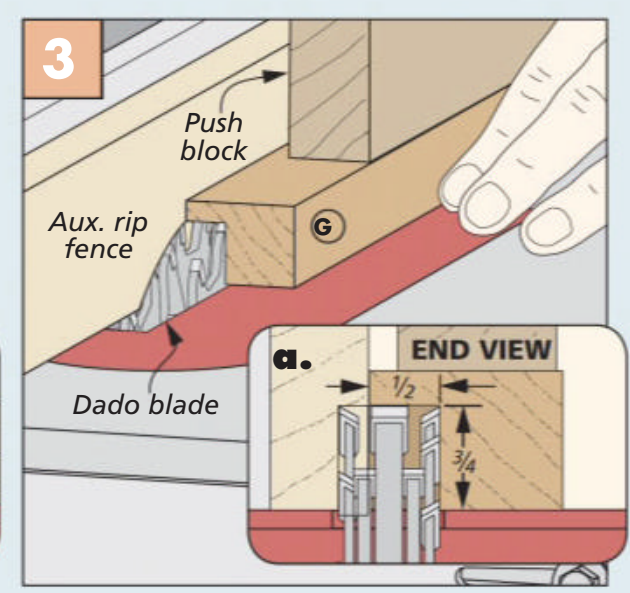
How-To: MAKE THE BACK PANEL & TOP CAP



Rabbets in the Back Panel. A dado blade and auxiliary fence make creating the rabbet in the back panel easy.



Groove for Bottom. At the base of the back panel, you'll need to cut a groove for the plywood chest bottom.



Rabbet in Top Cap. A generously sized rabbet is made in the top cap at the table saw with a buried dado blade.

How-To: MAKE THE REMAINING CHEST PARTS

the front panel. It's a long piece that's tapered on the ends like the other panels. Like the other panels, it also has tenons on the ends. But here, they've been separated into two to help control wood movement. There's also a groove on the inside face of the front panel for the divider (detail 'b', previous page).

Below that is an arched rail. It has angled shoulders on the tenons like the side rails. It also has a groove on the back. This is for the bottom panel.

A TWIST ON TENONS. With the front panel cut to overall size and the ends tapered, you can make the tenons (Figure 1 at right). One thing to note here; because this piece (and the arched rail) are narrower than the previous parts, I used the miter gauge to hold the workpiece stable as it's fed through the saw.

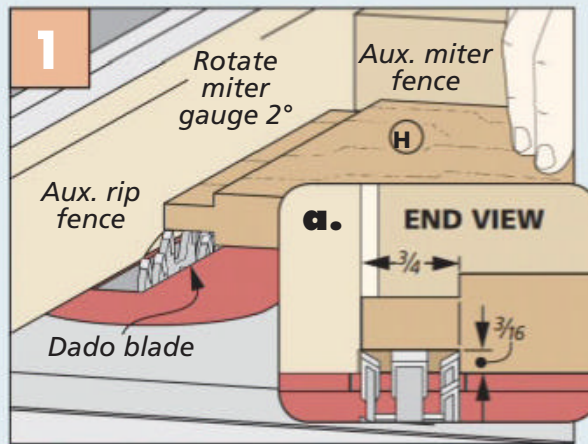
JOINERY DETAILS. While still at the table saw, cut the groove in the back of the front panel for the divider. Then remove the waste between the two tenons with a hand saw and chisel (Figure 2).

MORTISE FOR LOCK. Although you won't install it now, this is the perfect time to work on the mortise for the lock that's in the front panel. Figure 3 shows drilling the keyhole. For the rest of the process, turn to the article on page 56.

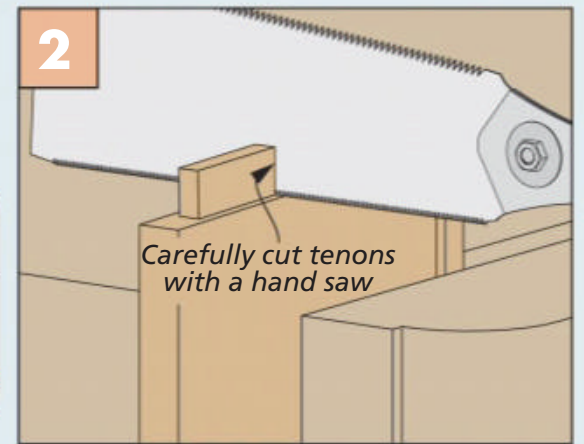
ARCHED RAIL. Cutting the tenons requires the same process as before (Figure 4). Also, cut the groove for the bottom. Next, it's time to draw the arch locations on the blank using a trammel, as you see in Figure 5. Then rough-out the profile of the arch (Figure 6). To finish, sand the arch smooth and ease the edges.

DRY ASSEMBLE. I took a moment to dry assemble the chest. This was to confirm the sizes of the divider, bottom panel, and the length of the cap for the back panel. With that information in hand, I went back to the table saw and cut the divider and chest bottom to size. Then, as you see in Figure 7, I cut a rabbet along all four edges of the divider.

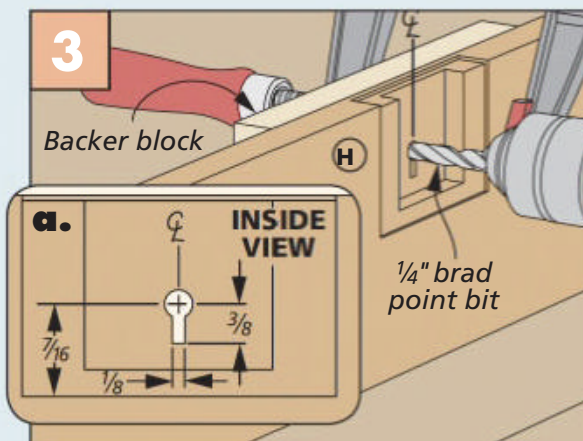
NOTCHES. The last thing to do before gluing up the chest is cut notches in the corners of the divider and bottom to fit around the legs (Figure 8). After everything is assembled, the next item on the docket is to make drawers that will occupy the large opening below the storage compartment.



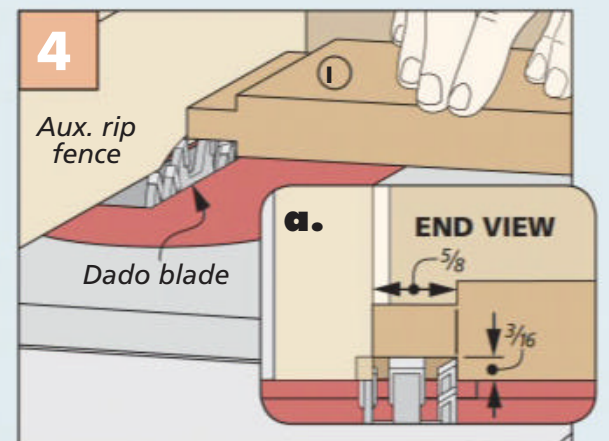
Rabbets Make Tenon. Rotate the miter gauge to support the tapered front panel while making the tenon.



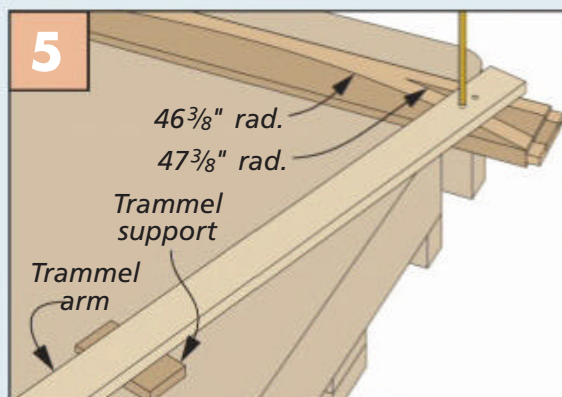
Two Tenons from One. A hand saw and chisel are used to make the two tenons on the ends of the front panel.



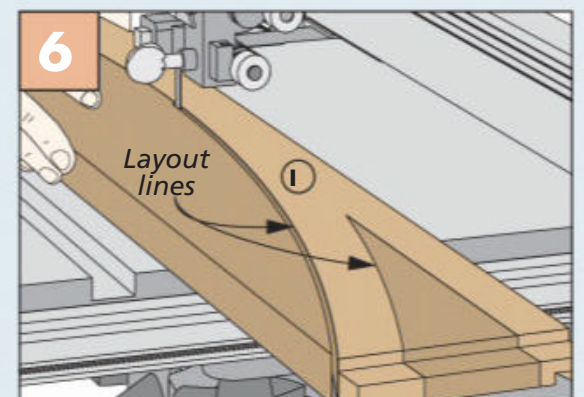
Drill for Keyhole. To prevent blow out, clamp a board to the front panel while drilling the keyhole.



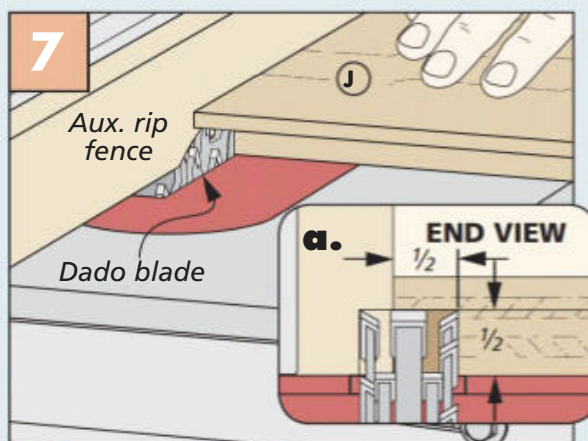
Arched Rail Tenons. Making the tenons on the arched rail is a repeat of what was done on the front panel.



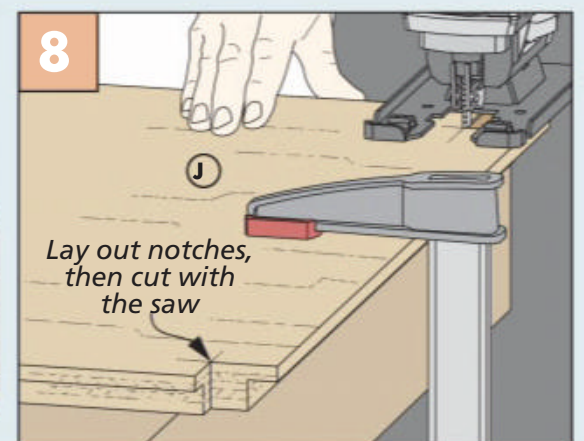
Big Ol' Trammel. A shop-made trammel is the best way to lay out the arc on the bottom of the arched rail.



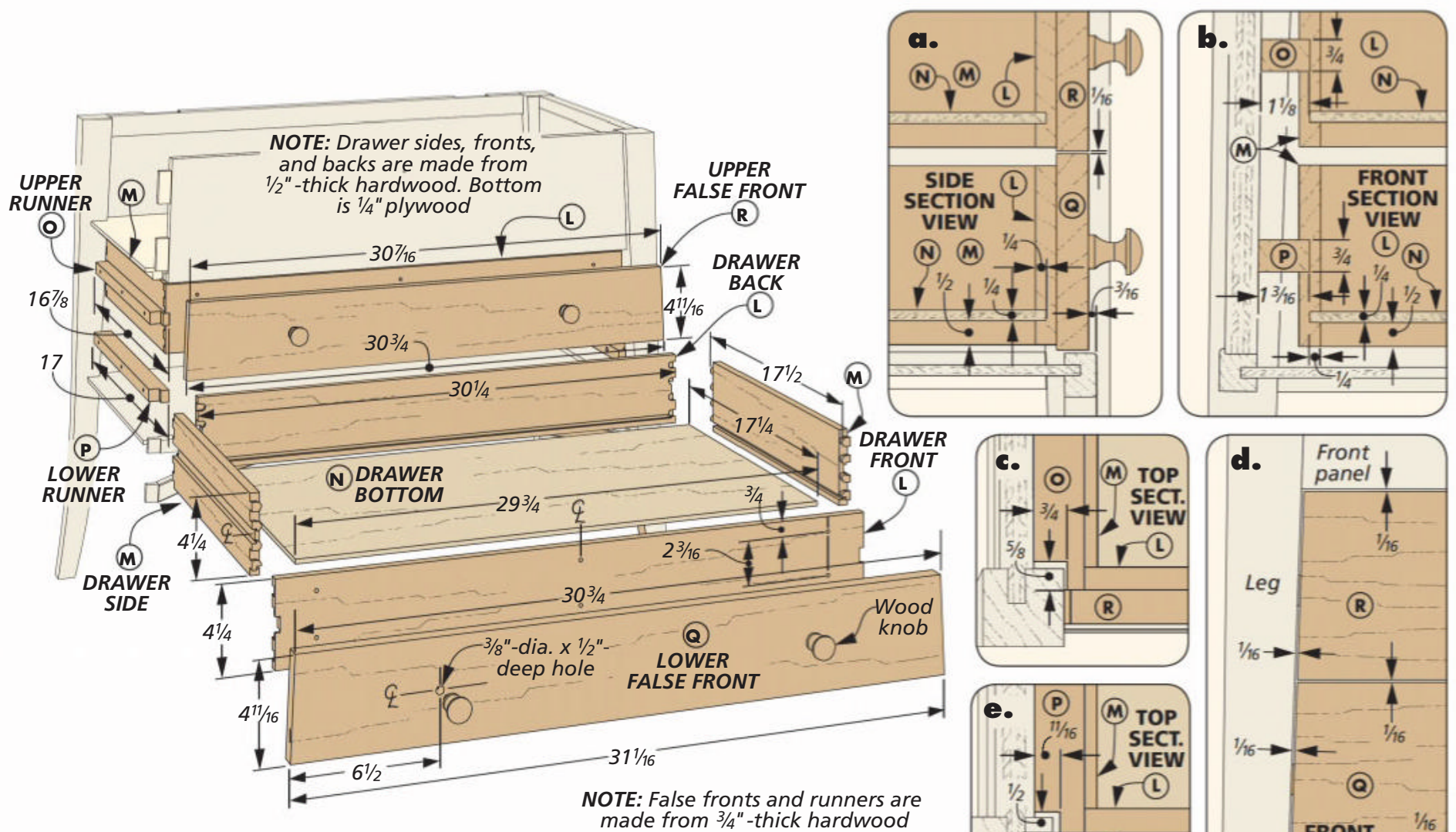
Rough Work. Cut out the arc at the band saw. Leave the layout line for sanding the arc smooth.



Rabbets in the Divider. An auxiliary fence with a buried dado blade makes a perfect rabbet in the divider.



Notches Next. The notches for the legs in the divider and bottom are easily made with a jig saw.



Building the **DRAWERS**

You're pretty much out of the forest of tapers, bevels, and angles. There's only a handful of tasks left that aren't square cuts. What you're facing now are some large drawers that reside in the lower portion of the chest. You've earned the change in pace, so drag out your dovetail jig and prepare to make some sawdust.

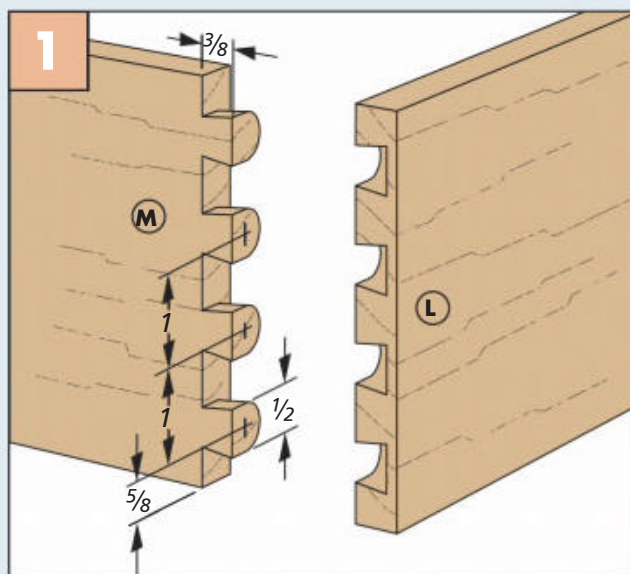
The two drawers run the length of the chest. The 1/2" maple boxes are the same size and joined with half-blind dovetails. Both have 1/4" plywood bottoms.

The false fronts are 3/4" cherry hardwood and are tapered on the ends (as I said, pretty much out of the forest, not all the way) to match the opening in the

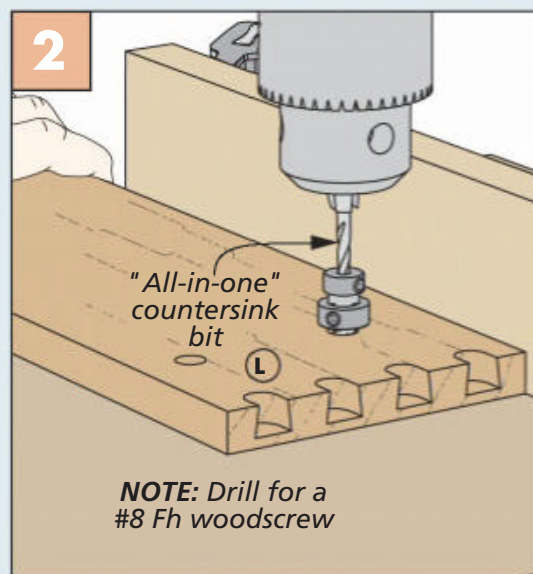
case (detail 'd'). They're attached with screws from the inside of the drawers. The simple but sturdy wood pulls that you see in the drawing above and detail 'a' are a nice accent that flows along with the design and spirit of this chest.

That sentiment was also the motive behind choosing to make wood runners

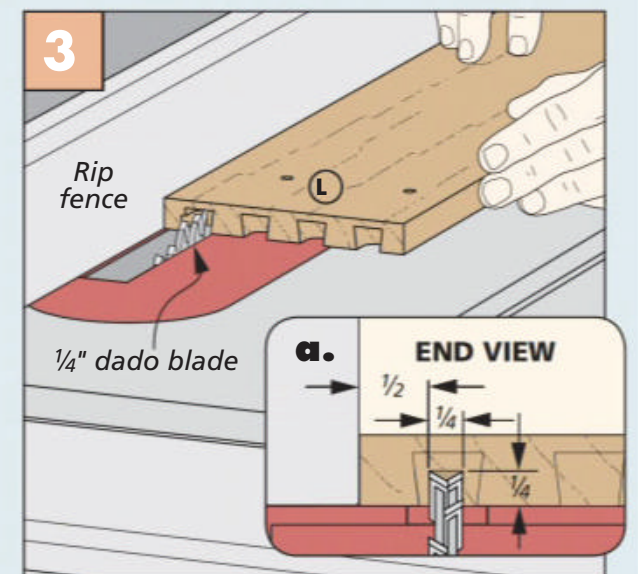
How-To: MAKE THE INDIVIDUAL DRAWER PARTS



Dovetail Detail. Standard half-blind dovetails are used on the drawers. Tails on the sides, pins on the front and back.



Countersinks for False Fronts. Drill the countersinks on the inside face of the drawer front.



Drawer Bottom Groove. A dado blade set up makes the groove needed to hold the drawer bottom.

How-To: PREPARE & INSTALL THE DRAWERS

(detail 'b') for the drawers to ride on. Those get built in a little while. For now, let's get after those drawers.

DOVETAILS. I won't get into the details of making half-blind dovetails here. I will say that while there are quicker ways to make drawers, none of them are stronger. If I had chosen to use metal drawer slides on the chest, I might have opted for some simpler joinery. But since the drawers are going to be moving on wood runners, there's not a joinery configuration for a drawer that will take the beating that dovetails will endure.

Speaking of dovetails, Figure 1 on the previous page shows the proper pin and tail configuration for a well-made drawer. Once the router and dovetail jig are stowed away, you can move over to the drill press with the drawer fronts in hand to drill the holes for screwing the drawer to the false front (Figure 2).

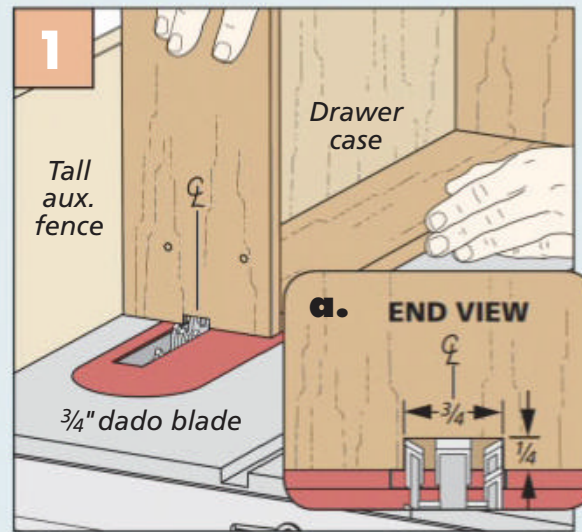
One more thing you need to do before assembling the drawers — cut a groove in the lower portion of the inside face of the sides, front, and back for the drawer bottom (Figure 3). That being done, go ahead and glue up the drawers.

GROOVE IN DRAWER SIDE. For the drawers to ride on the runners, you need to cut a shallow groove in the sides of the drawers. Figure 1 at the top of this page shows the best way to do this.

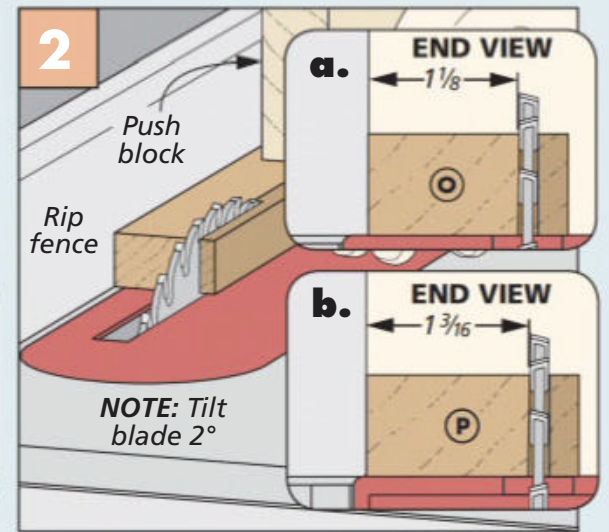
RUNNERS. Now it's time to make the runners. To start, I cut a bevel on four extra-wide runner blanks at the table saw (Figure 2). Then, return the blade to square and rip each runner to the widths shown in detail 'b' on the previous page. In preparation for the next step, I drilled countersunk pilot holes in all the runners. A hand saw made quick work of the notches needed at the ends of the runners (detail 'c' and 'e' on the previous page).

INSTALLING RUNNERS. To ensure that each pair of runners is positioned at the same height, I employed a spacer to install them. Figure 3 shows installing the runners for the upper drawer first. Then, rip the spacer to the width shown in Figure 4 to install the lower runners.

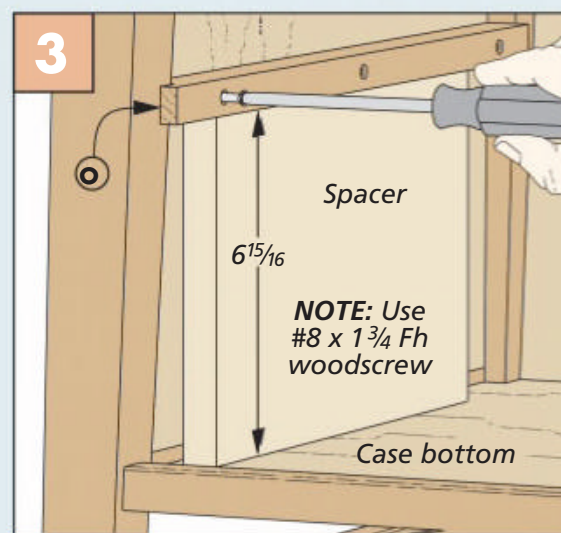
At this time, you can test the fit of the drawers and sand the runners as needed for a smooth fit. When that's done, you are looking at the last set of taper cuts you'll have to make. They're the most



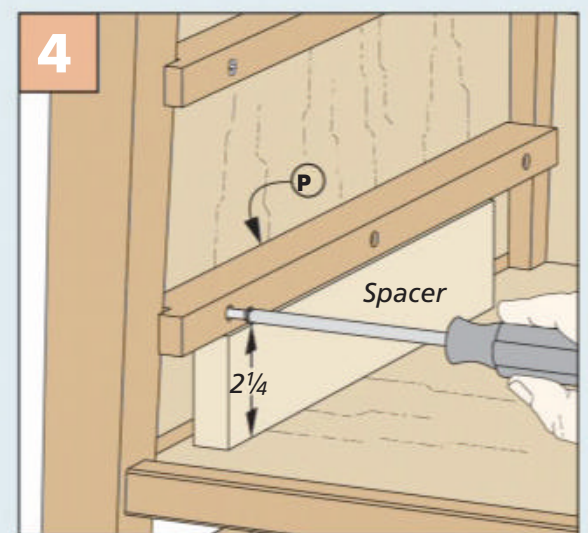
Groove for Runner. While making the groove in the drawer side, use a tall auxiliary fence for support.



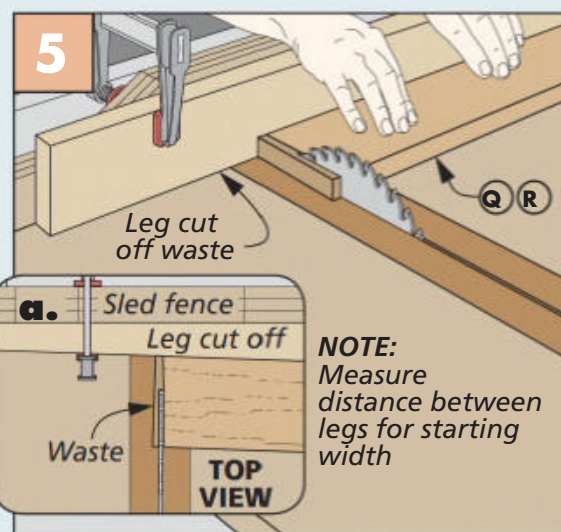
Beveled Rip. The drawer sides are beveled to match the case sides. Cut these bevels first, then notch them.



Spacer for Top Runners. A spacer resting on the case bottom positions the top runners perfectly.



Lower Runners Next. All you need to do is trim the spacer to screw the lower runner in place.



Size the False Front. After checking the opening, use the crosscut sled to trim the lower false front to size.

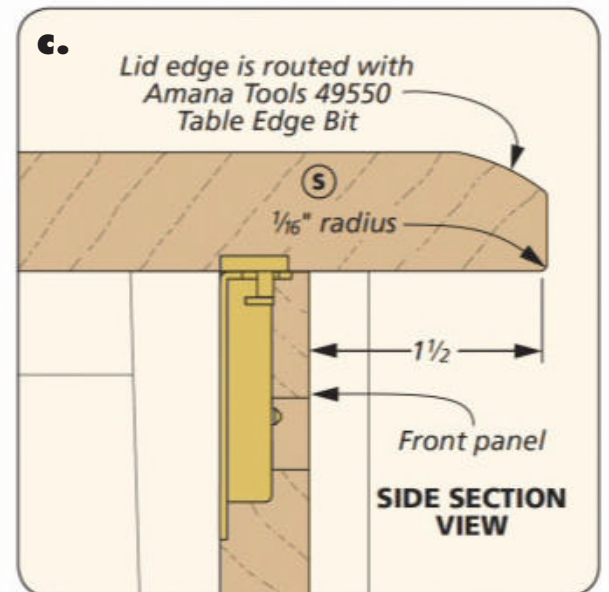
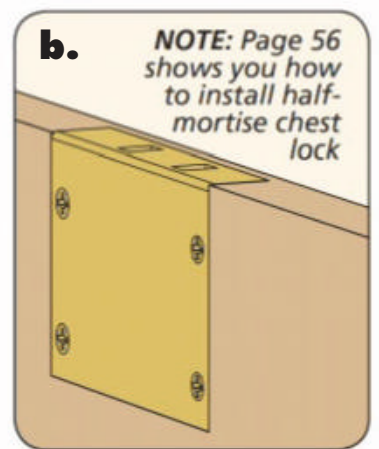
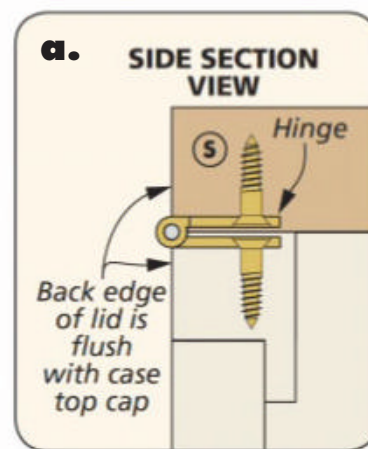
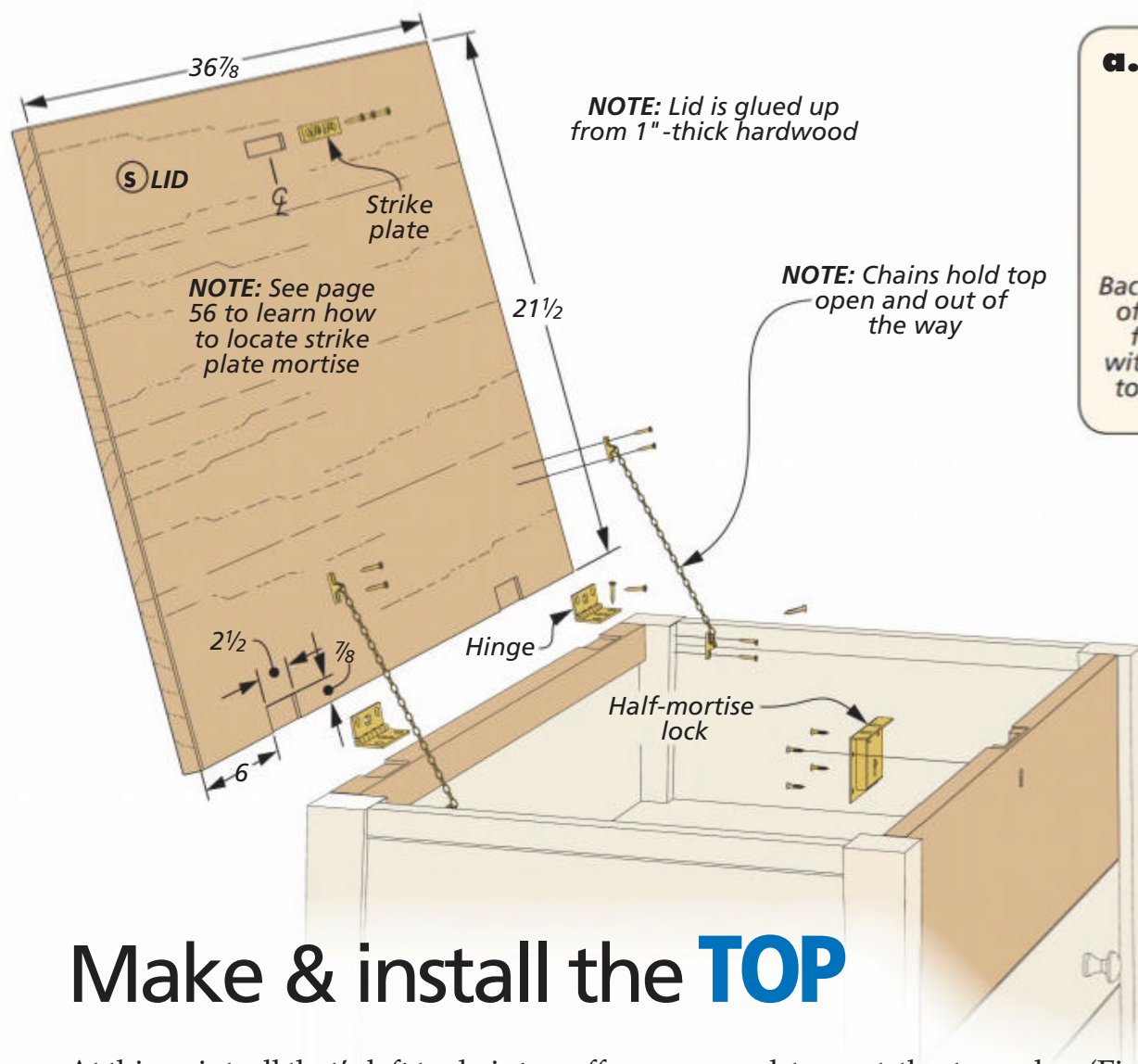


Fit the False Front. Use shims to ensure even spacing between the doors and in the opening.

visible by far, but that's okay — you're a master of the taper by this time.

FALSE FRONTS. Making perfect-fitting false fronts starts from the bottom up. Cut the lower drawer, using the crosscut setup in Figure 5 to size the piece.

After sizing the front, drill and install the wood knobs. Use shims to space the front in the opening and double-sided tape to hold it in place while screwing it to the drawer. Now, repeat the process for the upper false front (Figure 6).



Make & install the TOP

At this point, all that's left to do is top off the sugar chest with a lid. And I think you'll agree that it's a fine-looking lid at that. As the drawing above reveals, the lid is a 1"-thick solid wood panel that's glued up from narrow boards. It's mortised for the hinges on the back and the strike plate for the lock on the front. But first, let's make the lid.

LID DETAILS. After gluing up the panel for the lid and squaring up the ends,

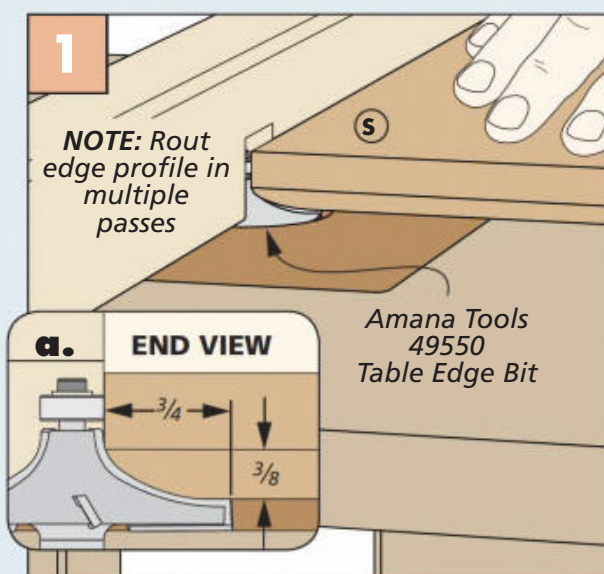
you need to rout the top edge (Figure 1). This wide, sweeping profile softens the edge without drawing too much attention to itself (detail 'c').

LOCATING HINGES. This thick, large lid is a wonderful thing to look at and complements the chest nicely. But this creates a challenge when it comes to mounting the lid to the chest. To tackle this safely and accurately, I placed the lid on sawhorses, then traced the profile of the

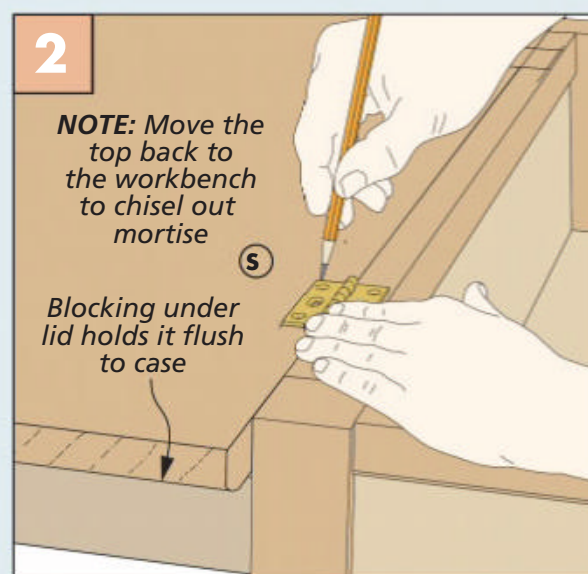
hinges onto the lid and top cap, Figure 2 shows how to do this.

HINGE MORTISES. I moved the lid back to the workbench to make the mortises. This started with scoring the edges of the hinge profile with a utility blade, followed by chiseling out the mortises. Figure 3 below shows the same process on the top cap. To install the lid, I just set it back on the sawhorses and screwed the hinges in place.

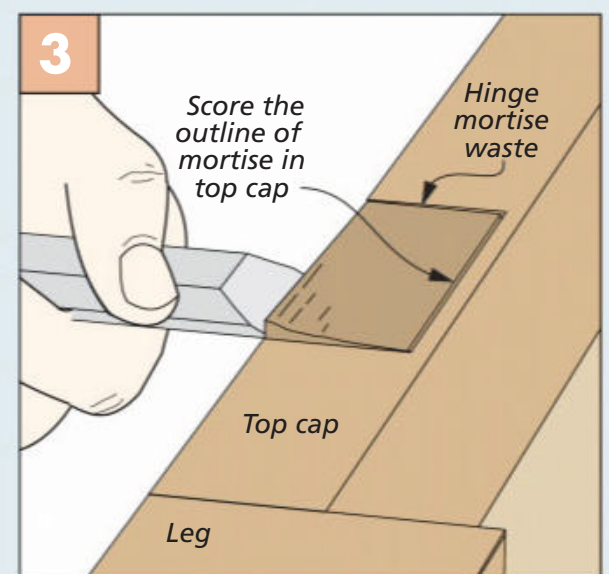
How-To: PREPARE & ATTACH THE LID



Rout the Lid. The front and sides of the lid are shaped at the router table in multiple passes to avoid burning the lid.



Locate the Hinge. With the lid supported and against the case, use a pencil to trace the outline of the hinges.



Hinge Mortise. First, use a knife to score the walls of the hinge mortise. Then chop out the waste area.

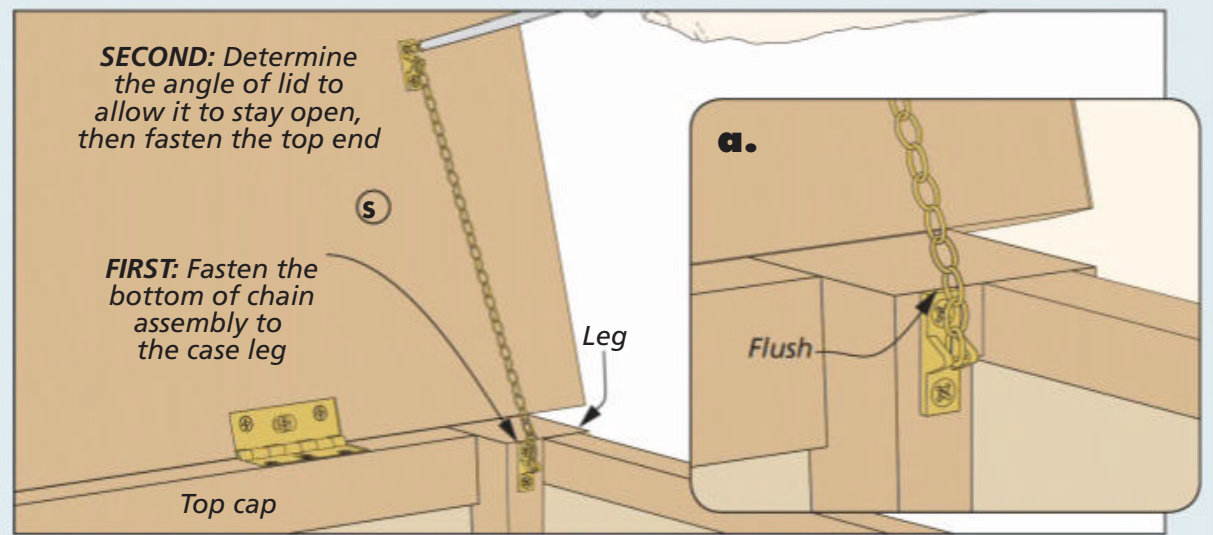
How-To: INSTALL BOTH SETS OF CHAINS

FINAL DETAILS. You have one more wood-working task to do — create the mortise in the lid to house the strike plate of the lock (detail 'c'). The article on page 56 covers all the steps in detail.

After applying *Varathane* Traditional Cherry gel stain and two coats of lacquer, install the lock and strike plate.

To complete the project, you'll want to install chain stays that prevent the lid from opening too far back. There are two of these to deal with, so I tackled them one at time. The box to the right shows how to do this.

That completes the chest. You might not have sugar cones to hide away in the chest. But that's okay. It can protect other items that you're sweet on. **W**



Locating the Chains. The heavy lid requires two chains to hold it open. Install the first with the top propped at the desired angle. Then install the second chain on the opposite side, matching the tautness of the first.

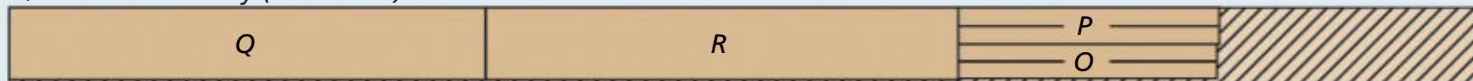
Materials, Supplies & Cutting Diagram

A Legs (4)	3 x 3 - 31	K Bottom (1)	$\frac{1}{4}$ ply. - $18\frac{15}{16}$ x 33	• (12) #8 x $1\frac{1}{4}$ " Fh Woodscrews
B Side Panels (2)	$\frac{3}{4}$ ply. - $18\frac{1}{2}$ x $16\frac{1}{4}$	L Drawer Front/Back (4)	$\frac{1}{2}$ x $4\frac{1}{4}$ - $30\frac{1}{4}$	• (12) #8 x $1\frac{3}{4}$ " Fh Woodscrews
C Side Rails (2)	$\frac{3}{4}$ x 1 - $18\frac{7}{16}$	M Drawer Sides (4)	$\frac{1}{2}$ x $4\frac{1}{4}$ - $17\frac{1}{2}$	• (4) Wood Drawer Pulls
D Upper Edging (2)	$\frac{7}{8}$ x 1 - $16\frac{1}{16}$	N Drawer Bottom (2)	$\frac{1}{4}$ ply. - $17\frac{1}{4}$ x $29\frac{3}{4}$	• (2) Hinges
E Lower Edging (2)	$\frac{7}{8}$ x 1 - 17	O Upper Runners (2)	$\frac{3}{4}$ x $1\frac{1}{8}$ - $16\frac{7}{8}$	• (1) Half-Mortise Chest Lock
F Back Panel (1)	$\frac{3}{4}$ ply. - $17\frac{1}{8}$ x $32\frac{3}{4}$	P Lower Runners (2)	$\frac{3}{4}$ x $1\frac{3}{16}$ - 17	• (2) Limiter Chains
G Top Cap (1)	1 x $1\frac{3}{8}$ - $30\frac{1}{8}$	Q Lower False Front (1)	$\frac{3}{4}$ x $4\frac{11}{16}$ - $31\frac{1}{16}$	
H Front Panel (1)	$\frac{3}{4}$ x $7\frac{5}{8}$ - $32\frac{1}{16}$	R Upper False Front (1)	$\frac{3}{4}$ x $4\frac{11}{16}$ - $30\frac{3}{4}$	
I Arched Rail (1)	$\frac{3}{4}$ x $3\frac{13}{16}$ - $32\frac{11}{16}$	S Lid (1)	1 x $21\frac{1}{2}$ - $36\frac{7}{8}$	
J Divider (1)	$\frac{3}{4}$ ply. - $18\frac{3}{4}$ x $32\frac{11}{16}$			

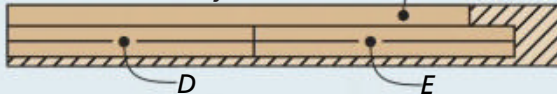
$\frac{3}{4}$ " x 8" - 72" Cherry (4.0 Bd. Ft.)



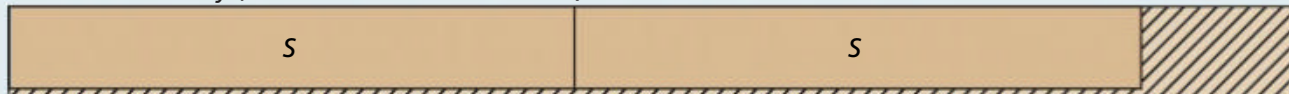
$\frac{3}{4}$ " x 5" - 96" Cherry (3.3 Bd. Ft.)



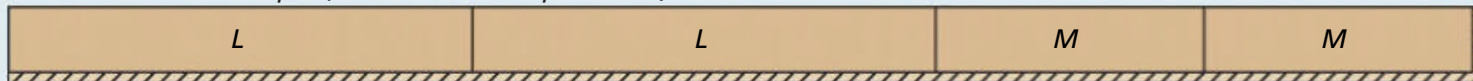
1 x 4" - 36" Cherry (1.3 Bd. Ft.)



1 x 6" - 84" Cherry (2 Boards @ 4.4 Bd. Ft. Each)



$\frac{1}{2}$ " x 5" - 96" Hard Maple (2 Boards @ 3.3 Sq. Ft. Each)



Also needed: One 48" x 96" sheet of $\frac{1}{4}$ " maple plywood
One 48" x 96" sheet of $\frac{3}{4}$ " cherry plywood
Four 3" x 3" x 36" cherry turning blanks

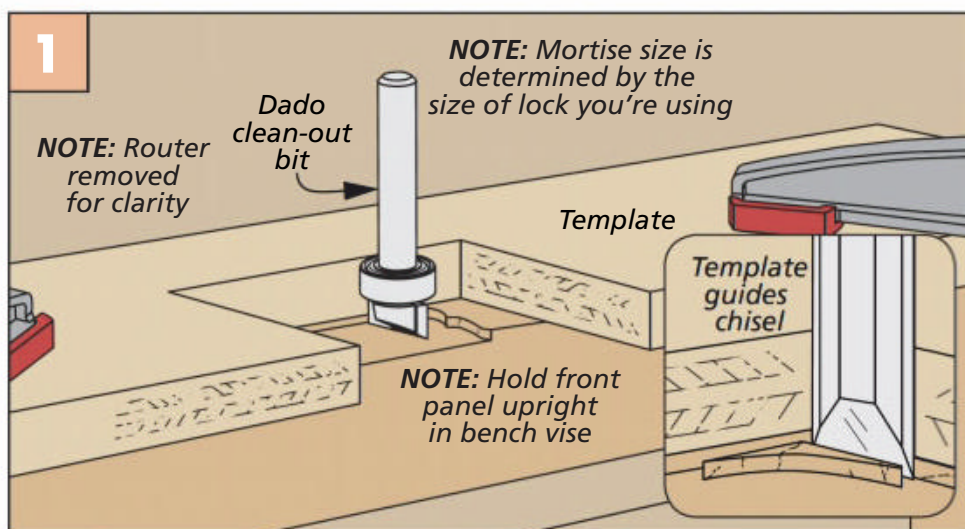


Installing a Half-Mortise Lock

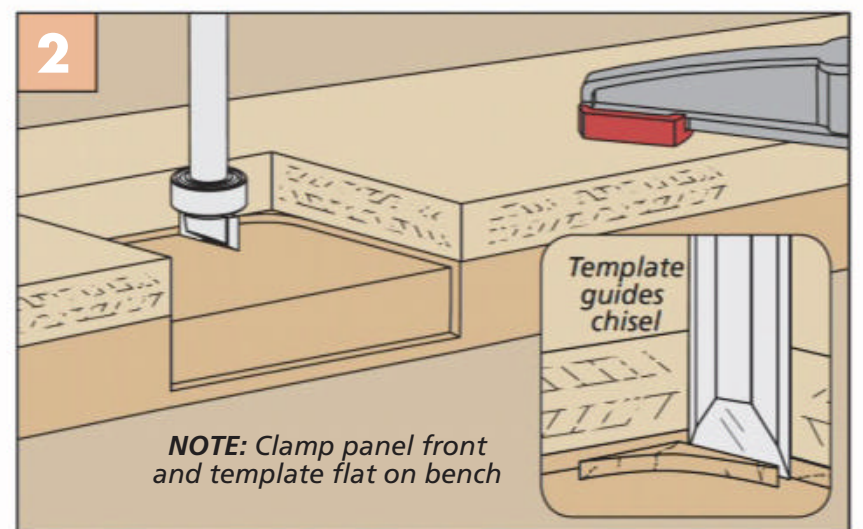
For centuries, locks have been used to secure the contents of all sorts of furniture. A perfect example is the sugar chest on page 44. The upper compartment of the chest is secured with a traditional half-mortise lock. The body of the lock is hidden on the inner wall of the chest.

The lock is also mortised into the back of the front panel so that it's flush with the top edge and the inside wall. It works in tandem with a strike plate. To align it perfectly to the lock, the strike plate is mortised and screwed into the lid (after the chest is assembled).

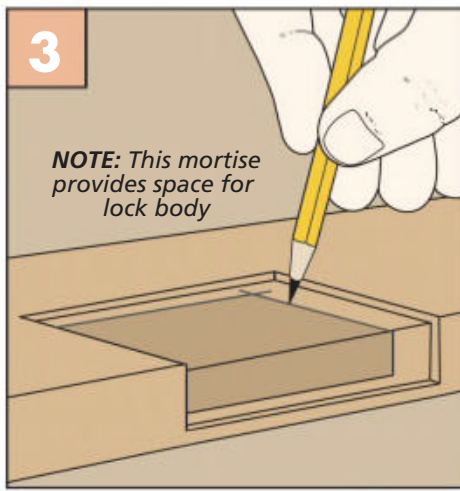
After the lock and strike plate are installed, all you'll see from the outside is the keyhole that you've fashioned. When the chest is closed, the whole works visually flies under the radar, all the while providing a secure storage area for your chest.



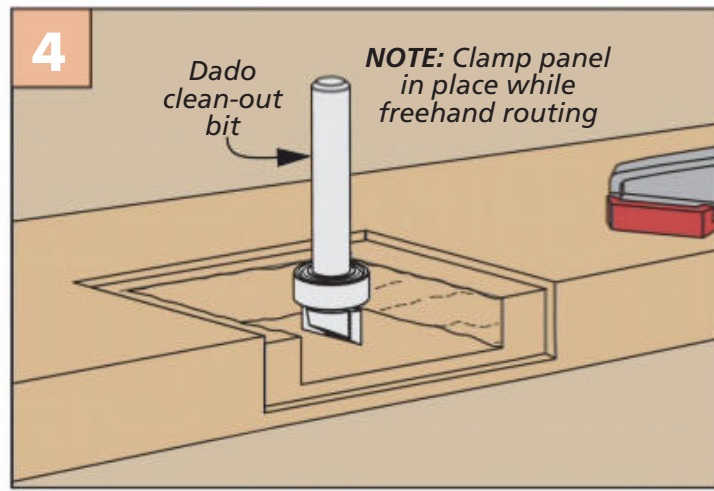
Top Edge First. Lock the front panel in your vise. Then clamp the template in place with bar clamps. Rout out the waste area for the top edge of the lock and square the corners with a chisel.



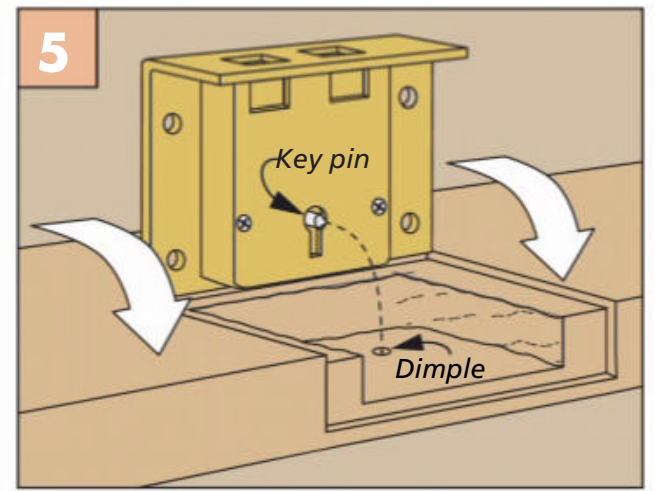
Panel Back Next. Lay the front panel flat on the workbench and clamp the template in place. Repeat the routing process, followed by squaring the corners.



Lay Out Deep Mortise. Use a pencil to mark out the rough area of the lock body.



Rout Deep Mortise. Rout the deep mortise in multiple passes. It's not required to square the corners here. Just make sure the lock body fits.



Keyhole Location. Lower the lock into the mortise. The pointed key pin forms a dimple to locate the keyhole.

I found the easiest way to work on this stepped mortise is before the chest is assembled. So once I had completed all of the joinery details, I took the front panel to the workbench to fit the lock without the rest of the chest getting in the way. The process starts with laying out the location of the lock so the keyhole is centered on the panel.

A SIMPLE TEMPLATE. A simple plywood template (main photo) is all that's needed. Using it will create the shallow recess for the thin plate that straddles the top edge and the back face.

There's a deeper mortise to hold the body of the lock. It's on the back side of the panel. For both, I used a router with a dado clean-out bit that has a bearing on top to ride against the template.

SHALLOW MORTISE FIRST. To start, I clamp the front panel upright in my vise at the bench. Then I position the template on the top edge and clamp it in place to rout the perimeter and waste (Figure 1).

To finish the shallow mortise, reposition the panel face down on the bench

and rout out the mortise on the back of the panel (Figure 2). Clean up and square the corners of the mortise on both faces of the front panel.

DEEP MORTISE NEXT. With the panel still on the bench, you need to clean out the area where the lock body resides. The boundaries of this mortise don't have to be exact, so I drew a rough outline on the panel (Figure 3).

On the deeper mortise, using the short dado clean-out bit means making multiple passes, as in Figure 4. Note that the template is no longer needed.

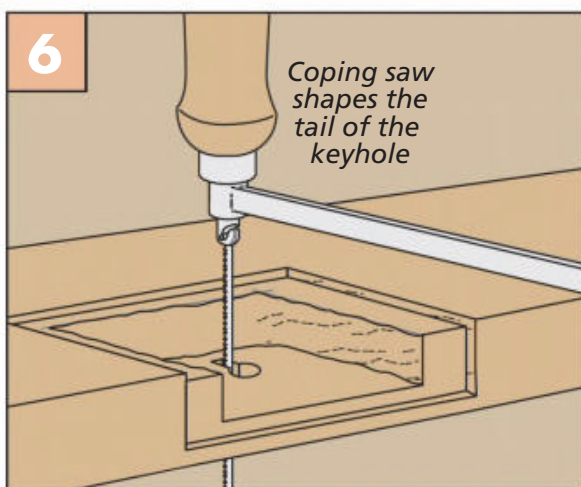
KEYHOLE. Your next task is to drill a hole in the panel for the shaft of the key to pass through. The lock can be used to locate the hole. Start by positioning the lock in the mortise opening. Then press the key pin into the panel. The point of the key pin will make a dimple in the wood where you can drill the hole. Figure 5 shows how to do this. By the way, if the key pin doesn't stick out beyond the body, you can always measure and transfer its location to the panel.

KEYHOLE TAIL. The main article on the chest (page 44) shows how to cleanly drill the keyhole. When it came to making the tail for the key, I used a coping saw to cut out its shape (Figure 7).

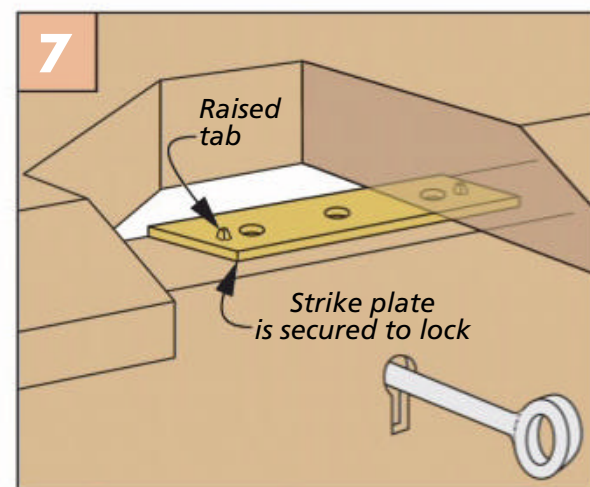
FINISH BUILDING. The keyhole completes the preparation needed for the chest lock. But you don't want to install it just yet. Go ahead and finish building the chest (applying the stain and finish if you like). This includes installing the lid. You'll need that in place to accurately locate the strike plate.

THE STRIKE PLATE. Start this final step by screwing the chest lock to the front panel and locking the strike plate in place (Figure 8). Now it's just a matter of closing the lid on the plate. The plate has tabs on the back that put a couple of dents in the lid to locate the plate.

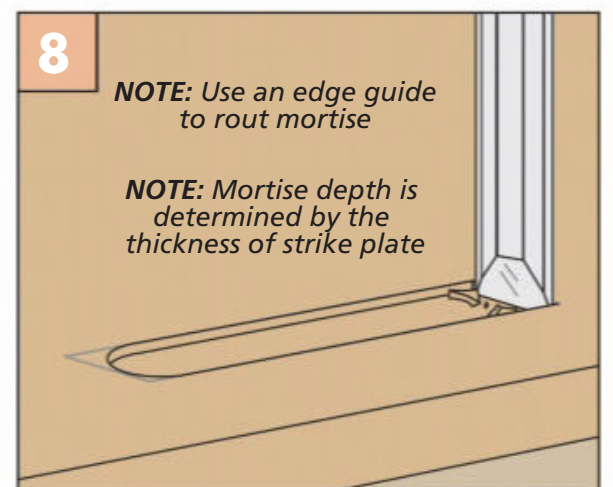
With the lid properly supported, place the strike plate in the dents and trace the profile on to the top. For expediency, I routed out the mortise (using an edge guide attached to the router) then cleaned up the corners with a chisel. **W**



Keyhole Tail. After the hole is drilled, thread a coping saw blade through the opening to shape the tail.



Strike Plate. Close the top of the chest onto the strike plate so the tabs will mark its location.



Shallow Mortise. When you've finished routing the shallow mortise for the strike plate, square the ends.



My must-have **Clamp Set**

One of the first challenges I had when it came to woodworking was choosing clamps. Every woodworking catalog or retail outlet offers dozens of possibilities. Plus, even if you only buy a few of each type of clamp, you're talking about a hefty investment. You certainly don't want to make any wrong choices. So, what do you really need?

The answer depends on the type of woodworking you're going to do, the size of the projects you plan to build, and even how many projects you plan to have going at any one time. Over the years, I've used a wide range of clamp types and styles. But what follows is the "set" I find myself using most of the time to meet my clamping needs — and I think it's a great set for any woodworker that's just starting out.

WORKHORSE CLAMPS

My woodworking journey started with small projects — things like boxes and cutting boards. With projects that size, I didn't need long, heavy-duty clamps.

Instead, I started with what amounts to the workhorse clamps of my shop, F-style clamps, as in the main photo and the one at right. This style of clamp is offered by a number of companies, but I've used the *Bessey* line of clamps for decades with great results.

GO WITH LIGHT DUTY. Just be aware that *Bessey* offers a number of different models in this style, from super light duty to heavy-duty monsters that rival pipe clamps in their weight and ability to apply clamping pressure. The ones I prefer are their light-duty Tradesman (TGJ) with the profiled rail.

BEEFY DESIGN. The cast iron jaws are stout and sturdy and will reach a depth of 2½". And the screw features Acme threads, which are stronger than conventional V-threads on a lot of clamps. Plus, the beefy wood handle allows you to get a good solid grip.



▲ Bessey F-clamps are the workhorse clamps in my shop. You can use them for just about every clamping need.

Newer versions of this clamp come with a composite, ergonomic handle you may want to check out, but I've found the wood handle suits me just fine. On either version, *Bessey* includes plastic protector pads for the jaws that help prevent any marring of your workpiece.

To handle a wide range of projects, it's best to have a few different lengths on hand. I started with 6", 12", and 18" lengths, buying four of each.

ADDING ON

As my woodworking progressed, I started building bigger, furniture-type projects and gluing up large, solid-wood panels, as in the photo below. For these types of tasks, I added a set of pipe clamps to my shop.

MAKE YOUR OWN. These clamps are the kind where you buy the jaw assembly and attach them to a length of black iron pipe, in either $\frac{1}{2}$ " or $\frac{3}{4}$ " sizes. Since the pipe is purchased separately, you can "build" clamps any length you'd like. As a matter of fact, to make a "new" clamp, all you have to do is buy a new piece of pipe and swap out the old one. Or simply buy an inexpensive coupler and join shorter lengths together to create one long one. Note: Skip the $\frac{1}{2}$ " size. They cost about the same as $\frac{3}{4}$ " and won't save you much in weight.

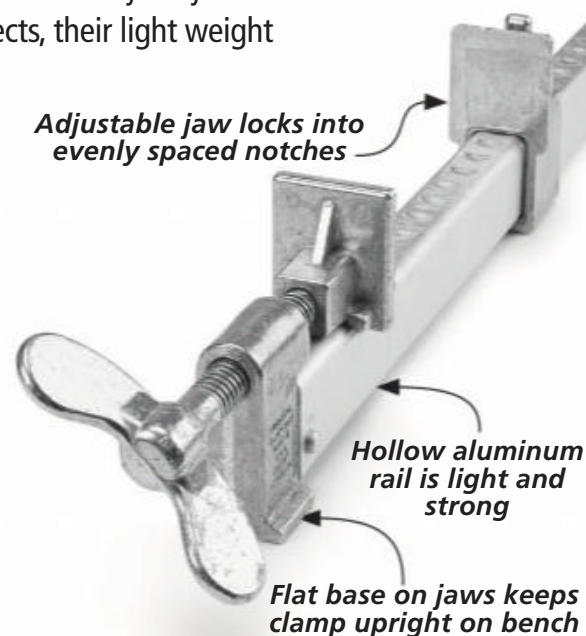


▲ Aluminum bar clamps make one-person project assembly easy. Even when you need longer versions for larger projects, their light weight makes them easy to position and tighten.

HEAVY. Pipe clamps do have one drawback — they weigh quite a bit. That's not a problem if you're gluing up a panel on the top of your workbench. But the weight gets a bit awkward to handle if you're assembling a large project by yourself.

To keep things manageable, I chose two different pipe lengths. Four each of 24" and 36" covered my bases.

GOING LIGHTWEIGHT. The real challenge comes when you need long clamps for a project and don't want to deal with heavy pipe clamps. To solve this problem, I switch to aluminum bar clamps (photo above). Although not as heavy-duty, they're a lot easier to handle



when it comes to working on large case assemblies by yourself.

The sturdy aluminum bars are hollow and lighten the weight of the clamp considerably. So you aren't likely to struggle with them while assembling a project — even if the clamps are fairly long. I started with 48"-long clamps and added 36" ones down the road to handle most of the work I do.

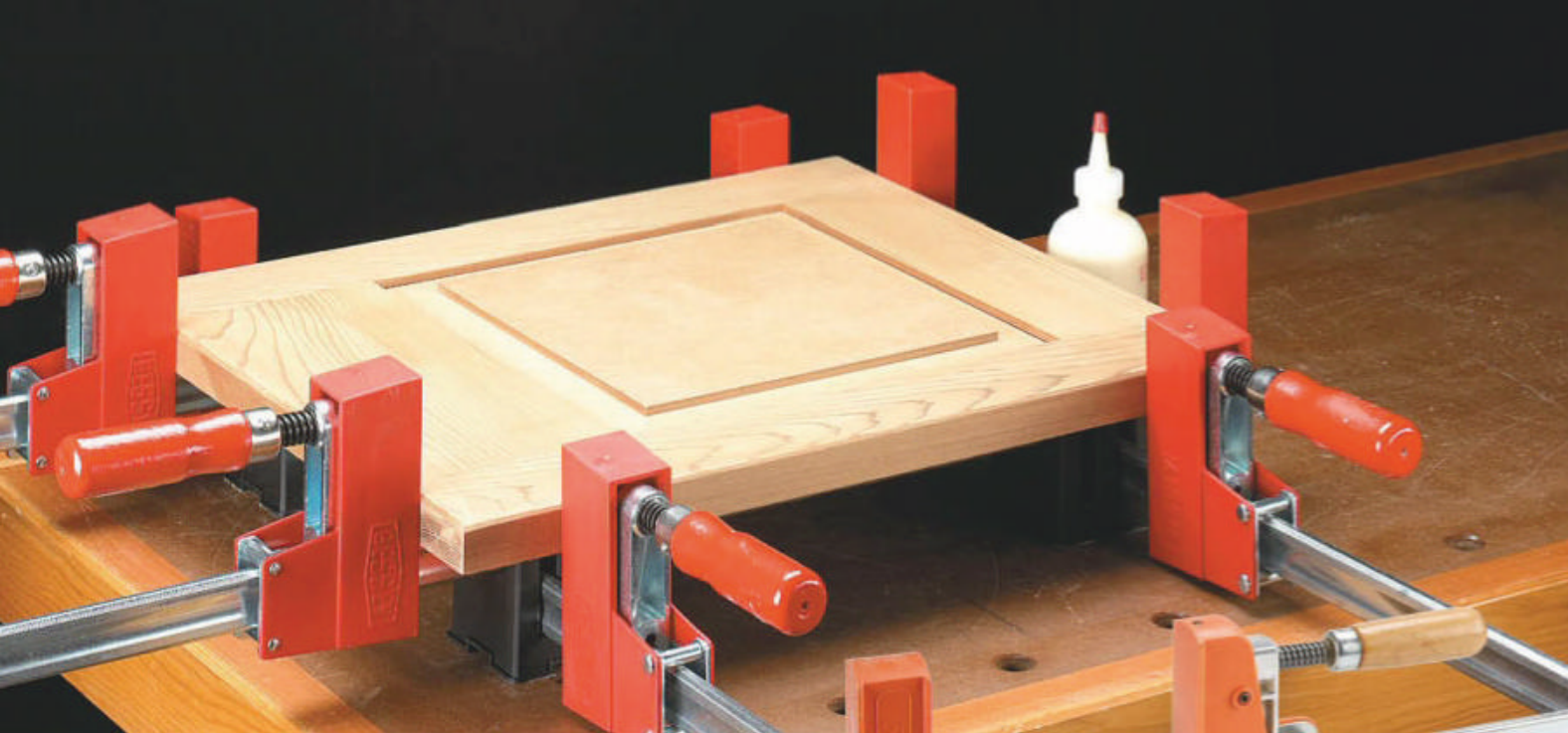
COST. Like the pipe clamps, aluminum bar clamps do have a drawback. They're a little more expensive than pipe clamps for similar lengths. But I think they're worth the money.

To find out about the rest of the clamps that round out my collection, turn the page.



▲ Pipe clamps are the standard for gluing up project panels. They're easy to use and provide consistent clamping pressure. Here, wax paper keeps the bars from staining the material.





Parallel jaw clamps keep a project flat and square while applying pressure. They're a lifesaver for assemblies like this frame and panel.

Heavy-duty steel bar stays straight under pressure

Large jaws remain parallel and square to bar when tightened

End stop supports clamp on benchtop

The clamps detailed on the previous pages took care of the majority of clamping tasks I had in my shop (and still do). But over the years, I ran into a few tough clamping jobs that required something more than basic bar and pipe clamps.

SPECIALIZED CLAMPS

What follows are the specialized clamps that solve those problems. I'm not saying you can't handle a few tasks that follow with the bar and pipe clamps. But these specialized clamps make those tasks a little quicker and easier.

FLAT & SQUARE. The big reason I added parallel jaw clamps to my collection was that unlike other types of bar clamps, the large jaws are designed to stay parallel to one another when the clamp is tightened.

As a result, pressure is applied more evenly across the assembly you're

working on. This makes them a great choice for case assemblies, as well as gluing up frame and panel assemblies like the one shown in the photo above. Because these clamps are self-squaring, I can rest assured that any assembly I put together will be flat and square.

Although the clamps are fairly rigid due to the heavy-duty bar, they're only designed for low to moderate pressure. Overtightening the clamps may defeat the self-squaring design. Like bar clamps, long versions can be fairly heavy, so I stick with the 24" and 36" sizes. And just be ready for sticker shock. Parallel jaw clamps are some of the most expensive ones out there, but I still think the shorter versions are well worth the investment.

AN EXTRA HAND. At the other extreme of price is another clamp style I think every shop should have. And that's a set of simple spring clamps, like the one you see in the photo at left.

I reach for a spring clamp whenever I need an extra hand. It works like a big clothespin. Depending on the size of the clamp, the capacity is fairly limited. But that doesn't mean the amount of pressure a spring clamp can exert is small. They work well to keep a small

workpiece right where it needs to be until the glue dries. And as detailed in the photo, a spring clamp works great for holding a stop block in place. They do have to be carefully positioned though, or the spring action may allow parts to shift out of position.

Spring clamps are inexpensive (a few dollars apiece). So there's no reason not to keep a set of four each of the 2" and 3" sizes around the shop.

FLEXIBILITY. If you're looking for a versatile clamp that's a bit out of the norm, you may want to check out a band clamp. Band clamps are a must-have for those assembly tasks where you just can't figure out how to make a "straight" clamp work, like the corner cabinet shown at the upper right on the next page. They work great for cylindrical projects built using stave construction.

The band clamp I use is nothing more than a long cloth strap that feeds through a metal ratchet assembly. After wrapping the strap around the project, you simply tighten it down with the built-in ratchet. Some bands come with metal brackets that fit over right angle corners to prevent the strap from crushing the sharp points.

A pair of band clamps will usually handle just about any project. You can add in a third if you run across a really demanding assembly.

HANDSCREW. Although I don't use them much for assembly, I like to have a few



Pivoting design provides pinpoint pressure

The ability to use one hand to position a spring clamp makes it a great choice for many tasks, like holding this stop block in place.

Corner brackets prevent marring

Ratchet assembly provides easy adjustment

The strap of a band clamp conforms to the shape of a project, applying consistent pressure.

Non-marring wooden jaws can be adjusted out of parallel to match assembly

Wide clamping capacity

Fast action threads adjust jaws quickly

handscrews in my shop for a number of reasons. The main reason is the jaws can be pivoted out of parallel using the threaded rods that pass through them.

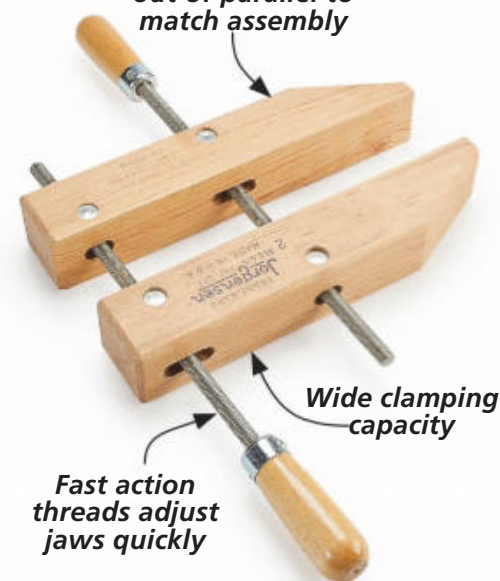
This feature makes the handscrew a versatile clamp. You can see how adjusting the jaws allows you to reach and apply pressure where other clamps just won't do, as in the far right photo.

Handscrews aren't just for assembly though. I use them for holding small pieces while working at the drill press or router table. And if you need an extra hand, you can use one to hold the side of a cabinet upright during assembly.

They range in size from 4" to 24". But I find the 6" and 8" sizes to be the most useful for the work and tasks I run across in my shop.

PUTTING ON THE SQUEEZE. The last must-have clamp type is one that can apply a lot of clamping pressure in a concentrated spot. Here, C-clamps are my choice.

I use C-clamps any time I have to hold metal parts in place for drilling or assembly, like you see in the lower left photo. You can use them with wood, as well, provided you protect the surface of



▲ When it comes to clamping challenges, handscrews can be lifesavers. The ability to angle the jaws, along with their deep reach, allows you to apply pressure right where you need it, like the shaped trim being added to this assembly.

any pieces you clamp. The serious pressure you can apply makes it all too easy to put a dent in your workpiece.

Like all clamps, they come in a wide range of sizes, but the 2" and 4" versions find the most use in my shop. Since they're inexpensive (as clamps go), you can always add other sizes for specific projects as the need comes up.

◀ C-clamps are the best choice when whenever you need high clamping pressure, as when working with metal.



CLAMP BUYING STRATEGY

Up to this point, I've suggested both the types and sizes of the various clamps that I added to my basic furniture-making set of clamps. Over the years, I've added additional quantities and sizes of them to suit the new projects I was building. No doubt, you'll end up doing the same thing.

One thing to avoid is buying too many clamps that are dedicated to a single purpose (like picture frame clamps or clamps for gluing edging onto plywood). Single-purpose clamps like these can be expensive, and you need to be doing a lot of that type of work to justify the cost.

As I did, you'll need to decide which clamps suit your needs. Later, you can add more clamps as your budget allows. It's a good way to take the sting out of the buying decision. And you'll wind up with a clamp collection that provides the most versatility for your shop. **W**



Straightline Ripping

For a few years now, “live edge” furniture has been all the rage. You see examples of this everywhere — a board with one or both edges that still retain the profile of the tree trunk. To some, this style and look is new and interesting.

Fads in furniture are all fine and good, and “live edge” deserves its fifteen minutes of fame. But for more traditional

woodworking, boards like the one you see in the photo above are still a few steps away from being production-ready for a project. One of those steps is having a straight edge on at least one side of the board.

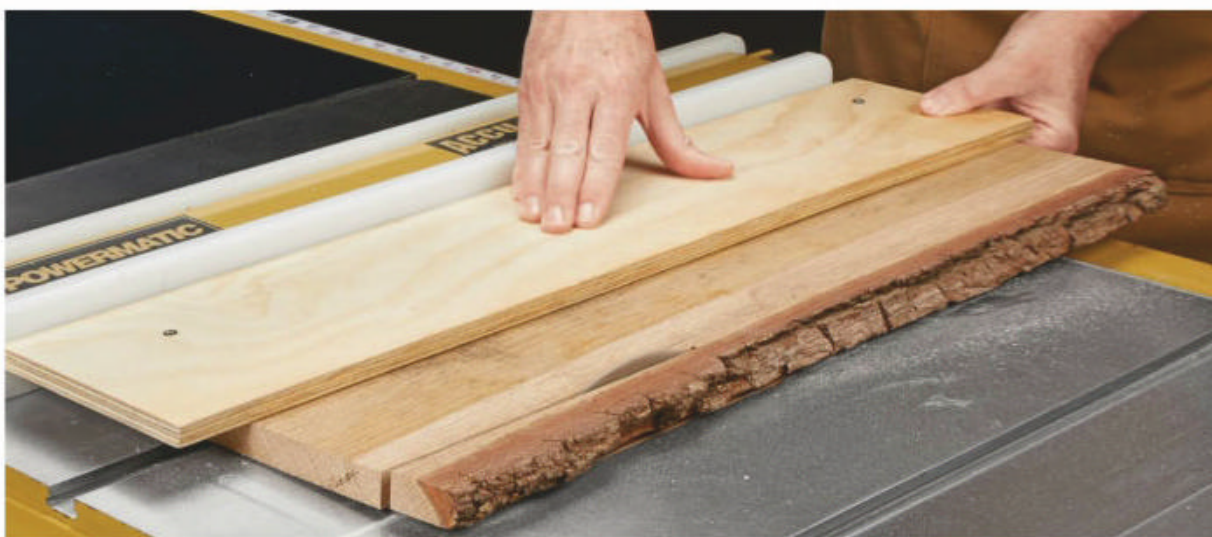
CONTROLLING CHAOS. Making controlled cuts on long boards at the table saw requires the use of the rip fence.

Continuous support of the board as it passes through the blade is critical for safety and proper dimensioning of rough lumber. But sometimes the condition of the board’s edge won’t allow for this. (And even a jointer can’t tackle these rough edges yet.)

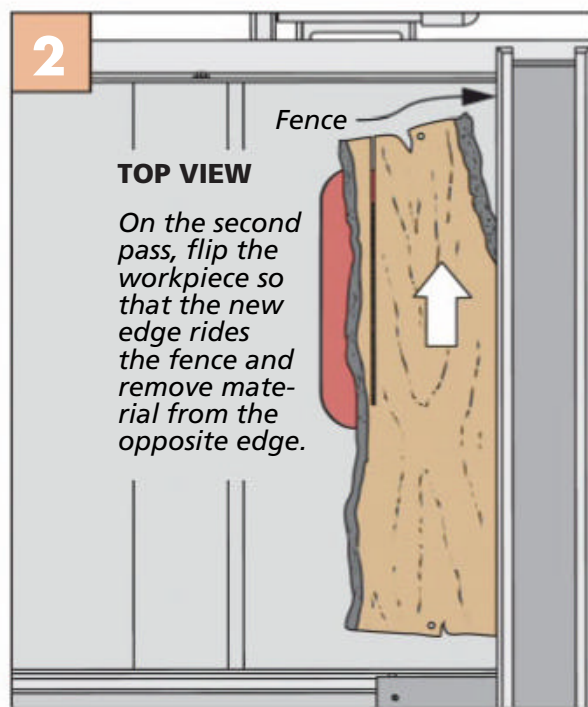
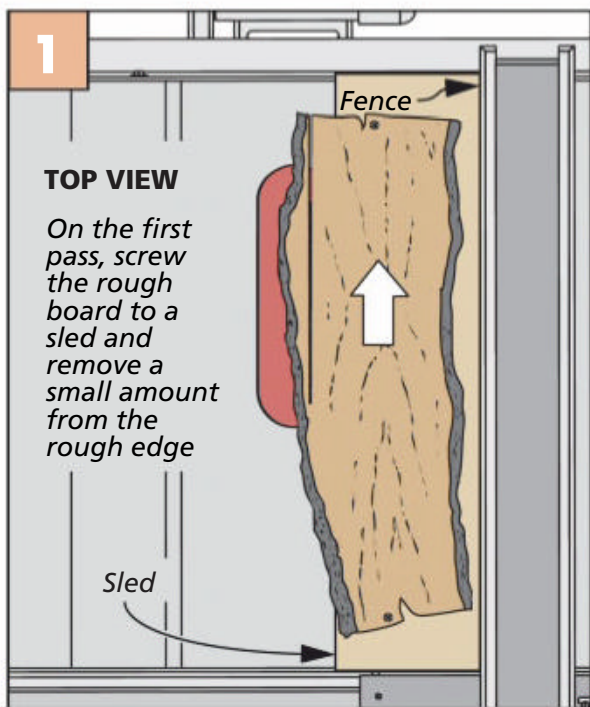
To get a straight edge as a starting point, you’ll have to give your rip fence some additional aid. Here are three options that will do that for you.

SLIDING FENCE. This is a quick way to tame a board with an unruly edge. As the main photo above shows, all that’s required is a straight board longer than the piece you need to rip. Holding the two together, with the straight board against the rip fence, you feed the board through the saw. Screwing a cleat to the end of the sliding fence gives you plenty of control as you make the cut.

ATTACHED CLEAT. The previous method is fine for certain situations, like when you have just one board that needs attention. But if you don’t feel



▲ Short boards with an unruly edge can be dealt with in the simple way you see here. All it takes is a scrap of plywood that has a straight edge. Just overlap the scrap on one edge and screw it to the board.



▲ A sharp, quality rip blade is important to achieve good results. This Freud 30-tooth glue line rip is a great choice.

comfortable with how that operation “floats,” there’s another way to get the same results almost as quickly.

The photo at the bottom of the previous page shows attaching a cleat to the top of the board with screws. It’s a stable, quick way to achieve good results on small boards that have untamed edges. Another option is to reverse the order of this and screw the board to the cleat, in effect creating a sled.

QUICK SLEDS. Figure 1 above shows this sled in action. The advantage here is that the boards rides on the sled, so there’s no risk of it shifting during the cut.

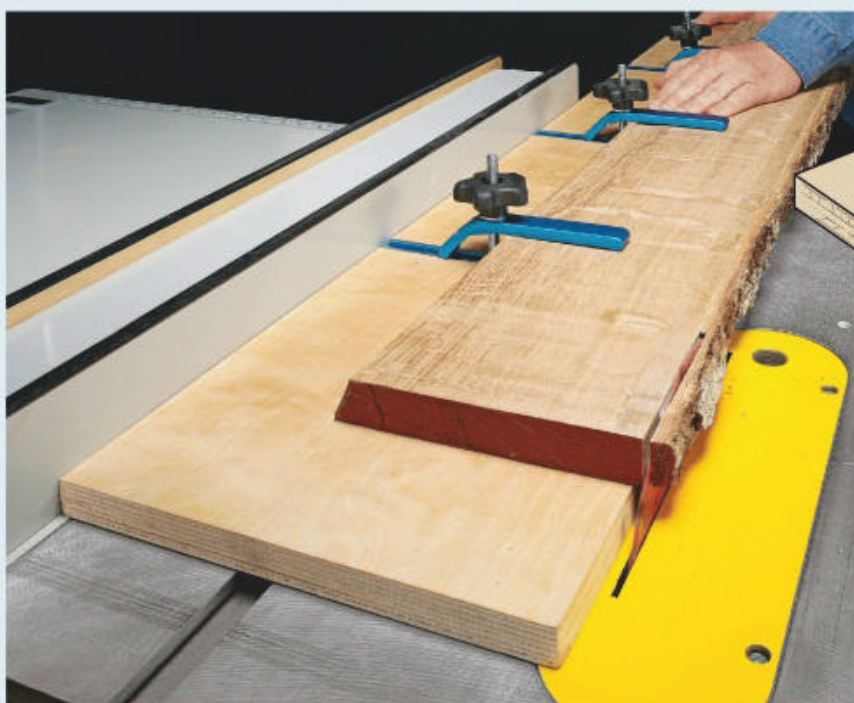
A GOOD STARTING POINT. The new straight edge you’ve created doesn’t have to run the whole length of the board. It only needs to be long enough so that when you remove the cleat, the freshly cut edge contacts the fence just before the cutting starts (Figure 2).

You don’t need to make wide rips here. Often, thinner is better. There might be stress in the board that’s released if you’re making big cuts. Also, the cut doesn’t have to be dead straight either. What you’re after is a starting point. You can always refine the cuts you’re making as you get a better edge to work with.

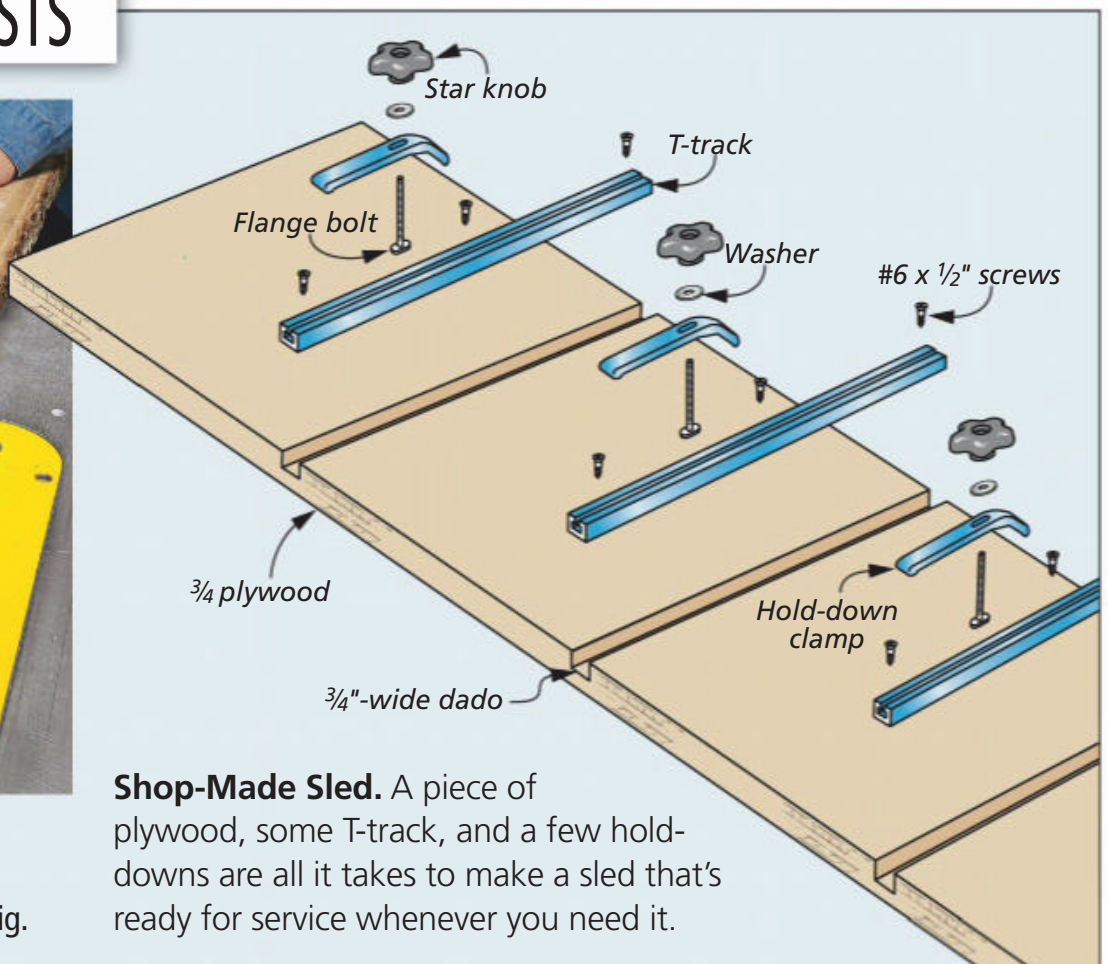
SLEDS. Making a sled that’s reusable (like you see in the box below) is worth considering for several reasons. It locks the board in place and can manage boards with some twist. Plus, there are no worries about screw holes. And finally, if you find yourself straightening a lot of material of varying widths, this will be handy to have around.

Whichever of these methods suits your fancy, rest assured they’ll all perform equally well. Next time you’re working a “live edge” or unruly board, you have plenty of options to get it into shape to take a starring role. **W**

How-To: MAKE A SLED THAT LASTS



▲ A sled like you see here can tackle all the situations we’ve looked at in this article — long, short, wide, and narrow. Even if the board has twist in it, it’s no problem with this jig.



Shop-Made Sled. A piece of plywood, some T-track, and a few hold-downs are all it takes to make a sled that’s ready for service whenever you need it.

Shop Notes

Spline Slot Jig

The outdoor furniture on page 34 has a back rest that's slightly reclined. To strengthen the miter joint on the back rest for the corner chair, a pair of splines are added. For safe and accurate slot cuts, you'll need to build the jig shown here.

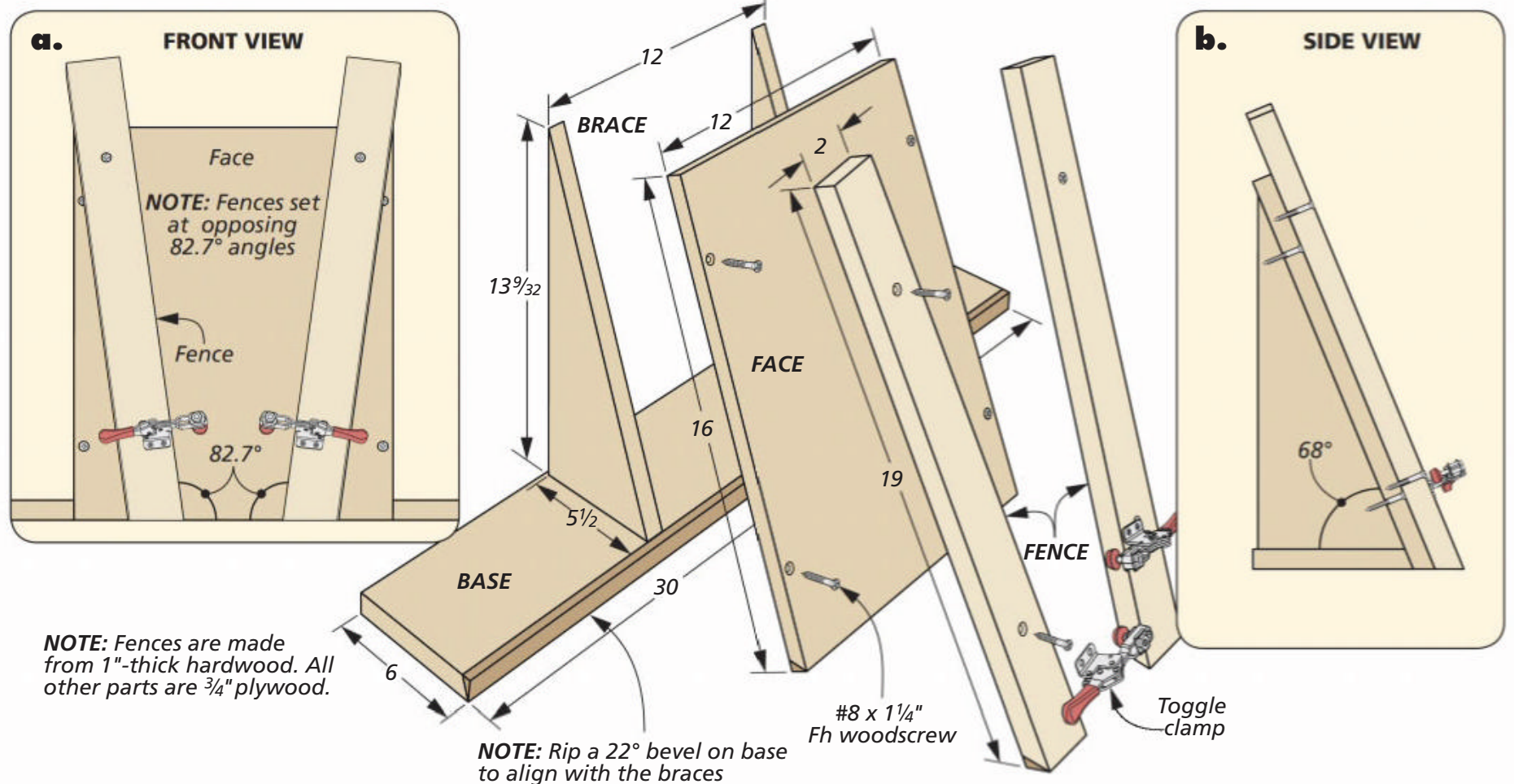
MITER JIG. The jig consists of a wide plywood base. On top of the base, a pair of tapered braces hold a plywood face. The braces hold the face at a 68° angle in relation to the saw table. Two fences are attached to the face of the jig, at opposing 82.7° angles. See detail 'a' below. A toggle clamp attached to each fence holds the workpiece in place. The entire jig is held together with glue and screws.



A PAIR OF KERFS. The premise behind the jig is that each fence is designed to cut the spline kerf on one side of the miter joint. And because there's a pair of splines, each half of the joint will get two cuts. (Cut one slot on all pieces first, then reset the fence.)

To start, clamp one back rail against the corresponding fence. Make sure the flat face is against the jig. Then, position

the fence and cut the kerf. Next, load up the other half of the miter joint against the opposite fence (inset photo). You can then cut that kerf. These two passes have then created one spline slot in one miter joint. Then, it's a simple matter of repeating this set up for all of the miters. Once one kerf is cut in each miter joint, you can then reposition the fence and repeat the process to cut the second slot.



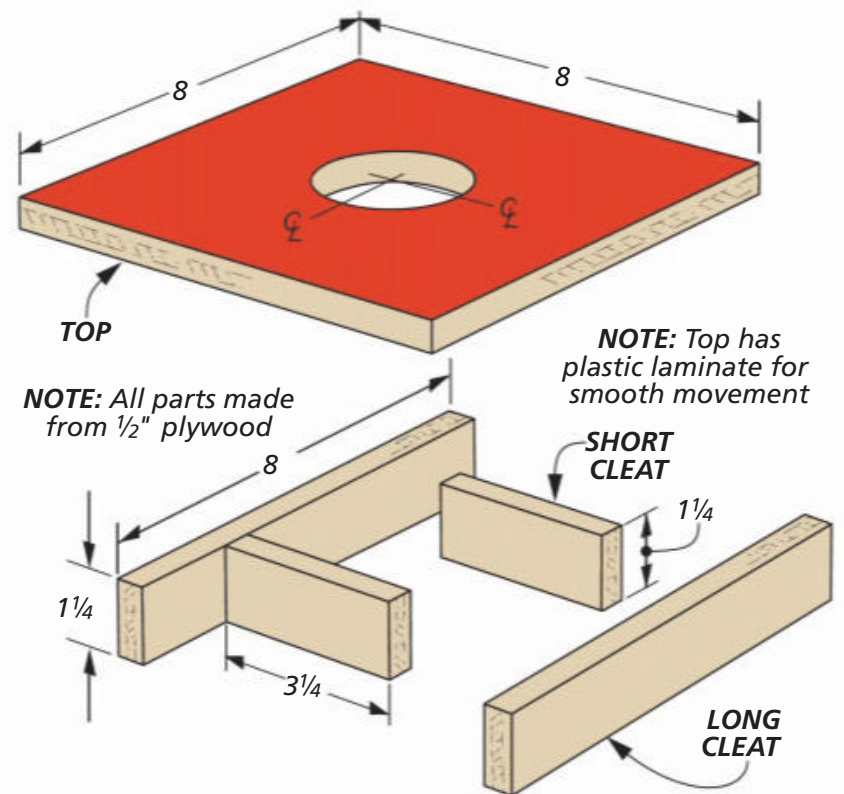
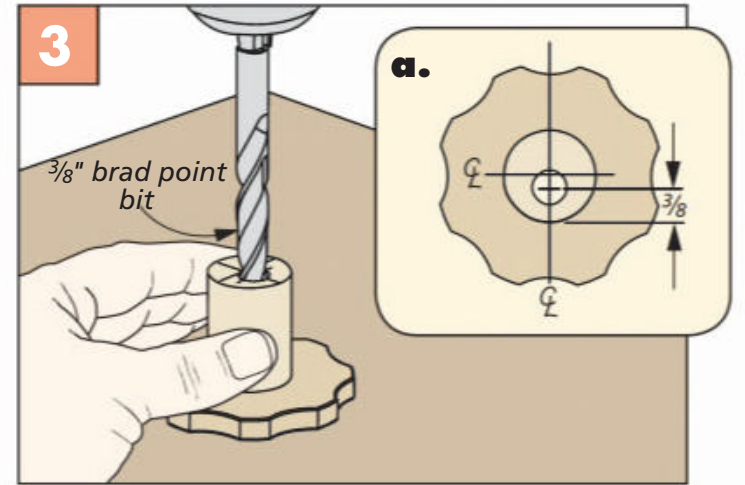
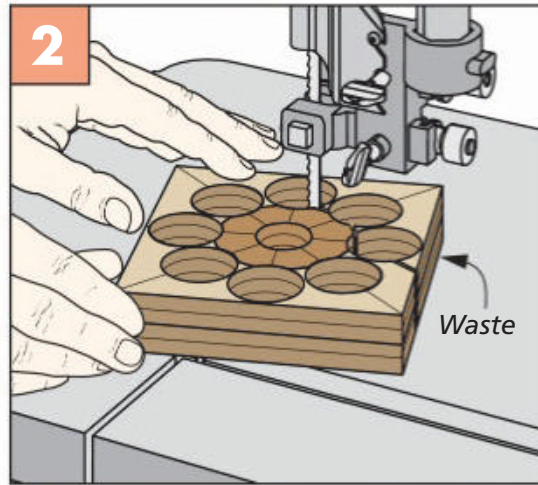
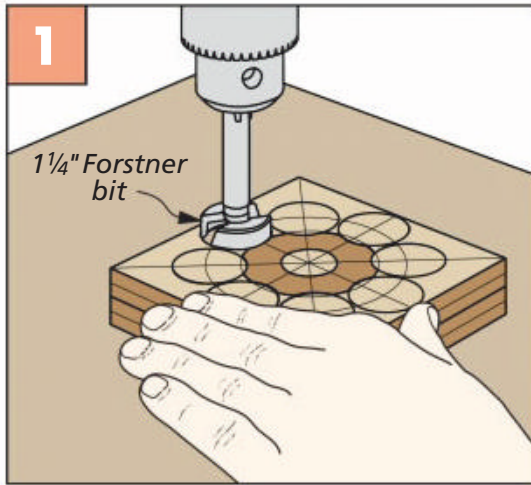
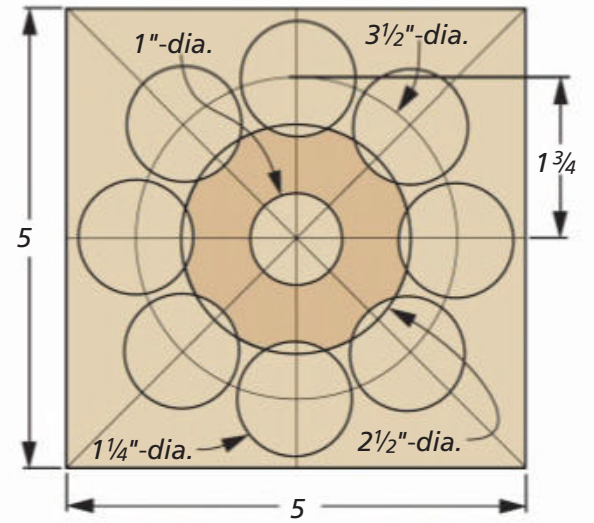
Lobed Cam Knobs

Creating the lobed knobs and cam for the CNC router on page 22 is straightforward. It just takes a little bit of time at the drill press and band saw.

LOBED KNOB. Making each knob requires you to start with an oversized blank, as shown at right. Here, I taped the four blanks together using double-sided tape. On the top blank, mark the center and grab a compass to lay out the lobes as shown. Then, at the drill press you

can drill the outer holes to create the lobes of the knob (Figure 1). A quick trip to the band saw cuts the knob from the waste, as seen in Figure 2.

CAM SHAFT. After separating the four knobs, you can glue in the section of dowel rod that will become the cam shaft. A thin bead of glue is plenty here. When the glue is dry, head over to the drill press and drill the offset hole, as seen in Figure 3.



Routing a Recess

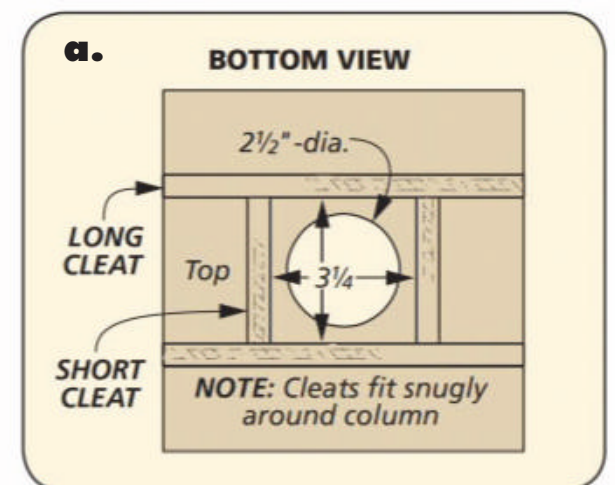
The plant stands that are built on page 18 have a recess routed in the top of each column. These round recesses are the basins that hold plants.

The top of the column is too small to support a router base. So I made the jig you see in the photo above.

THE PARTS. As you see in the main drawing this is not a complicated jig. All the parts are made from plywood. The plastic laminate on the top makes routing

the recess a smooth operation. The cleats are positioned to fit snugly over the end of the column. This way, you don't need any clamps to hold the jig in place.

OPERATION. To start, slide the jig onto the top of the column. When positioning the column in the vise, have the jig resting on the surface of your workbench. Doing this will prevent the jig from tipping while you rout the basin. Multiple passes puts less stress on the bit. **W**



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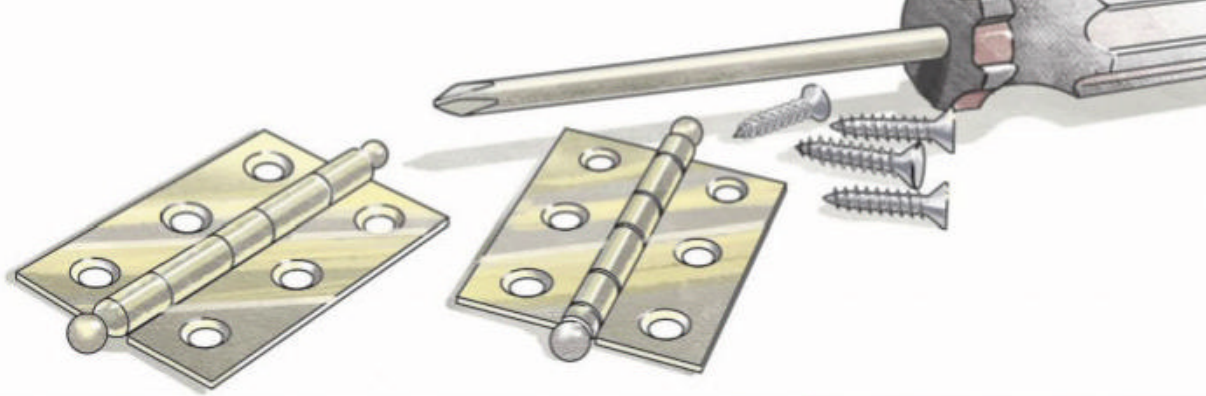
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hardware & supplies Sources



Most of the materials and supplies you'll need to build the projects are available at hardware stores or home centers. For specific products or hard-to-find items, take a look at the sources listed here. You'll find each part number listed by the company name. See the right margin for contact information.

BUILD FOR OUTDOORS (p.10)

The adhesives and finishes covered in this article are available from most hardware stores and online retailers.

5 COOL TOOLS (p.14)

- **Amazon**
Oneida Univ. Hd . B07481HTY6
- **Rockler**
Vacuum Pod Kit 53418
CRB7 Router Base 45924
HomeRight Shelter 50535
Bosch Palm Edge Router . 64864

DRILL PRESS MORTISES (p.16)

- **MSC**
5/16" End Mill 84509124
3/8" End Mill 91199687

CNC ROUTER (p.22)

Due to the amount of hardware needed for this project, you can find a complete list of materials at *Woodsmith.com*. The body of the CNC was painted with *Benjamin Moore* "New Hope Gray."

PATIO SEATING (p.34)

The patio seating was finished with a coat of *Penofin* "TMF Hardwood oil" in natural color. The cushions were custom ordered deep-seating ottoman cushions from *cushions.com*.

SUGAR CHEST (p.44)

- **Horton Brasses**
Cherry Knobs WK-7
Brass Butt Hinge PB-410
Brass Chest Lock CL-2

- **Rockler**
Chain Support 30663
- **Amana Tool**
Table Edge Bit 49550
The chest is stained with *Varathane* "Traditional" Cherry Gel Stain. Then, it's sprayed with a couple coats of clear lacquer.

HALF-MORTISE LOCK (p.56)

- **Amana Tool**
Dado Clean-Out Bit . . . 45460-S

MUST-HAVE CLAMPS (p.58)

The various styles of clamps covered in this article are available from most local hardware stores or home centers as well as online retailers.

TABLE SAW RIPPING (p.62)

- **Amazon**
Freud Rip Blade . . B00006XMTU
- **Rockler**
Hold Downs 35283
T-track 31532

MAIL ORDER SOURCES

Project supplies may be ordered from the following companies:

Amana Tool
800-445-0077
amanatool.com

amazon.com

cushions.com

General Finishes
800-783-6050
generalfinishes.com

Horton Brasses
800-754-9127
horton-brasses.com

MSC
800-645-7270
mscdirect.com

Rockler
800-279-4441
rockler.com

Woodsmith Sharpening Booklet

Recently, we came across a small supply of sharpening booklets in a corner of our warehouse. This 16-page booklet was first published over 25 years ago as a companion to our Woodsmith sharpening kit. It offers a step-by-step process for quickly establishing a razor-sharp edge on your chisels and plane irons. While we no longer offer the sharpening kit, most of the information contained in this booklet is still just as relevant today as it was when first published.

In order to clear out our remaining inventory of these booklets, we're offering them at a discounted price of \$5.95 (postpaid). We have a limited supply of these on hand and once the supply is exhausted, that's it.

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