Woodsmith

CUSTOM WOODWORKING

Bookcases, Shelves & Cabinets

Oxmoor House®

CUSTOM WOODWORKING

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By the editors of *Woodsmith* magazine

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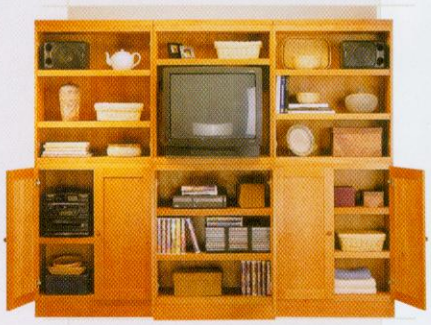


Modular Cabinets


DEIN USA
Eberhard Faber
Amberican
HB

SHELVES

A house can't have too many shelves, so the first project is a simple wall shelf that you can adapt for a variety of practical uses. Then there's a dovetailed shelf with a clean contemporary look. While you can cut the pins and tails with hand tools or a router, we include plans for a set of unique band saw dovetailing jigs.

Next you'll find a traditional country-style wall cupboard with a choice of designs for the back panel. You can make our stacking storage racks in two sizes that can be mixed and matched for use in the study, a school dorm, or where you need functional storage space. Add a sturdy top and you have a workstation. Finally, the knock-down shelf system can literally go anywhere by itself or in multiples.

Versatile Shelf

Here's a weekend project you can customize for a variety of uses — a clothes rack for the hall or kids' room, a mug holder for the kitchen, or a towel rack for the bathroom.

This versatile shelf is the type of project I like to work on. First of all, it can be completed quickly. You should be able to build it in a weekend or even a single evening.

The thing that makes this project really interesting, though, is how you can adapt it to fit your needs. The design is flexible enough so that by adding a dowel and leaving out the pegs it can be changed from a coat rack in a hallway (or kid's room) to a quilt rack for the guest room or towel rack in the bathroom (see photo at right and page 12). Or by simply changing the style and number of pegs, it can become a mug rack in the kitchen (see opposite page).

And there's still another thing I like about this project. Since the main pieces aren't glued together, it can easily be "broken down" should you ever move to a new home. Or, you can

build it for a friend or relative and send it in pieces to be put back together with just a screwdriver.

WALL HANGERS. One of the most common concerns when building a shelf is how it's going to hang on the wall. With this project I used some special metal keyhole hangers. (An alternative technique is to use a keyhole router bit as explained on page 11.)

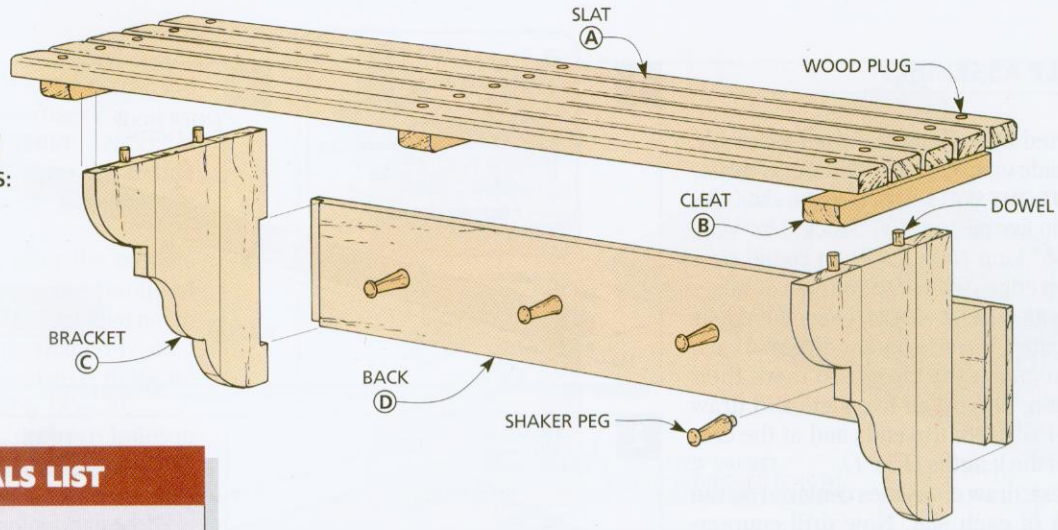
The shelf was designed so that the keyhole hangers will fall over wall studs that are located 16" on center. Then it's just a matter of screwing roundhead screws into the wall studs and dropping the shelf onto the screws.

WOOD. "Shaker-style" pegs and dowels are generally available in birch, oak, walnut, and cherry (see mail order sources on page 126). So if you want the shelf to match the pegs or dowel, purchase your pegs or dowel first, and then build your shelf from the same type of wood. The shelf in the photo above is made from red oak. The one at the left is made from birch.

FINISH. To get finish in-between the slats, it's easiest to use an oil finish.

EXPLODED VIEW

OVERALL DIMENSIONS:
38W x 9¾D x 10¾H



MATERIALS LIST

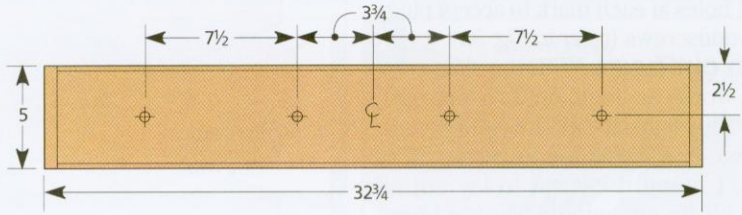
WOOD

A	Slats (5)	¾ x 1¾ - 38
B	Cleats (3)	¾ x 1½ - 9¼
C	Brackets (2)*	¾ x 8⅞ - 10
D	Back (1)	¾ x 5 - 32¾

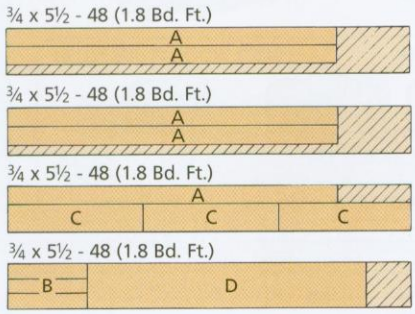
* Cut both brackets from one edge-glued blank, see Fig. 4 on page 10.

HARDWARE SUPPLIES

(15) ½"-dia. wood plugs
(15) No. 8 x 1" Fh woodscrews
(4) No. 8 x 1¼" Fh woodscrews
(1) ⅜"-dia. x 4"-long dowel rod
(4) ⅞"-dia. x 3⅜"-long Shaker pegs
(2) 9/16" x 1 11/16" keyhole hangers w/screws



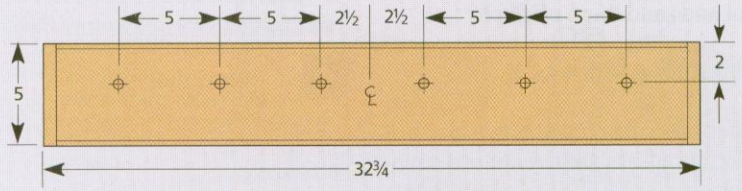
CUTTING DIAGRAM



DESIGNER'S NOTEBOOK

The only major change necessary to turn the coat rack into a mug rack is to use mug pegs instead of Shaker pegs. Mug pegs have slightly smaller heads so it's easier to fit the mugs on them (see photo at lower left). The mugs rest on a little concave area of the peg.

You can comfortably fit six mug pegs on the back piece (D) of the mug rack (see drawing below). (There are only four Shaker pegs on the coat rack.) Locate the mug peg holes 2" from the top edge. Then drill holes to size that will accept the tenons on the pegs.



SHELF ASSEMBLY

I started by making the shelf assembly. It's made up of five slats and three cleats.

CUT OUT SLATS. To make the slats (A), first rip five pieces of 3/4" stock, 1 3/4" wide and 38" long *(Fig. 1)*. Then round over the top edges with a 1/4" roundover bit.

MARK & DRILL HOLES. Once the edges are routed, three holes are drilled in each slat to attach the cleats. To mark their location, line up all five slats and draw lines 1 3/4" from the ends and at the centers of the lengths *(Fig. 1)*.

Next, draw crosslines centered on the *width* of each slat. Now drill counterbored holes at each mark to accept plugs and woodscrews (refer to *Fig. 3a*).

CUT OUT CLEATS. With the slats complete, work can begin on the cleats (B). Since the cleats are all the same length and one end is rounded over on all of them, I found it easiest to lay out all three cleats on a single 5"-wide board *(Fig. 2)*. Then round over the bottom edge of one end with a 1/4" roundover bit.

MARK PILOT HOLES. Before cutting the cleats apart, mark the location of the pilot hole lines for the screws *(Fig. 2)*. Now, the three cleats can be ripped to their final width of 1 1/2". Then drill 3/32" pilot holes centered on the width of each cleat.

ASSEMBLE SLATS & CLEATS. With the holes drilled, assembly can begin. Start by screwing and gluing the two outside cleats to the first and last slats *(Fig. 3)*. Overhang the front slat 1/2" *(Fig. 3a)*. Make sure this assembly is square. Then screw and glue on the rest of the slats.

Now glue plugs into the counterbores and cut and sand them off flush.

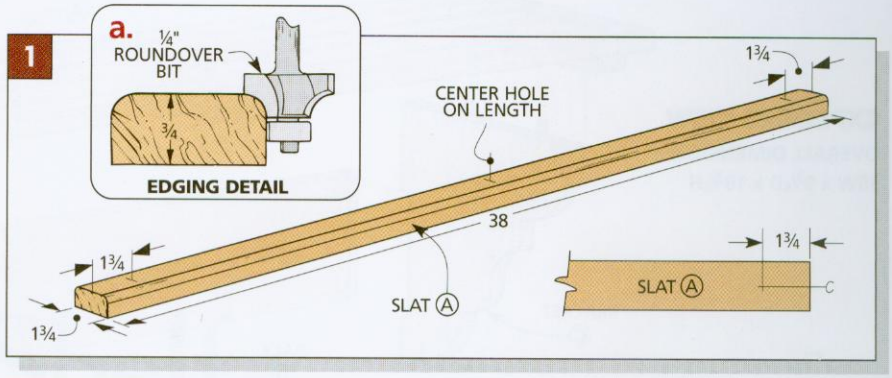
BRACKETS AND BACK

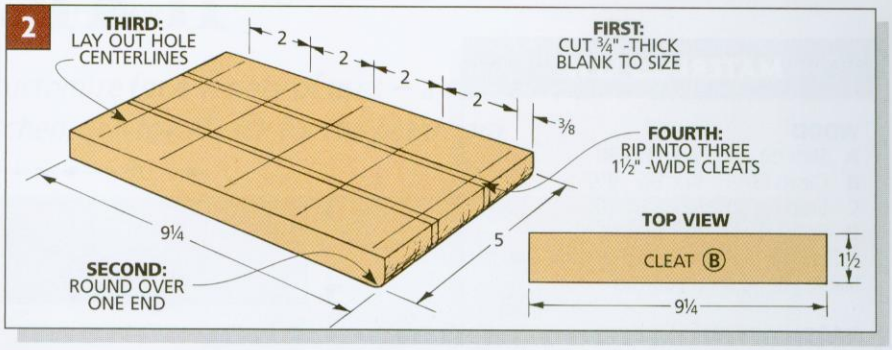
The shelf assembly rests on two brackets (C). Both brackets are cut out of a single edge-glued blank *(Fig. 4)*. For information about edge-gluing, see pages 92–93.

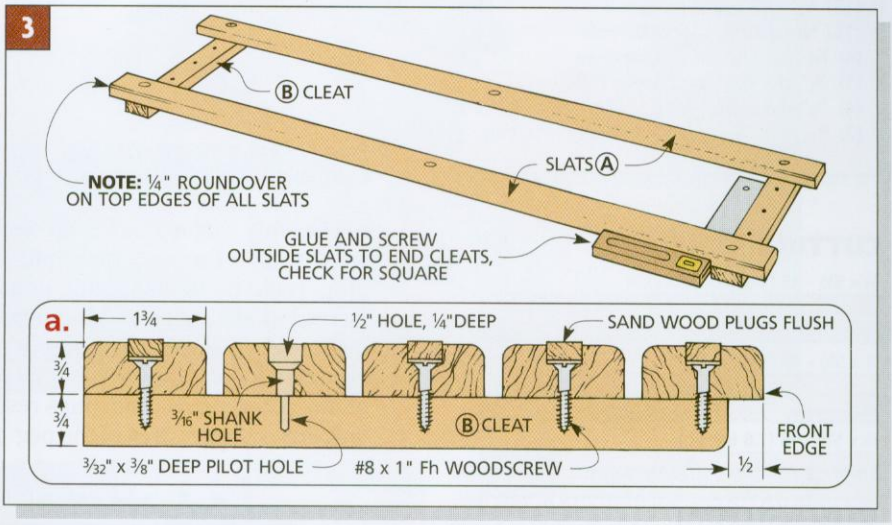
I made a cardboard template (see the Pattern in *Fig. 4*) and used the template to trace the brackets on the blank. Then I cut, filed, and sanded them smooth.

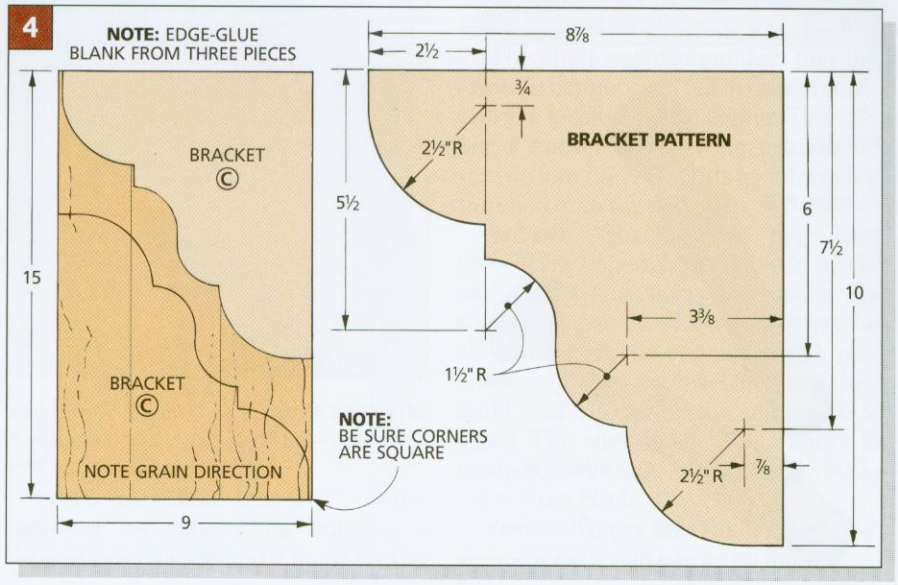
MORTISE FOR KEYHOLE HANGER. The shelves are held on the wall with two nifty little metal keyhole hangers (or you can use a special keyhole router bit as shown in the Shop Tip on the opposite page.)

To hold a hanger in each bracket, a 3/16"-deep, 9/16"-wide mortise is routed on the back edge *(Fig. 5a)*. Then, a section of the slot is drilled out to accept a screw









head. Finally, drill holes and screw the metal hanger into the mortise *(Fig. 5b)*.

ROUT STOPPED RABBET. Next, a stopped rabbet is routed on the *inside* back edge of each bracket to accept the back (D) *(Fig. 5)*.

MOUNT BRACKETS. After the rabbets are routed, the brackets are mounted under the shelf assembly. I decided not to fasten the brackets permanently so I used two short pins (dowels) to locate and stabilize the assembly *(Fig. 6)*.

To mount the pins, drill two holes in the bottom of the second and fourth slats. I used 3/8" dowel centers to mark the locations of the matching holes on the tops of the brackets. Then drill these holes.

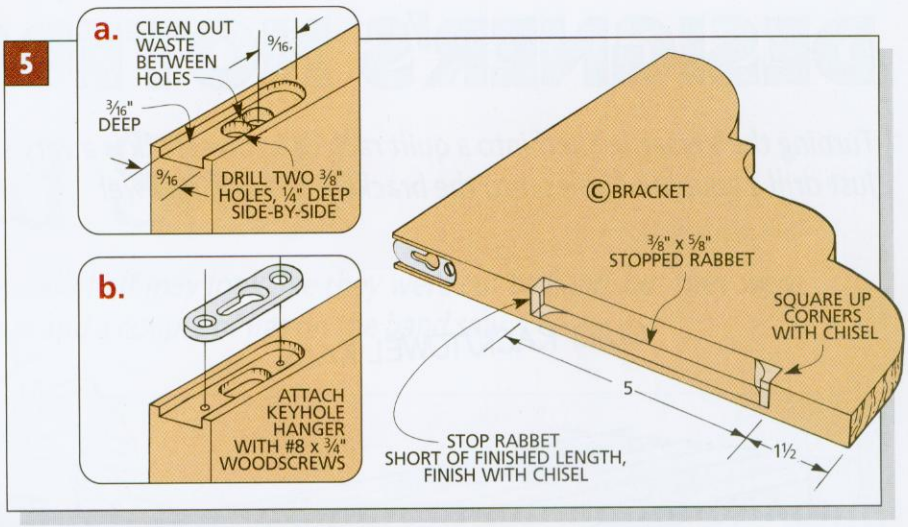
Finally, glue two short dowels into the top of each bracket to act as locating pins. After they're glued in place, round over the end of each dowel with sandpaper.

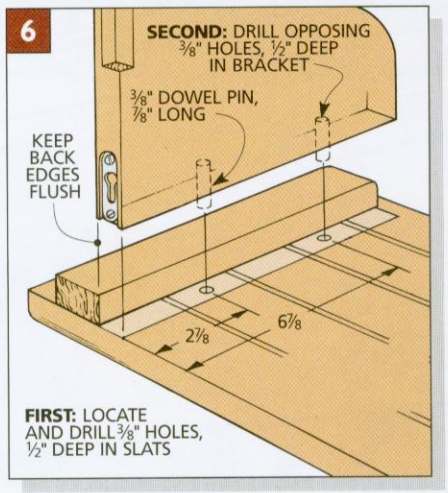
CUT OUT BACK. The final piece to cut is the back (D). It's ripped 5" wide and to length to fit between the stopped rabbets.

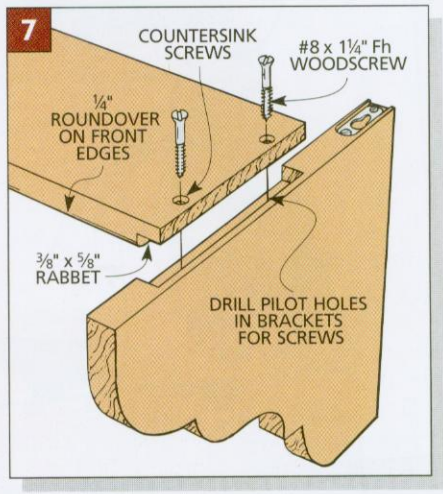
Next, rabbet the ends to produce tongues that fit in the stopped rabbets *(Fig. 7)*. Then round over the front edges with a 1/4" roundover bit.

MOUNT PEGS. Now locate and drill 1/2" peg holes as shown on page 9. And then glue in the Shaker pegs (or mug pegs).

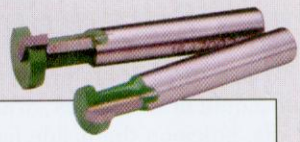
ATTACH BACK. Finally, the back is screwed to the brackets *(Fig. 7)*. ■







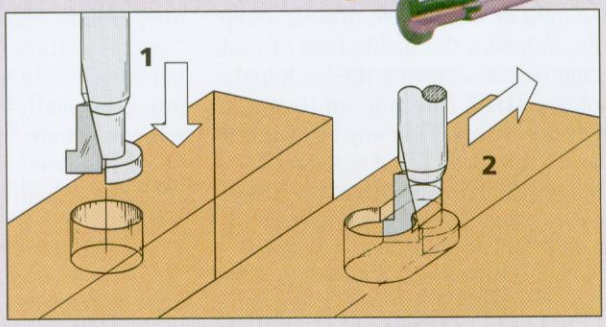
SHOP TIP ..... Using a Keyhole Bit

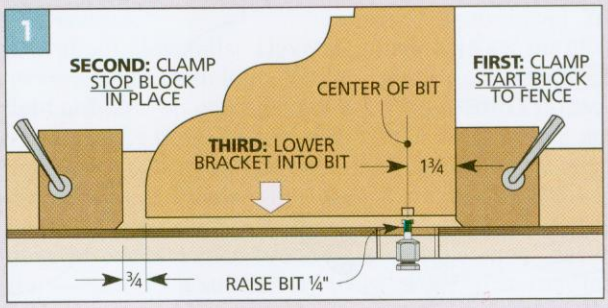


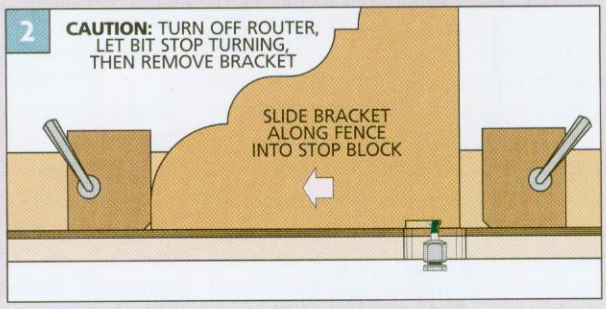
One alternative to using metal keyhole hangers is to cut a keyhole shape in the wood itself. To do this I use a keyhole router bit on the router table.

The bit first drills a large hole (see drawing at right). Then, as the workpiece is moved, it cleans out a slot. But what's really happening you can't see. The head of the bit is cleaning out a wide area *under* the surface.

To use the bit, clamp two stop blocks to the router table fence. The first stop block determines the location of the large hole *(Fig. 1)*. The second stop block determines the length of the slot *(Fig. 2)*.

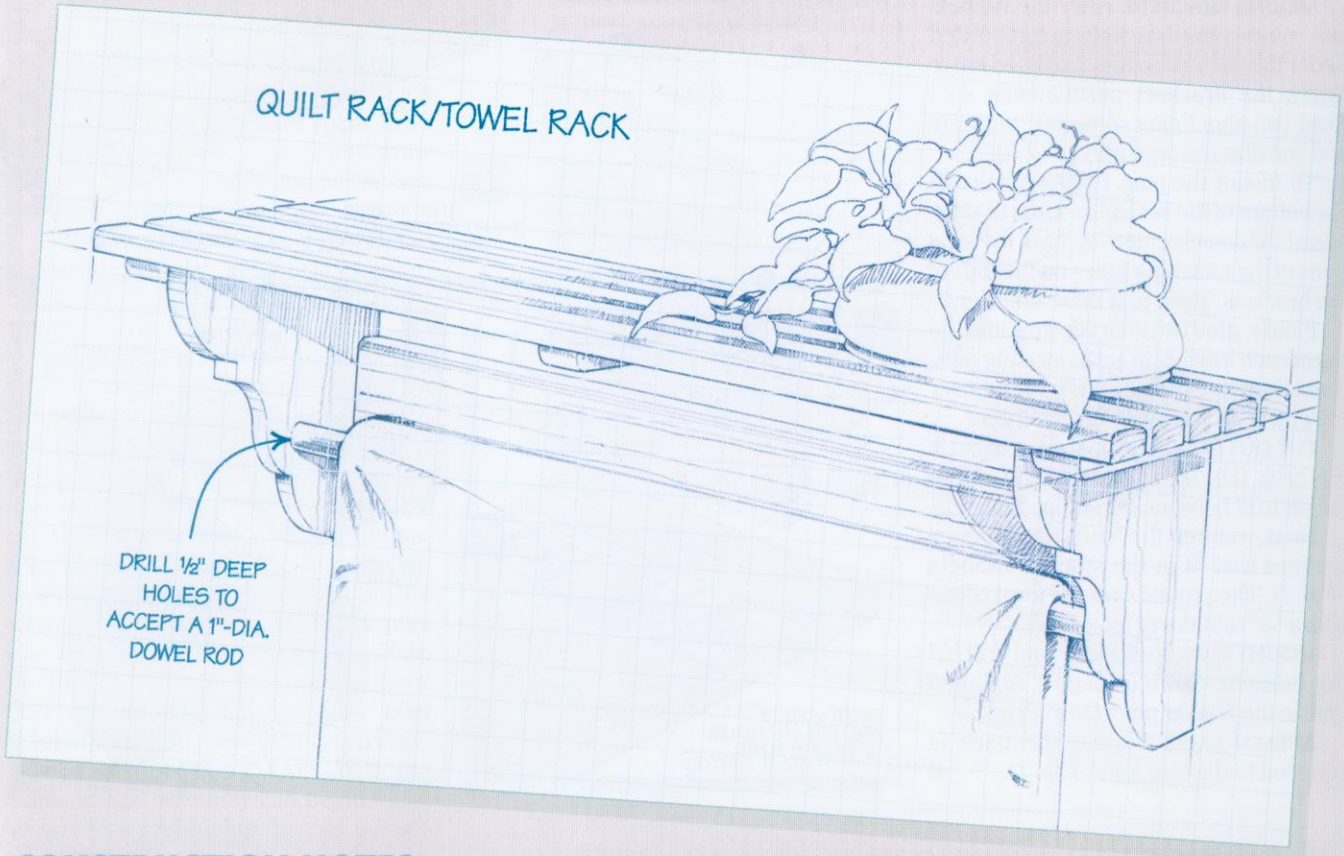






DESIGNER'S NOTEBOOK

Turning the Versatile Shelf into a quilt rack or a towel rack is a very simple procedure. Just drill a couple of holes into the brackets and add a dowel.



CONSTRUCTION NOTES:

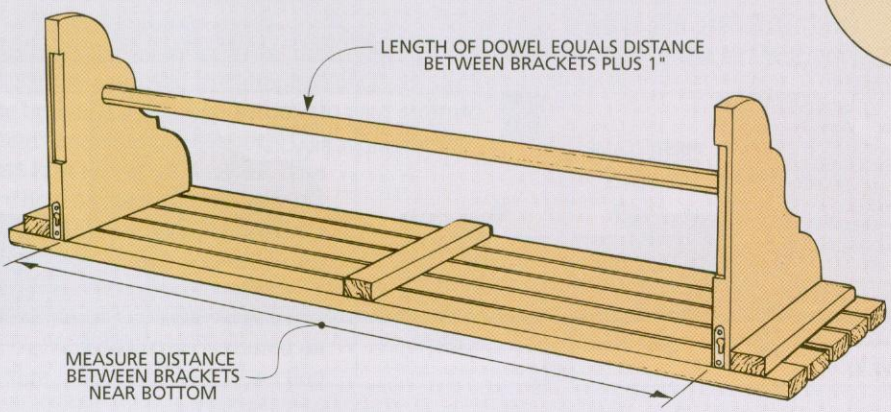
■ To add a dowel and turn the coat rack into a quilt or towel rack, drill ½"-deep, 1"-dia. holes on the inside face of each bracket *before* screwing the back to the brackets. (Drill the hole on the same face as the rabbet. This way you will end up with a mirrored set of brackets.)

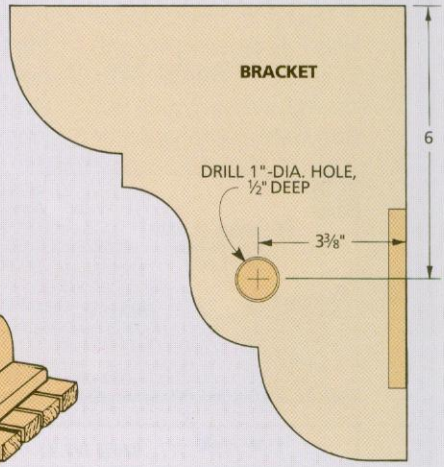
■ To determine the length of the dowel, measure the distance between the brackets and add 1" (for the two ½"-deep holes). Since the brackets might "toe-in" slightly, measure the distance between the brackets right where the brackets join the shelf slats.

■ If you decide to use it as a towel rack, be sure to finish the dowel with a water-resistant finish such as an exterior polyurethane or marine varnish.

CHANGES TO MATERIALS

QUILT OR TOWEL RACK:
(1) 1"-dia. dowel, 32½" long





Dovetailed Shelf

The dovetails accenting this simple wall shelf may look like they were cut by hand, but they were actually cut using a special technique and a couple of jigs on the band saw.

This wall shelf is a great way to try out the technique of cutting dovetails on a band saw. (For a full explanation of this technique, see pages 18 to 23.) The four sides of the shelf, as well as the drawers, are all joined with through dovetails.

A word about dovetails. Dovetail joinery is an age-old technique. Yet, it seems right at home on contemporary furniture, especially those pieces with very simple lines that allow the dovetails to be accented. That's why this shelf is an ideal candidate for dovetails. The joinery provides a nice touch of decoration — and it's a subtle way to show off your craftsmanship.

THE DRAWERS. I also used through dovetails to make the three drawers that fit in this shelf. However, with the drawers closed, what you see on the front of the drawer doesn't look like a dovetail — it looks more like a box joint (see photo above). You have to open the drawer to see the characteristic dovetail shape on the drawer's sides.

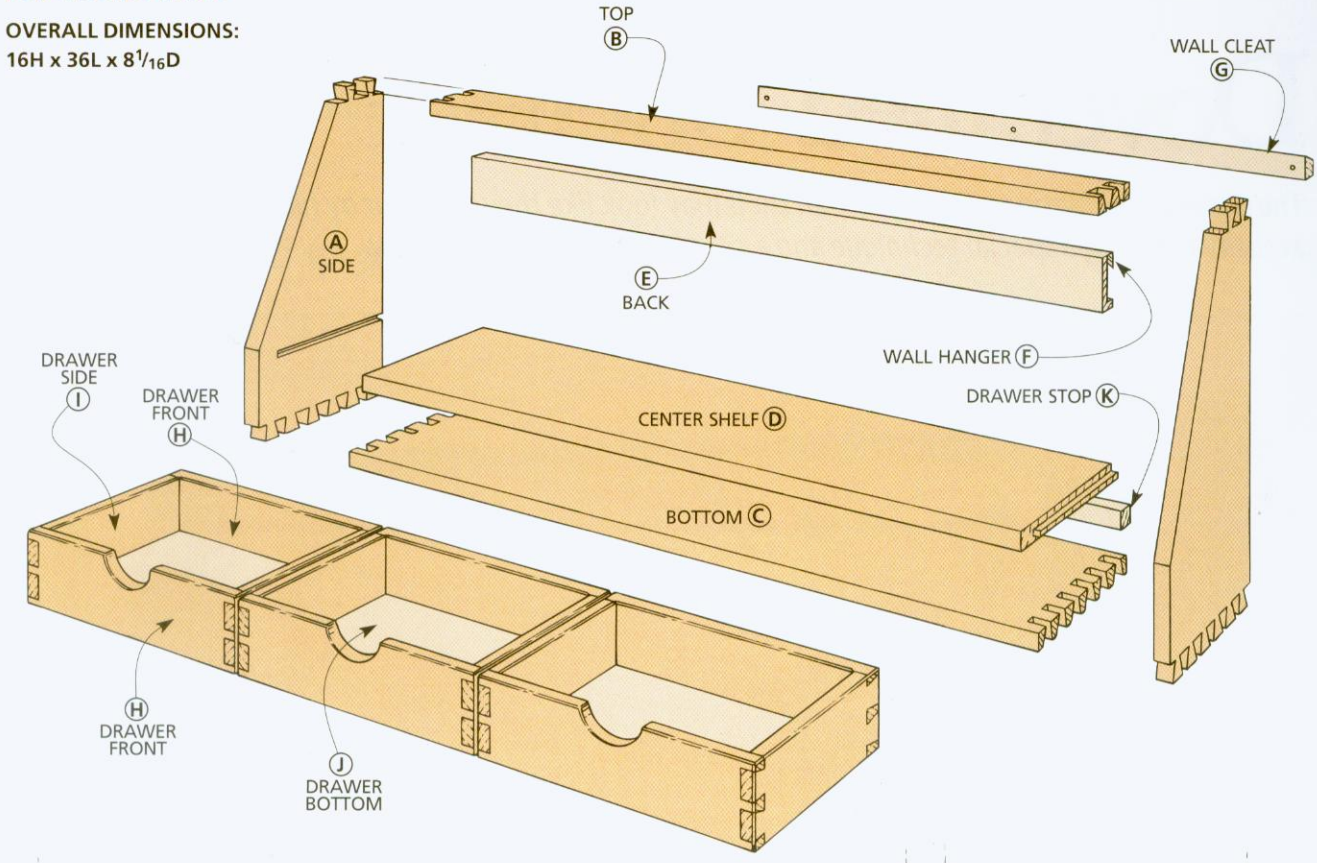
HANGING SYSTEM. Besides dovetails, this shelf offers another interesting challenge — hanging it on the wall once it's done. Of course, if you use screws or any type of anchor devices, you'll want to drive them securely into the wall studs. Not an easy task. Even if you can locate the studs, there's only a slim chance they'll be in the right location for hanging the shelf.

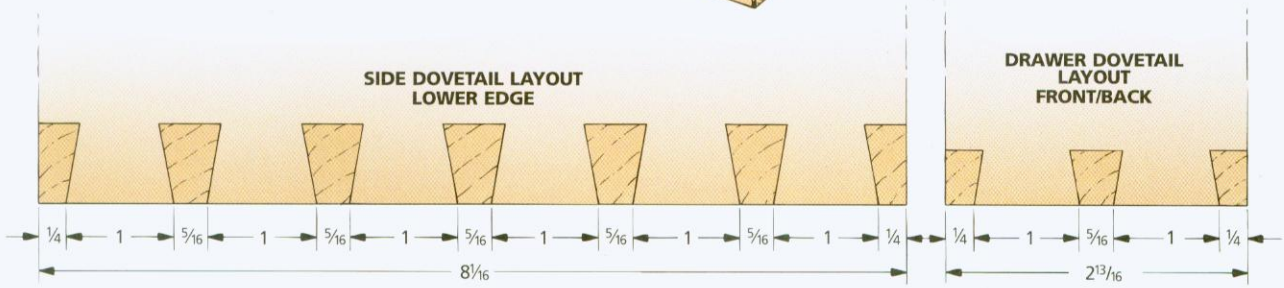
Instead, I mounted the shelf by hanging it on a long cleat that is in turn mounted to the wall. The nice part is that the screws can be located anywhere along the length of the cleat. Then the whole system is hidden from view so you don't see any screw heads or even the cleat. (For more on the hanging system, see page 17.)

WOOD AND FINISH. The shelf shown in the photo above was made from red oak and finished with two coats of an eggshell (matte) varnish. The combination of oak and a matte finish enhances its contemporary look.

EXPLODED VIEW

OVERALL DIMENSIONS:
16H x 36L x 8 1/16D





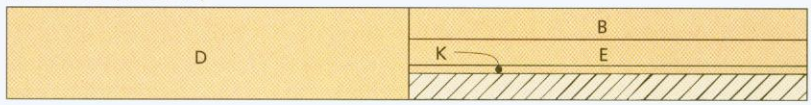
MATERIALS LIST

SHELF		
A	Sides (2)	3/4 x 8 1/16 - 16
B	Top (1)	3/4 x 2 13/16 - 36
C	Bottom (1)	3/4 x 8 1/16 - 36
D	Center Shelf (1)	3/4 x 8 1/16 - 35
E	Back (1)	3/4 x 2 1/4 - 34 1/2
HANGER		
F	Wall Hanger (1)	1/2 x 3/4 - 34 1/2
G	Wall Cleat (1)	1/2 x 1 1/8 - 34 1/2
DRAWERS		
H	Fronts/Backs (6)	1/2 x 2 13/16 - 11 7/16
I	Sides (6)	1/2 x 2 13/16 - 7 3/8
J	Bottoms (3)	1/4 ply x 7 1/8 - 11 3/16
K	Drawer Stop (1)	3/4 x 9/16 - 34 1/2

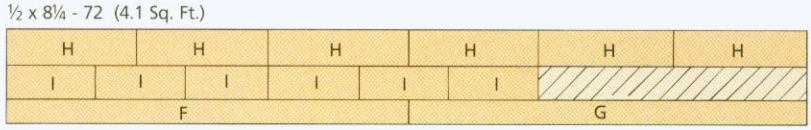
CUTTING DIAGRAM

3/4 x 8 1/4 - 72 (4.1 Bd. Ft.)

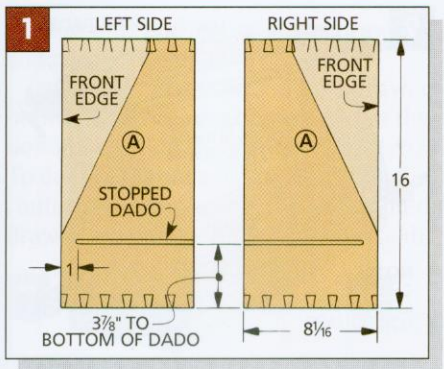
3/4 x 8 1/4 - 72 (4.1 Bd. Ft.)

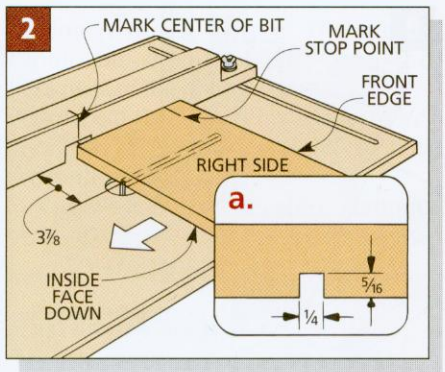


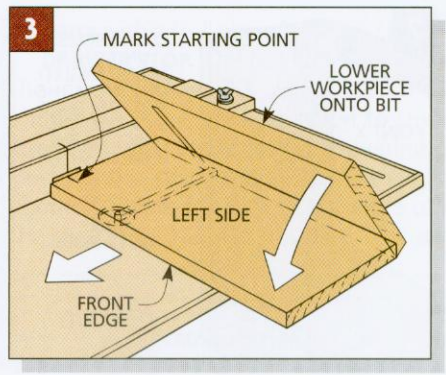
1/2 x 8 1/4 - 72 (4.1 Sq. Ft.)



Note: Drawers require 12" x 24" piece of 1/4" plywood.







SIDES

I started building the wall shelf by making the two sides (A). Cut these pieces 8¹⁄₁₆" wide (to accommodate the dovetail layout) and to a length of 16" *(Fig. 1)*. (The angled front edge of these side pieces will be cut off later.) If you don't have flat, wide boards, build up the width by edge gluing some narrower pieces.

STOPPED DADO. Before cutting the dovetail joints, I routed a stopped dado for the center shelf. This dado is stopped about 1" from the front edge of both side pieces so it doesn't show.

There are a couple of ways to cut these stopped dadoes. You could rout them with a hand-held router as discussed on page 32. This time I decided to use the router table.

To do this, mount a ¼" straight bit in the router table and set it to cut 5⁄16" deep. Position the fence 3⅞" from the bit *(Fig. 2)*.

Since this is a blind cut (the bit is under the workpiece and you can't see where it is), I put a reference mark on the router table fence at the center of the bit *(Fig. 2)*. Then I put another mark on the workpiece 1" from the front edge to indicate the stopping point for the dado *(Fig. 2)*.

To rout the dado in the side piece for the right side of the shelf, lay the piece down on the router table and push it through the straight bit, stopping when the two reference marks are aligned *(Fig. 2)*.

However, for the piece on the left side, you have to make a plunge cut. Turn on the router and slowly lower the workpiece onto the turning bit. You have to lower it so the reference marks align when the piece is flat on the table. Then push the workpiece across the router table moving from right to left *(Fig. 3)*.

Note: Although you can accomplish the same thing by routing from left to right, I don't often do it. The rotation of the bit can pull the workpiece away from the fence.

TOP, BOTTOM & SHELF

After the dadoes are routed in the side pieces, you can cut the top and bottom pieces to finished size.

CUT TO SIZE. Start by ripping the top (B) to a width of 2¹³⁄₁₆" *(Fig. 4)*. Then rip the bottom (C) to match the width of the side pieces (8¹⁄₁₆"). As for length, cut both pieces to a uniform length of 36".

DOVETAILS. With the pieces cut to size, you can lay out the dovetail joints. I followed the layout on page 14 laying out the tails on the side pieces and the pins on the top and bottom pieces.

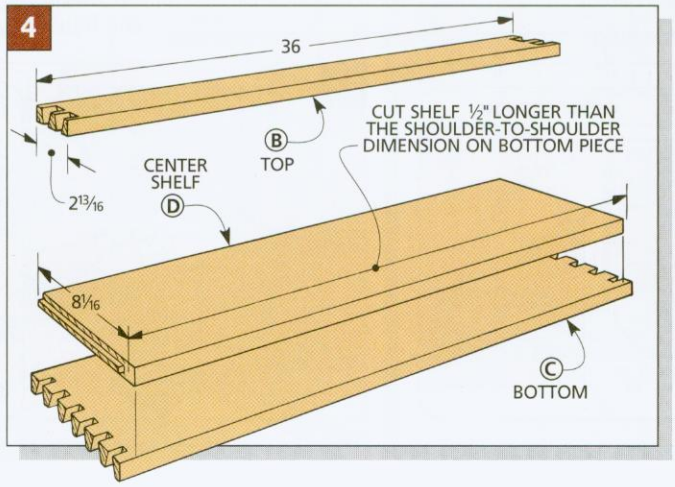
To cut the dovetails, I used the band saw technique shown on pages 18 to 23. There's only one small problem. The angle hasn't been cut off the front edge of the side pieces yet (refer to *Fig. 1*). But I found it easiest to lay out and cut the tails all the way across the side pieces to prevent confusion. (You don't have to chop them all out. Just chop out the three waste areas on the side pieces that match the pins on the top piece.)

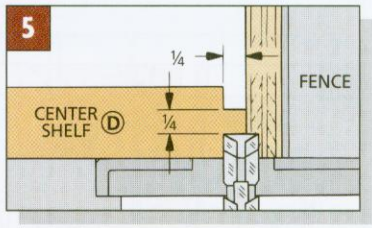
CENTER SHELF. After the dovetail joints are cut, you can begin work on the center shelf (D). Start by cutting the shelf the same width (8¹⁄₁₆") as the sides and bottom *(Fig. 4)*.

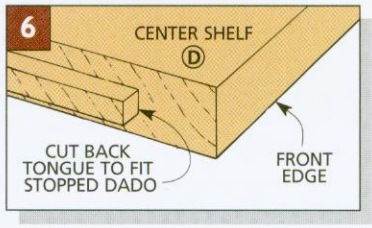
To determine the length of the center shelf, dry assemble the top, bottom and sides. Then measure the inside distance between the sides. (In my case, this was 34½".) Then add ½" for ¼"-long tongues (to fit the 5⁄16"-deep dadoes) on each end of the center shelf and cut the shelf to length (35").

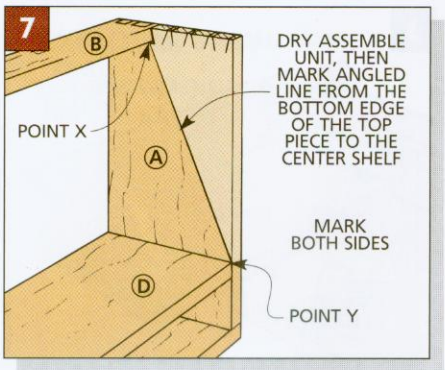
CUT TONGUES. To make the tongues at the ends of the center shelf, I cut rabbets on the top and bottom faces of the shelf with a dado blade *(Fig. 5)*. Sneak up on the height of the blade until the tongue fits snugly into the dado in the side piece.

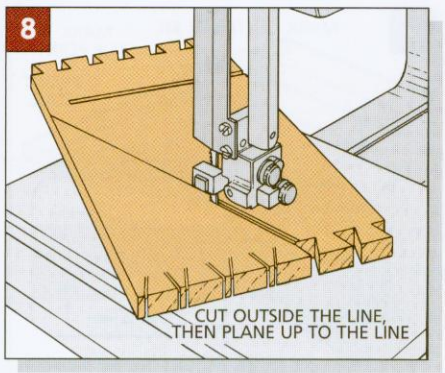
TRIM TONGUES. Since the dadoes on the side pieces are stopped, you have to trim the tongues back *(Fig. 6)*. To do this, score the front edge with a chisel, and then pare back the tongue just as you did when cutting the dovetails (refer to *Step 8* on page 21).

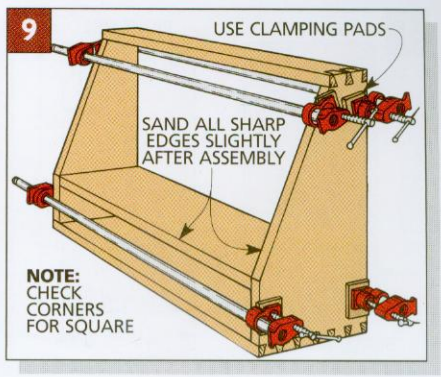












ASSEMBLY

At this point all the joinery is complete. All that remains is to mark and cut the angles off the front of the side pieces.

MARK ENDS. To mark the angles, first dry assemble all of the pieces. Then mark a point "X" where the bottom edge of the top piece (B) meets the side pieces (A) *(Fig. 7)*. Next, mark a point "Y" where the top edge of the center shelf (D) meets the side pieces. Now, disassemble the pieces and draw a line between the marks.

CUT OFF ANGLE. Once the angles are marked, cut just shy of the line with the band saw *(Fig. 8)*. Then plane to the line with a hand plane.

Now the whole unit can be glued and clamped up *(Fig. 9)*. (Don't overtighten or the top piece might bow.)

CLEAN UP JOINTS. After the glue dries, check the joints. If the pins and tails stick above the surface of the boards, plane or sand them off flush. If they're slightly recessed, shave the boards down to the pins and tails.

DRAWERS

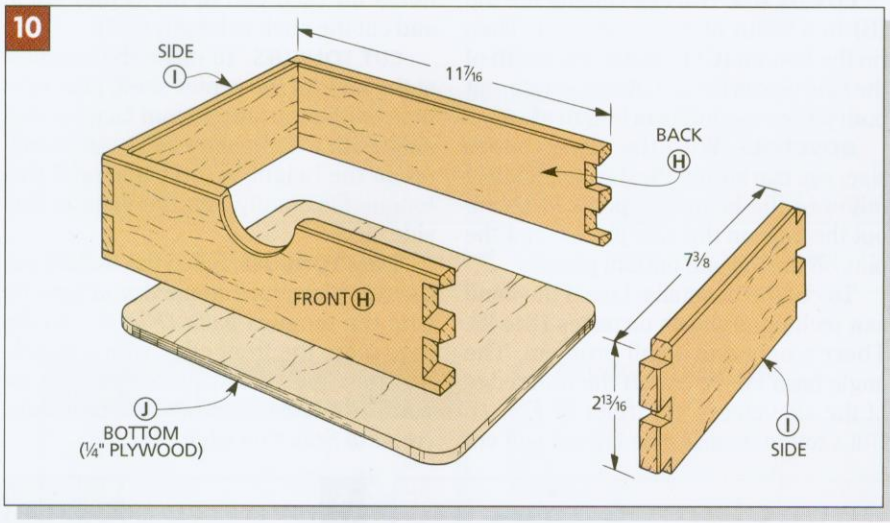
After building the basic shelf, I built three drawers that would fit the opening between the center shelf and the bottom. The three drawers are simply open boxes with through dovetail corner joints.

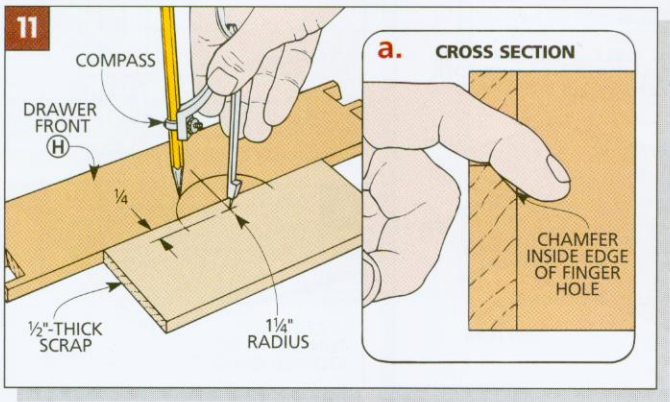
CUT THE PIECES. Start building the drawers by cutting the $\frac{1}{2}$"-thick drawer fronts/backs (H) and drawer sides (I) to a width $\frac{1}{16}$" less than the height of the opening. In my case, I cut these pieces $2\frac{13}{16}$" wide *(Fig. 10)*.

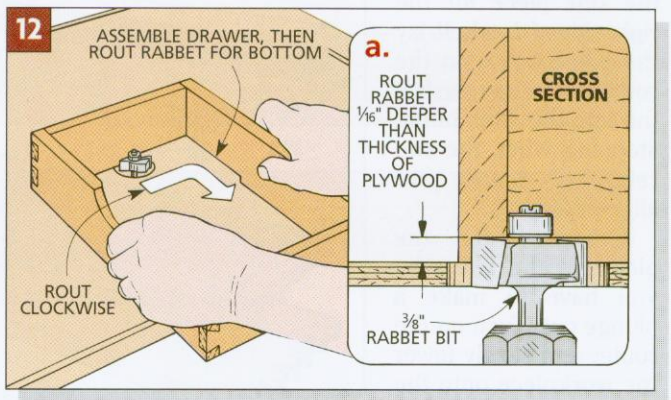
As for length, cut the sides (I) $7\frac{3}{8}$" long. To determine the length of the fronts/backs (H), measure the inside opening on the shelf ($34\frac{1}{2}$") and subtract $\frac{3}{16}$" (to allow space between the drawers). Then, to determine the length of one front/back piece, divide by three ($11\frac{7}{16}$").

DOVETAILS. After cutting the drawer pieces to size, I cut the dovetails following the Drawer Layout shown on page 14. To use the band saw method described on pages 18 to 23, you only need one $1\frac{5}{16}$"-wide spacer block. (Note: The $\frac{1}{2}$" thickness of the drawer parts doesn't effect the basic procedure for cutting the dovetails, just the location of the base lines.)

FINGER HOLE. After cutting the dovetail joints, lay out and cut a finger hole centered on the length of each drawer front *(Fig. 11)*. Then, to make it smooth for fingers, file down the inside edge of the hole *(Fig. 11a)*.







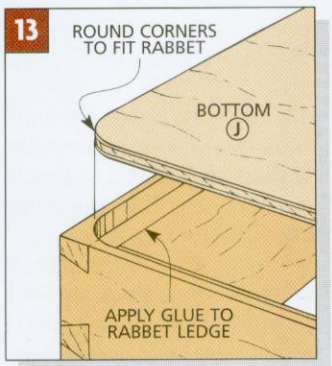
Now glue and assemble the drawers, and check for square.

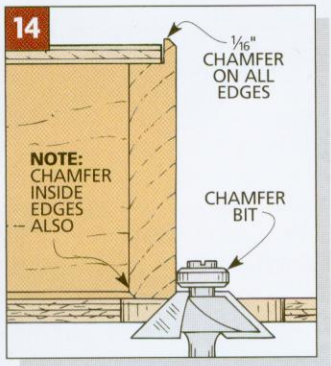
DRAWER BOTTOM. The drawer bottom (J) fits in a rabbet routed in the bottom edges of the drawer *(Fig. 12a)*. To do this, mount a 3/8" rabbet bit on the router table and move the assembled drawer around the bit in a clockwise direction *(Fig. 12)*. (Note: The rabbet should be slightly deeper than the thickness of the plywood bottom.)

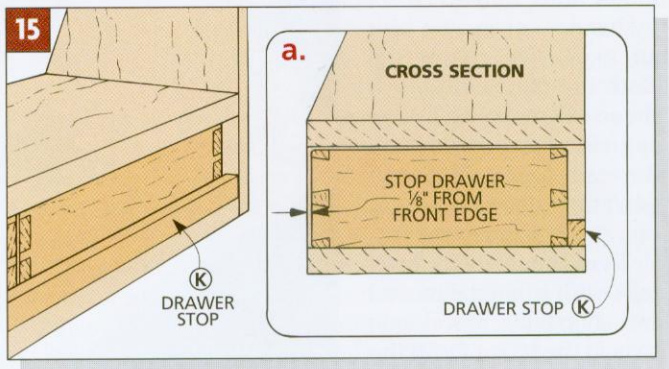
Now cut the drawer bottom from 1/4" plywood , and round the corners to fit in the rabbets *(Fig. 13)*.

CHAMFER. After gluing the bottoms in place, I softened all the edges of the drawers with a 1/16" chamfer *(Fig. 14)*.

DRAWER STOP. The last step is to add the drawer stop (K) *(Fig. 15)*. It's simply a 3/4" x 9/16" strip glued to the shelf bottom at the back of the opening. Position the strip so the drawers stop about 1/8" back from the front edge of the shelf *(Fig. 15a)*. ■







SHOP TIP ..... Invisible Hanging System

To mount the shelf to the wall, I used a hidden hanging system. It consists of two beveled strips that interlock and permits the mounting screws to be located anywhere (so they can screw into the wall studs, and be hidden).

Start by cutting a shelf back (E) to a rough width of 3" and to length to fit between the shelf sides (A) *(Fig. 1)*.

To accommodate the hidden strips, first cut a 2 1/2"-wide groove in the back face of the shelf back (E). I cut the groove by making repeat passes over a dado blade *(Fig. 2)*.

Then cut this piece 2 1/4" wide to produce an L-shaped piece*(Fig. 3)*.

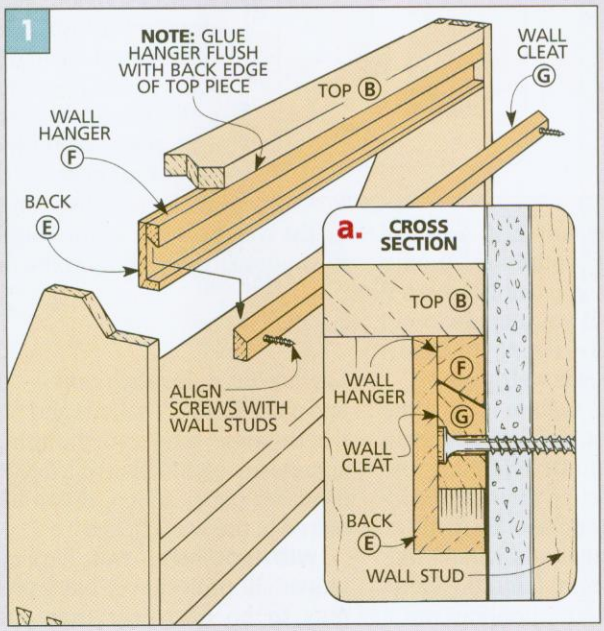
The shelf actually hangs on two 1/2"-thick interlocking strips — a hanger and a wall cleat. To make the hanger (F), cut a piece about 2" wide and the same length as the back (34 1/2"). Then bevel-rip off a 3/4"-wide strip *(Fig. 4)*.

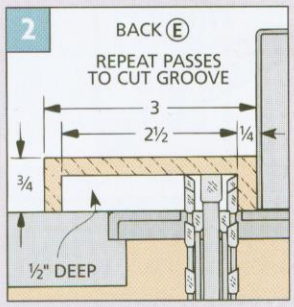
Now follow the same procedure to make the wall cleat (G) *(Fig. 5)*.

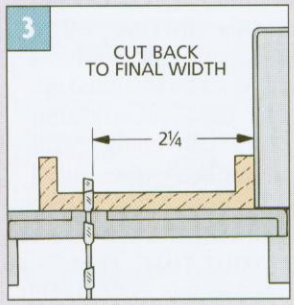
Next, glue the hanger (F) to the top back face of the back piece (E). Face the bevel toward the back piece *(Fig. 1a)*.

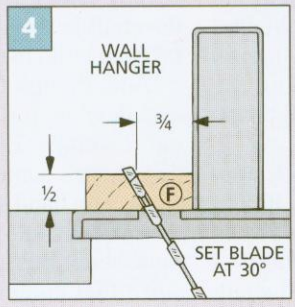
Once the glue dries, glue this unit under the top (B) of the wall shelf*(Fig. 1)*.

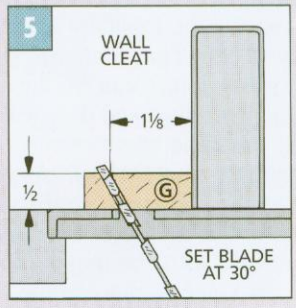
Next, screw the cleat (G) to the studs. Then set the shelf over the cleat so the bevels interlock *(Fig. 1a)*.







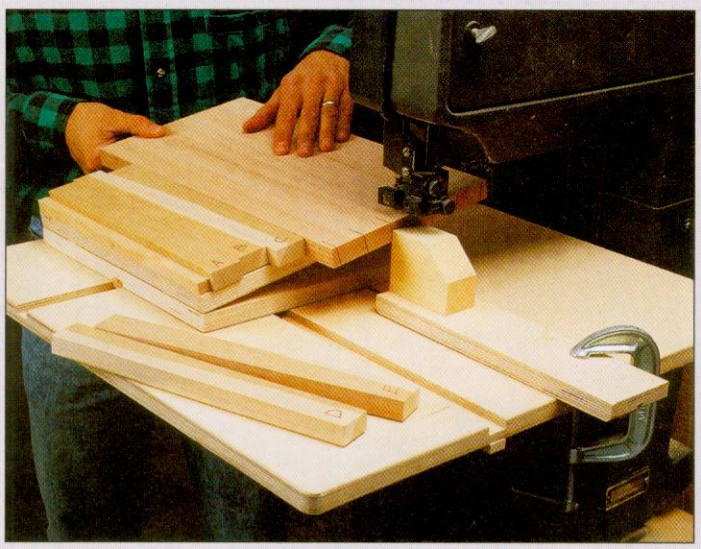




TECHNIQUE ..... Bandsawn Dovetails

When you first take a look at the dovetails on the wall shelf shown in the photo on page 13, you might think they were cut by hand — or maybe with an expensive router jig. Both the pins and tails of the joint are exposed. (It's actually called a *through* dovetail joint.) But you don't need an expensive jig or a steady hand to cut it.

I cut the through dovetails with a band saw and two shop-built jigs — one to hold the board to cut the tails and one to cut the pins. (These are the two interconnecting parts of a dovetail; see drawing below.)



SPACER BLOCK SYSTEM

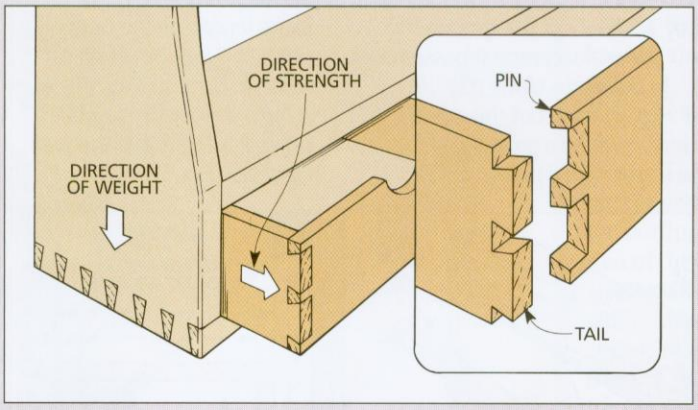
The basis of the system is the jigs — and a series of spacer blocks. When cutting on the band saw, the blocks space the tail and pin cuts so the two pieces will interlock perfectly. To vary the width of the pins or tails, all you have to do is vary the width of the blocks. Using this system you can create an infinite variety of patterns.

CLEAN INITIAL CUTS. The system solves what I consider to be the most difficult part of cutting through dovetails with hand tools — the initial cuts. They have to be straight, square, and a consistent depth.

LAYOUT TIME. There's another advantage to this system. You don't have to spend a lot of time accurately laying out each joint. I usually lay out the first joint so I don't get confused. But then all the other joints can be cut using the same procedure and they will all be exactly the same.

WIDTH LIMITATION. As with any dovetailing system, there are limitations to this method. The most obvious has to do with the maximum width of the workpieces. Since some of the cutting is done with the workpiece between the blade and the arm of the band saw, the pieces can't be too wide. On my 12" band saw, I found that the workpieces couldn't be much wider than 11½".

PREPARATION TIME. Another disadvantage is the time it takes to build the necessary jigs. If you only want to cut dovetail joints for *one* project, this system may not be worth it. You will have to spend a couple of hours building jigs before you can get started cutting joints. But if you expect to cut dovetails in the future, I think the time it takes to build the jigs is well spent.



And, though this system is accurate and flexible, it's not the fastest way to cut dovetails. Even after building the jigs, there's some set-up time and handwork. The band saw doesn't do it all.

HANDWORK. But that's what I like most about this system. I find the handwork that comes with chopping out a dovetail joint especially satisfying. This band saw system eliminates the hard part — cutting to a line — and allows me to concentrate on the final fit of the joint.

TAILS AND PINS

A through dovetail joint consists of two halves: the tails and the pins. At first it can be a little confusing what is what.

The *tails* look like a dove's tail when viewed from the side of a drawer. The *pins* look like rectangles (sort of like a box joint) when viewed from the front or back of the drawer.

To add to the confusion, when viewed from the ends of the boards, the tails look like pins (usually tall ones), and the pins look like little tails. This all may sound confusing now, but it will clear up once you've cut a few joints.

Okay, which board gets the tails, and which one gets the pins? And does it make a difference? A dovetail joint is *mechanically* strong in only one direction.

On a drawer the pins should be cut on the drawer front; see the drawing at left. Then the mechanical strength of the joint holds the drawer together as it's pulled open. On the dovetailed wall shelf (on page 13) the pins are cut on the top to hold up the weight of the whole cabinet, and the bottom to help support the drawers.

LAYOUT

Laying out a dovetail joint — the size and placement of the tails and pins — is worth some time and thought. If the layout isn't on the plan, it's best to draw it out on paper. Then, it can be transferred to the workpieces.

WIDTH OF PIN VS. TAIL. It's a matter of individual preference, but I prefer the pins to be narrower than the tails. Generally, I like the widest part of the

tails to be about four times as wide as the narrowest part of the pins.

ANGLES. The angles of the dovetails is also a matter of personal (visual) preference within limits. The general rule is that the angle should be somewhere between 78½° and 83°.

When setting up to cut dovetails on the band saw, I found it easiest to build the jigs at an 80° angle. This works out to a ratio of about 1:5¾.

SYMMETRICAL LAYOUT. There's one more thing to consider. When using this technique, the layout has to be symmetrical. That is, one half of the layout has to be a mirror image of the other half. As long as the layout is symmetrical, you can still vary the width of the tails.

READY TO CUT. After you've decided on the layout, you can transfer it to one end of the board that will have the tails (see the next page). Then you're finally ready to start cutting your first dovetail joint. (Well, almost. You still have to make an auxiliary band saw table and the jigs. Instructions for building the band saw table appear below.)

AUXILIARY BAND SAW TABLE

You can cut dovetails on your band saw with only two jigs — the tail jig (shown on page 20) and the pin jig (shown on page 22). But I found it difficult to balance these jigs and a long workpiece on my band saw table.

To solve this problem, I built a 24" x 24" auxiliary table from a piece of ¾" plywood *(Fig. 1)*. It clamps directly to the band saw table (refer to *Fig. 4*).

ADD RUNNER. To hold the auxiliary table in position on the band saw, I glued a ¼"-thick hardwood runner to the bottom of the plywood *(Fig. 1)*. Cut the runner to width to match the miter gauge slot on your band saw. Then glue it in position so the edge of the auxiliary table clears the arm on the band saw.

NEW SLOTS. After the runner was attached, I cut a slot in the auxiliary table directly over the runner *(Fig. 1a)*. This slot (dado) is used to guide a runner that's on the bottom of the tail jig. Since I wanted to use my miter gauge for other jobs, I cut it the same size as the slot in my band saw table.

Next, to hold and guide the pin jig, I cut a second slot the same size and at right angles to the first slot *(Fig. 1)*.

BLADE SLOT. With the slots cut, set the auxiliary table on the band saw and push it into the blade until an 11"-long slot is cut in the plywood *(Fig. 1)*.

Then, to provide enough of an opening for a stop block, I widened the blade slot to ¼". (Since the runner was attached, I turned the plywood upside down and cut this on the table saw.)

STOP BLOCK. The stop block stops jigs and workpieces that ride on the auxiliary table.

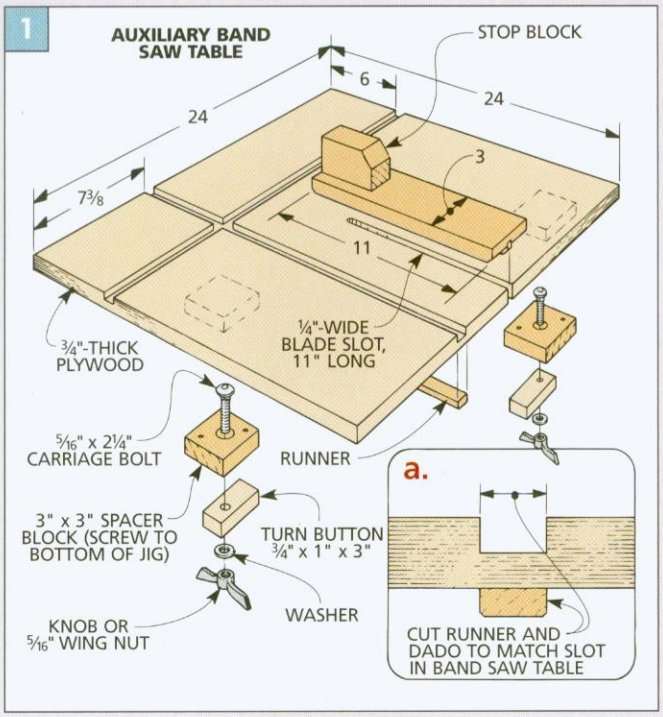
To make the stop, glue a 2½" x 3" block of 1½" stock to the top of a piece of plywood *(Figs. 1 and 2)*. Glue the block at one end of the plywood, and then cut the ends of the block and plywood off flush. (I also chamfered the bottom edge as a sawdust relief.)

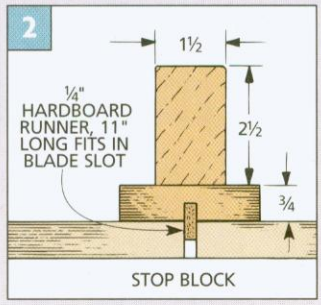
To keep the stop block square on the table, glue a ¼" hardboard runner into a groove cut in the bottom of the stop block *(Fig. 2)*. The runner slides in the blade slot on the auxiliary table.

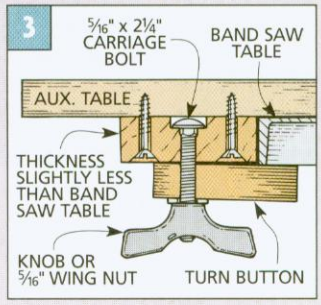
TURN BUTTONS. The auxiliary table is held down to the band saw table with a couple of turn buttons. To make the turn buttons, first cut spacer blocks just a hair thinner than the thickness of the band saw table *(Fig. 3)*.

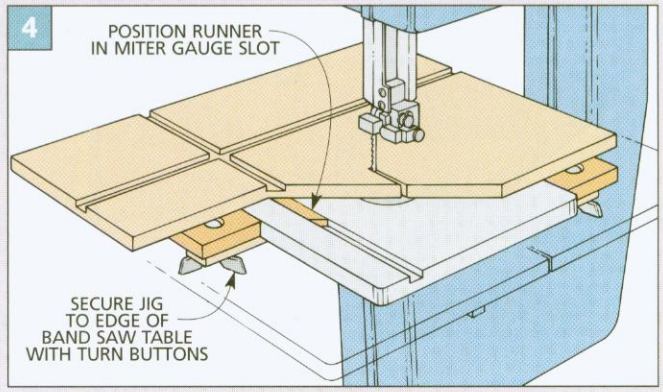
Next, drill a counterbored hole in the spacer block to accept a carriage bolt. Now insert the bolt into the hole, and then screw the spacer block to the bottom of the plywood table *(Fig. 3)*. The carriage bolt head should be captured in the counterbore between the block and the plywood.

The turn buttons are rectangular pieces of ¾" plywood with a 5/16" hole drilled off center *(Fig. 1)*. To tighten the turn buttons, you can use a wing nut or a plastic knob.



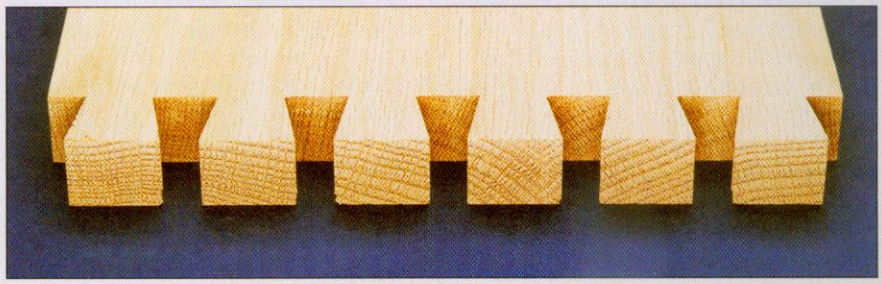






CUTTING THE TAILS

Before you begin bandsawing dovetails, there are a few things to do. The band saw has to be tuned up, two jigs built, and the workpieces prepared.



BAND SAW TUNE UP

To begin, you should spend a few minutes checking that your band saw is tuned up.

BLADE. To cut dovetails, I use a 1/4" blade with six teeth per inch. The blade should be sharp and tensioned correctly.

BLADE GUIDES. The most important thing to check is the location of the blade (side) guides — both above and below the table. These hold the blade in line for a straight cut and should be a hair away from the blade.

TAIL JIG

Now you can begin building the tail jig. This jig holds the workpiece at the correct position while cutting.

BASE. Start by cutting a 3/4" plywood base 15" wide and 24" long *(Fig. 1)*.

RUNNER. Next, cut a runner to fit in the miter gauge slot in the plywood auxiliary table *(Fig. 1a)*. Position the runner on the bottom of the base so the base clears the band saw arm when the runner is in the miter gauge slot.

FRONT FENCE. After the runner is glued in a dado, I screwed a fence on top of the base to hold the workpiece at a 10° angle to the blade. To position the fence, I used my table saw's miter gauge *(Fig. 2)*.

STOP FENCE. The last part to make is a stop fence. It's a piece of 3/4"-thick stock with a squared-off hole cut in it for a C-clamp *(Fig. 3)*.

STOCK PREPARATION

It's important that any stock to be joined with bandsawn dovetails is flat and planed to a uniform thickness.

SQUARE UP ENDS. After the boards are flat, next square up the ends of the workpieces and cut them to finished size. Then mark the base lines to correspond to the thickness of the matching board *(Step 1, opposite page)*.

CUTTING PROCEDURE

The procedure for cutting the tails is shown on the opposite page. Before you cut dovetails on a project, I'd recommend first working through the whole process — tails and pins — on scrap.

LAYOUT. I start by laying out all the tails *(Step 2)*. (This isn't really necessary when using spacer blocks, but there's security in seeing the cuts being made where they're supposed to be.)

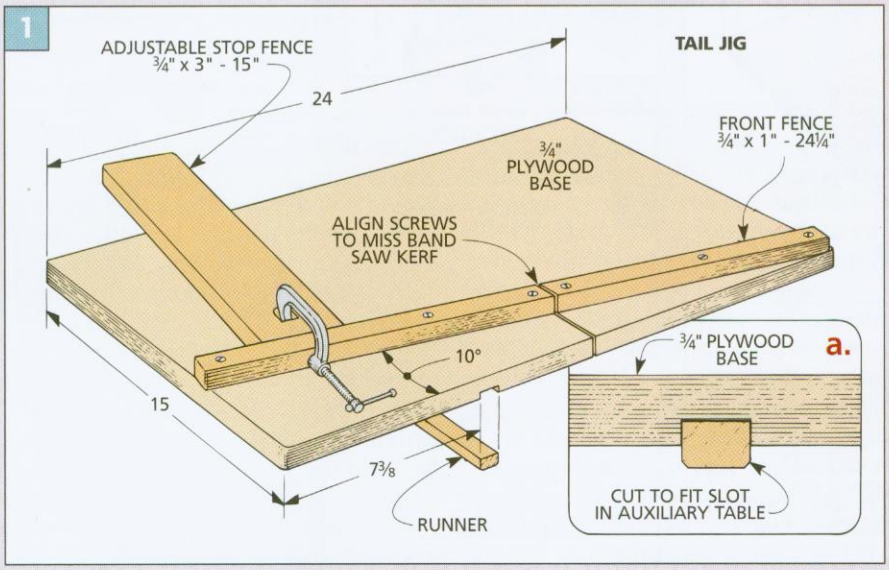
SPACER BLOCKS. Next, cut spacer blocks from 3/4"-thick stock that match the distances from the corner of one tail to the same corner on the next tail *(Step 3)*. (There will always be one more tail than the number of spacer blocks.) To help keep things straight, I alphabetize the spacer blocks.

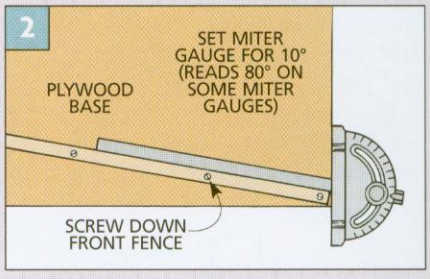
STOP FENCE & BLOCK. Then position the workpiece on the tail jig and clamp down the stop fence *(Steps 4 and 5)*. Next, push the jig into the blade until the blade touches the base line and clamp down the stop block *(Step 6)*.

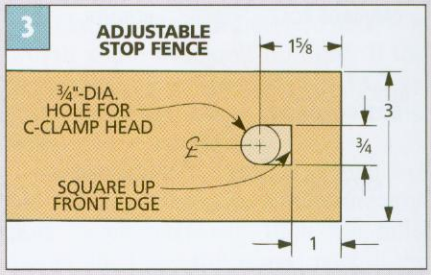
CUTTING. Now it's a matter of adding the spacer blocks one at a time and making cuts (see Cutting Sequence at far right). Then flip the board over and make the second sequence of cuts.

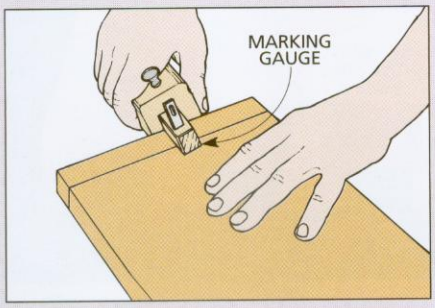
Note: Usually you will be joining both ends of a board with dovetails. To simplify the explanation, I'm showing only one end. Once you're familiar with the sequence, you can flip the board end-for-end and edge-for-edge before adding each spacer block.

CLEAN OUT WASTE. After both sides of the tails are cut, chip out the waste between the tails *(Steps 7 and 8)*.

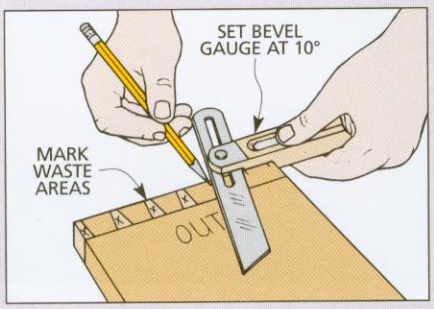




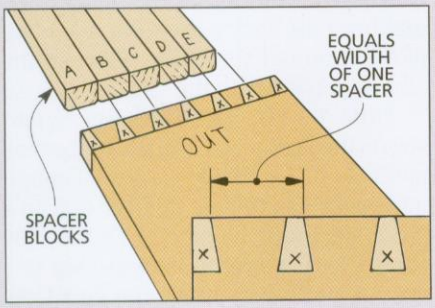




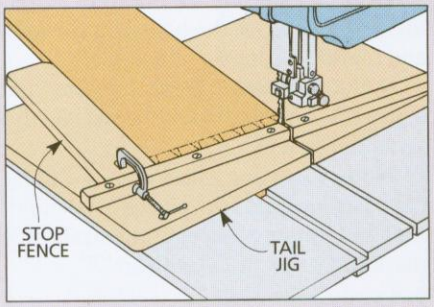
1 *Make sure board for tails is true with square ends. Then set the marking gauge to thickness of board for pins. Mark base line on both faces and edges.*



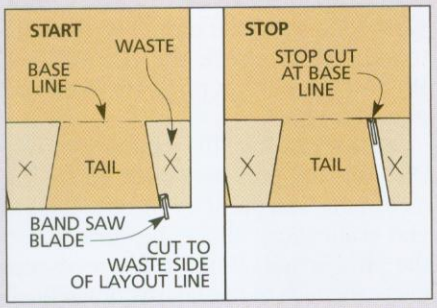
2 *For reference when cutting, mark size and spacing of tails on end of the board with a pencil and bevel gauge. Then mark waste areas with an "X."*



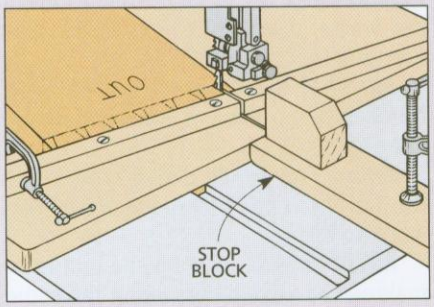
3 *To determine the width of each spacer block, measure from upper left corner of one tail to upper left corner of the next tail. Then cut the blocks to size.*



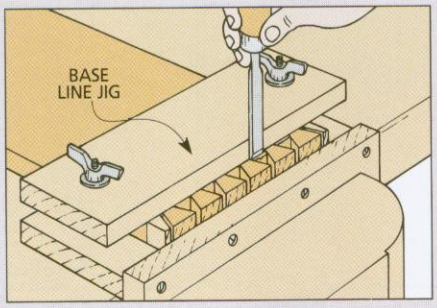
4 *Now mount the tail jig on the band saw. Next, set workpiece on the jig and align the first tail with the blade (see Step 5). Then clamp down the stop fence.*



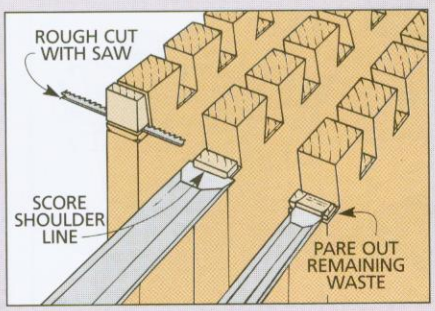
5 *For first cut, align blade with line on first tail, left drawing. Then push the jig (and workpiece) into the blade and stop at scribed base line, right drawing.*



6 *Next, clamp the stop block down to the auxiliary table with a C-clamp. Then follow the cutting sequence in box at right. Between cuts, add spacer blocks.*

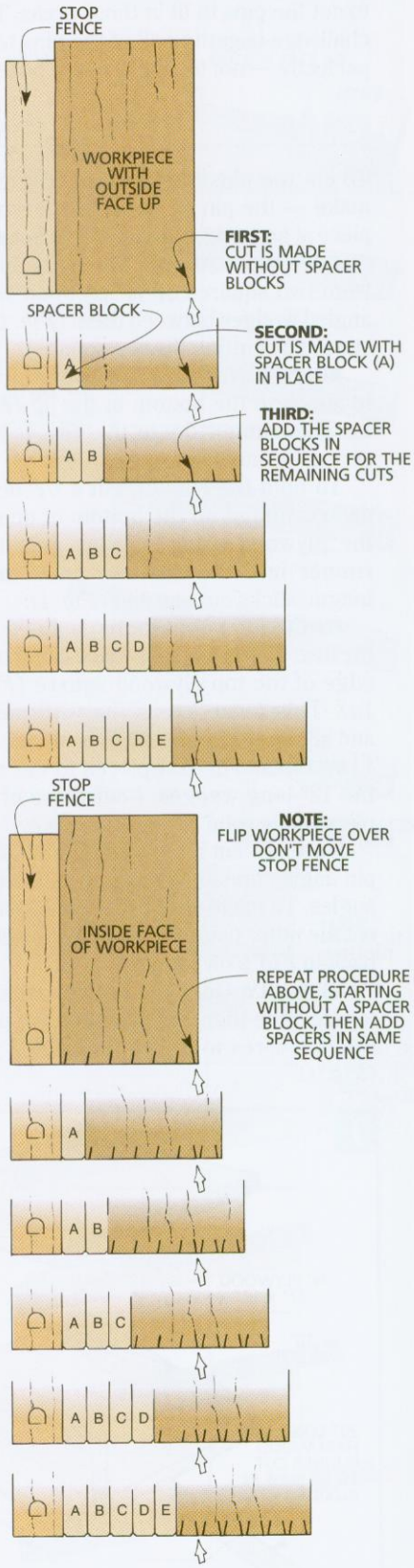


7 *To guide the chisel when chopping out the waste, I built a simple jig with a fence. Work from both sides of the board and undercut toward the center.*



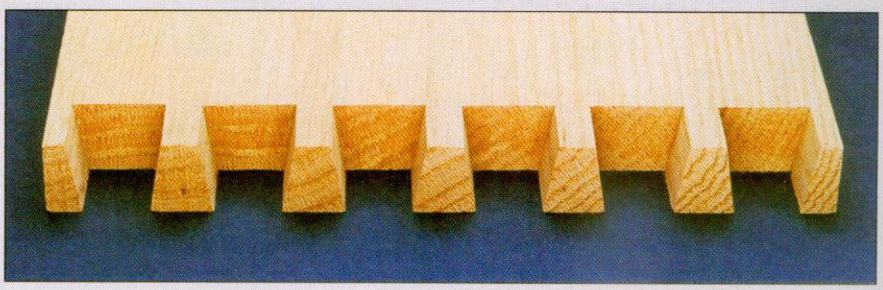
8 *Finally, rough cut area outside the last tail $^{1}/_{16}$" oversize. Then score the shoulder with a wide chisel (center) and pare out waste with a narrow chisel.*

CUTTING SEQUENCE



CUTTING THE PINS

After you've finished chopping out the waste between the tails, the next step is to cut the pins to fit in those areas. The challenge is getting all of the pins to fit perfectly — not too tight or too loose.



PIN JIG

To cut the pins, there's one last jig to make — the pin jig. It holds the workpiece at an angle to match the tail angle.

CUT TWO SQUARES. The jig is made from two squares of ¾" plywood with angled wedges between them *(Fig. 1)*. I started by cutting the two squares.

RUNNER. Next, cut a 20"-long runner to attach to the bottom of the jig *(Fig. 1)*. This runner fits in the groove cut across the auxiliary table.

To hold the runner, cut a ¼"-deep dado centered on the bottom of one of the plywood squares. Now glue the runner into the dado so an 8"-long tongue sticks out one end *(Fig. 1)*.

FENCE. After the runner is glued in, the next step is to glue a fence along one edge of the top plywood square *(Fig. 1a)*. This fence keeps the workpiece and all the spacer blocks in position.

WEDGES. The last pieces to cut are the 12"-long wedges. I cut these off a piece of plywood *(Fig. 2)*.

Note: To cut a tight-fitting joint, the pin angles must be the same as the tail angles. To make sure they're the same, set the miter gauge off the tail jig (refer back to *Fig. 2* on page 20).

ASSEMBLY. Once the wedges are cut to size, glue them between the two plywood squares to create the angled jig *(Fig. 1)*.

PIN LAYOUT

After the pin jig is built, you're ready to start laying out and cutting the pins.

Begin by setting the marking gauge to the thickness of the board for the tails and mark base lines on both faces.

MARK CUT LINES. Next, use the tails in the first board to mark the pins on the second board *(Step 1)*.

Note: Clamping a backer board along the base line holds the pieces in position.

Then, to keep everything straight, I mark the waste areas with an "X".

CUTTING PROCEDURE

After the layout is complete, you can mount the pin jig on the band saw *(Step 2)*. Then align the jig so the blade cuts in the waste area, right next to the line marking that area *(Step 3)*.

SET STOP BLOCK. Next, set the stop block to keep the cut from going too deep *(Step 4)*.

Note: The pin jig doesn't move like the tail jig. The workpiece slides forward on the jig.

MAKE CUTS. Now it's just a matter of making the angled cuts using the same spacer blocks as when cutting the tails.

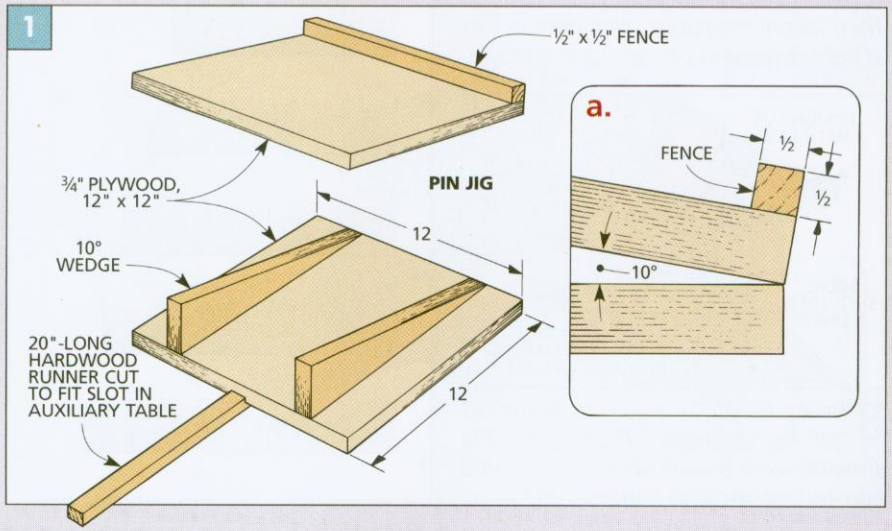
TURN JIG AROUND. After all of the cuts are made in one direction, turn the jig around and align the blade clearly in the waste area *(Step 5)*. Then repeat the process of adding spacer blocks and making cuts. After the cuts are complete, chop out the waste between the pins as you did with the tails.

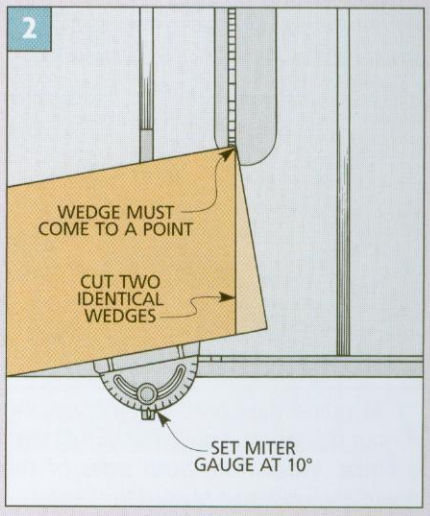
TRIM TO FIT. The most important step is the next one. Check how the pins and tails fit together *(Step 6)*. Then, if necessary, tap the pin jig over to trim a *little* more off the side of all the pins *(Step 7)*. (It's easy to take too big of a cut, so just barely move the jig.) Continue sneaking up and cutting until the fit is perfect.

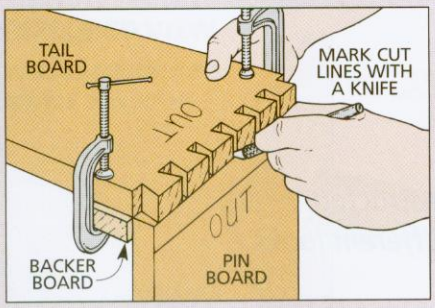
ASSEMBLY

Now comes the fun part. Tap the joint together and check the fit *(Step 8)*. When the joint fits properly, it can be glued together.

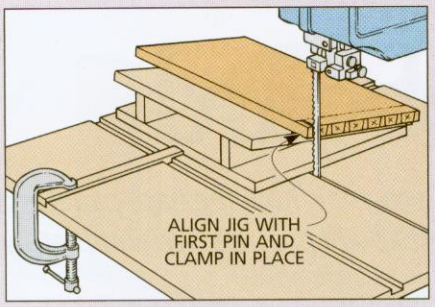
CLEAN UP. Once the joint is together, the pins and tails may stick above the face of the boards, or be recessed. If the end grain sticks above the surface, file the pins or tails flush. If it's recessed, plane the face of the boards down flush with the pins and tails.



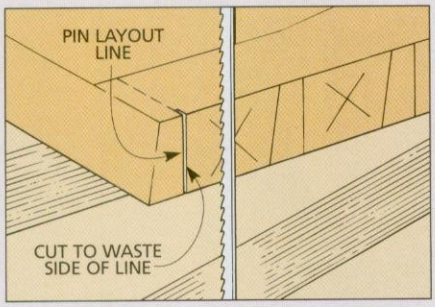




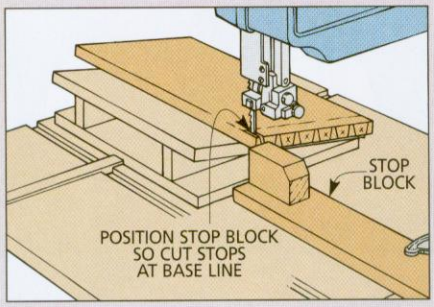
1 *To lay out pins, first mark base lines on both faces. Then hold tail board on the end of pin board and mark cut lines with a knife. Mark waste areas with "X's"*



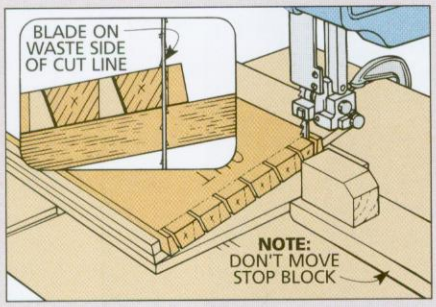
2 *Mount pin jig and workpiece (outside up) on band saw. Align jig so the blade will cut in waste next to first pin (see Step 3). Then clamp down tongue of jig.*



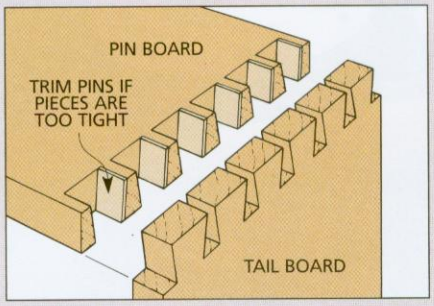
3 *Note the position of the blade in relation to the layout line. The blade should cut in the waste area so the layout line is just barely "saved."*



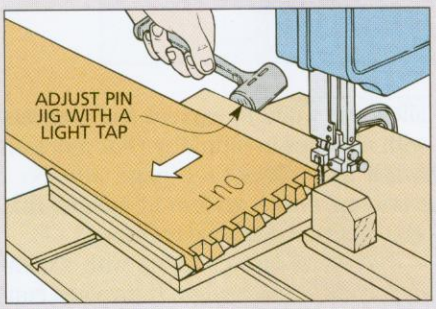
4 *Now push workpiece into blade and stop at the base line. Then clamp down the stop block and make cuts shown in cutting sequence at right.*



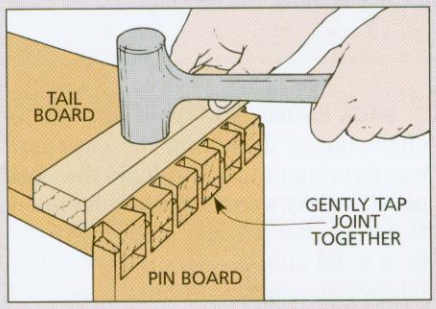
5 *Next, turn the pin jig around so angle faces opposite direction. Then align blade alongside the layout line, but clearly in the waste area. Clamp down jig.*



6 *After completing all the cuts, chop out waste then check how pins and tails fit. If they're too tight, trim a hair more off pins (see Step 7).*

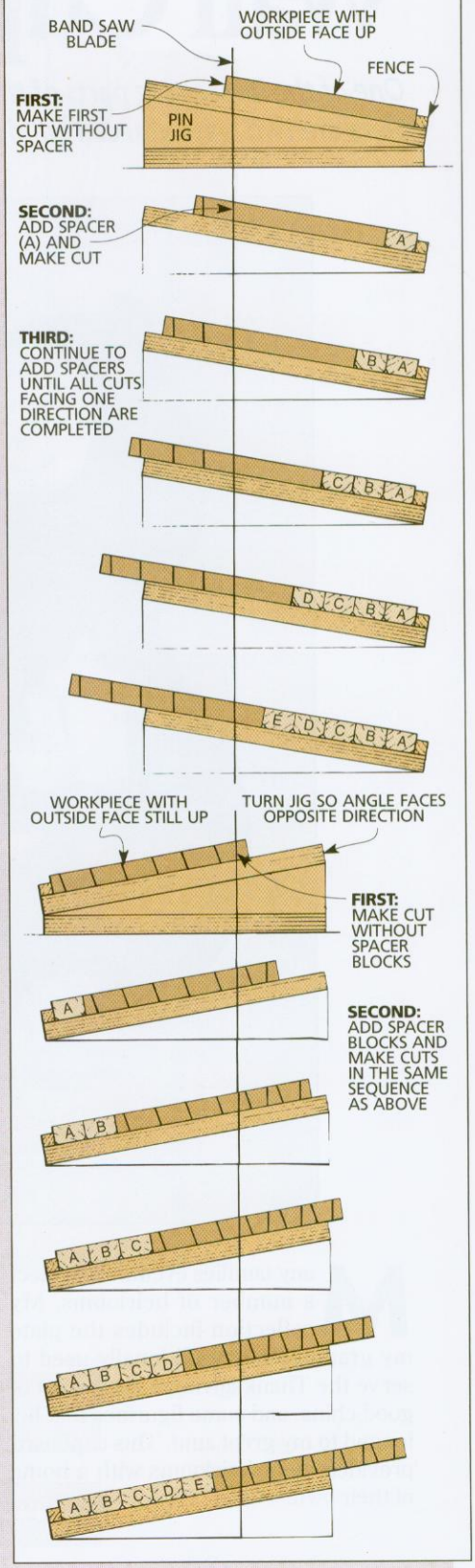


7 *To trim off just a hair more, keep the jig clamped to the table and tap the jig with a mallet. You should be able to move it a little without unclamping.*



8 *After the pins fit into the areas between the tails, the joint can be tapped together. Use a backing board for even pressure and to prevent splitting.*

CUTTING SEQUENCE



Wall Cupboard

One of the interesting parts of this project is how the back panel is constructed. Here are two ways you can build it that will provide two completely different looks.

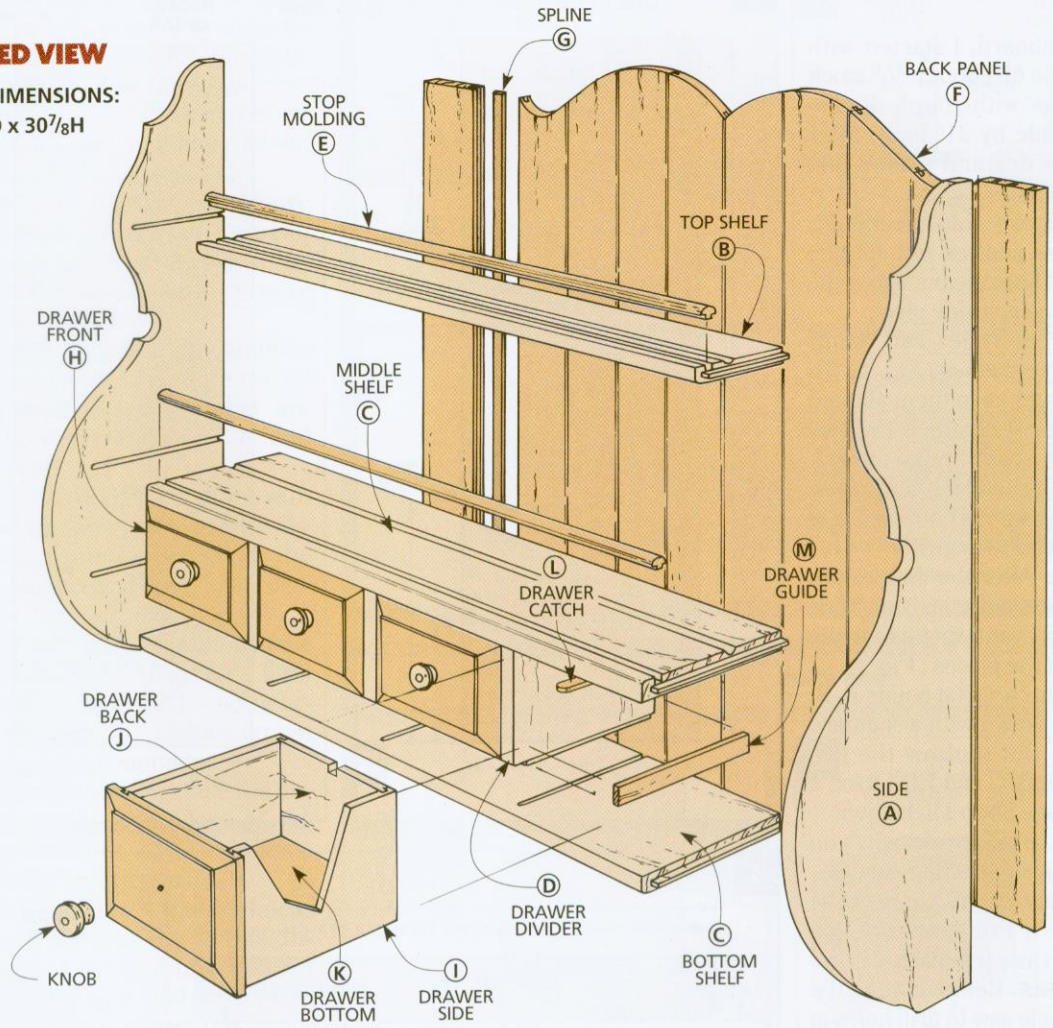
Many families eventually collect a number of heirlooms. My collection includes the plate my grandmother traditionally used to serve the Thanksgiving turkey, a set of good china, and some figurines that belonged to my great aunt. This cupboard provides these heirlooms with a home of their own.

BACK PANEL. The most interesting challenge of designing the cupboard was figuring out how to build the back panel. I really wanted to use solid wood. (I used butternut, but pine would also be a good choice.) So my first option (shown above) was to build it out of a number of $\frac{1}{2}$"-thick boards. The problem here was figuring out a way to allow the wood to expand and contract with changes in humidity (For more on wood movement, see page 29). So I came up with a system of splines that would permit the wood to "move."

But we've also come up with a completely different design. It involves running a couple boards horizontally and leaving the back open (see page 31).

EXPLODED VIEW

OVERALL DIMENSIONS:
36 1/2W x 9D x 30 7/8H



MATERIALS LIST

WOOD

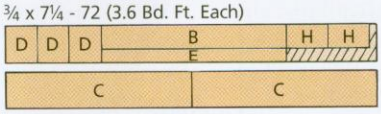
A	Sides (2)	3/4 x 9 - 29 1/2
B	Top Shelf (1)	3/4 x 4 1/2 - 35 3/4
C	Mid./Bot. Shelv. (2)	3/4 x 7 - 35 3/4
D	Drawer Dividers (3)	3/4 x 7 - 5 1/4
E	Stop Moldings (2)	3/4 x 3/4 - 35
F	Bk. Panel Pcs. (10)	1/2 x 3 1/2 - 32
G	Splines	cut from waste
H	Drawer Fronts (4)	3/4 x 4 7/16 - 8 1/8
I	Drawer Sides (8)	1/2 x 4 7/16 - 6 1/2
J	Drawer Backs (4)	1/2 x 3 1/2 - 7 1/8
K	Drawer Btms. (4)	1/4 ply (cut to fit)
L	Drawer Catches (4)	cut from waste
M	Drawer Guides (8)	cut from waste

HARDWARE SUPPLIES

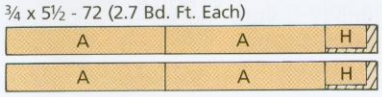
(24) No. 8 x 1" Fh woodscrews
(4) 1 1/4" maple knobs with brass centers
(2) Brass hangers with screws

CUTTING DIAGRAM

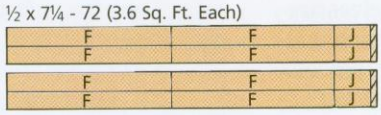
3/4 x 7 1/4 - 72 (3.6 Bd. Ft. Each)



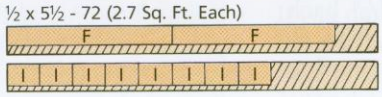
3/4 x 5 1/2 - 72 (2.7 Bd. Ft. Each)



1/2 x 7 1/4 - 72 (3.6 Sq. Ft. Each)



1/2 x 5 1/2 - 72 (2.7 Sq. Ft. Each)



SIDES

To build the cupboard, I started with the sides (A). Glue up enough 3/4" stock to get two blanks with rough dimensions of 10 1/2" wide by 31" long. After these blanks are dry and planed flat, trim them to final size *(Fig. 1)*.

DADOES. The two side pieces are joined to the three shelves with tongue and dado joints. This means three dadoes are routed in each side piece.

First, mark centerlines and "stop" points on the three dadoes *(Fig. 1)*. To rout the dadoes and keep them aligned across both sides, I clamped the two pieces together, back edge-to-back edge (bookmatch style), and then routed the dadoes across both pieces at the same time (refer to page 32).

SIDE PROFILES. After the dadoes are routed, the profiles can be laid out. Start by locating the six centerpoints for the six arcs on one of the pieces *(Fig. 2)*.

The small radius arcs (at points A, B, D, and F) can be drawn with a standard pencil compass. But to draw the two large arcs (at points C and E), I used a beam compass (see Shop Tip below).

After the six arcs are drawn, you have to draw some connecting curves.

Note: One easy way to connect the curves is to use a French curve, pie plate, or paint can as a template.

CUT OUT PROFILE. Before cutting the profile, I used a hole saw to drill holes at points D and F. Then cut out the profile using a sabre saw or band saw.

Note: Just to be on the safe side, I found it was best to cut about 1/16" outside of the marked profile. Then I sanded down to the marked lines.

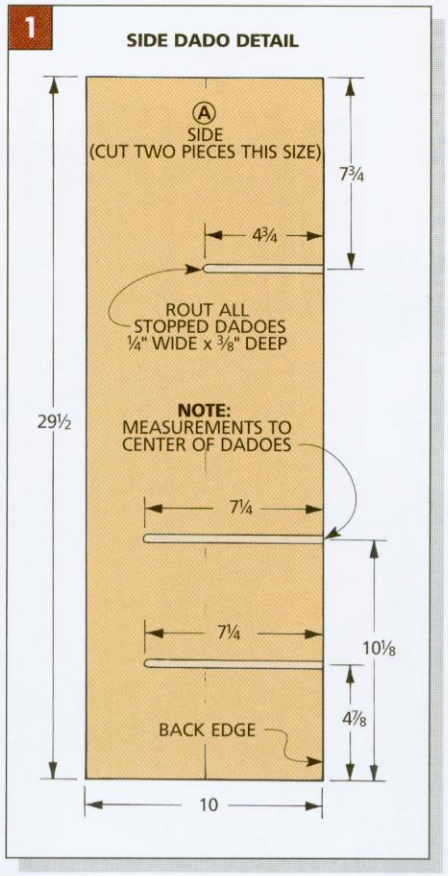
CUT SECOND SIDE. After the first side piece is sanded, use it as a template to mark and cut the other side piece.

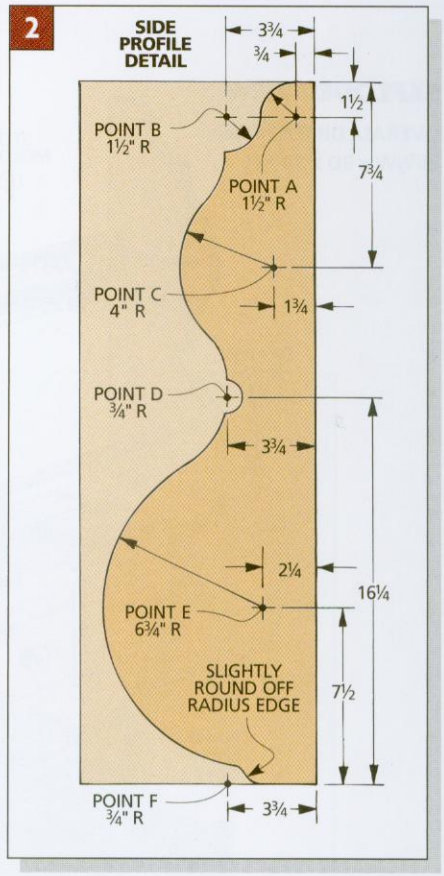
SHELVES

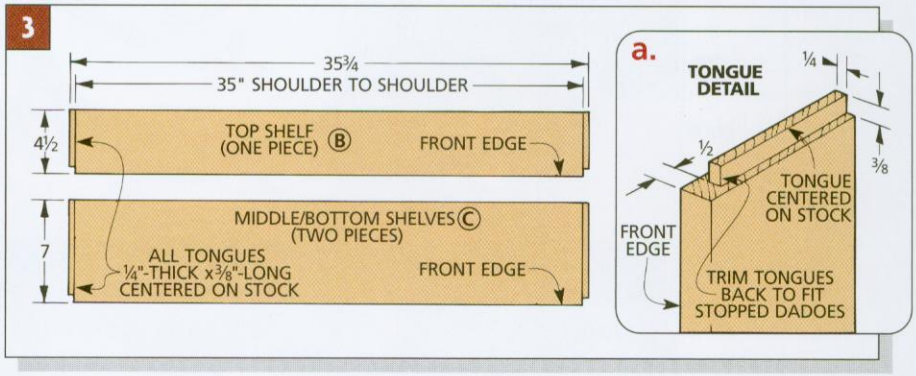
Next, the three shelves are cut to size. Rip the top shelf (B) to a width of 4 1/2", and the middle and bottom shelves (C) to a width of 7". Then cut all three to final length (35 3/4") *(Fig. 3)*.

CUT TONGUES. After the shelves are cut to size, a tongue is cut on each end to fit the dadoes in the side pieces. (Again, see pages 32 to 33 for more.)

Now notch each tongue 1/2" back from the front edge *(Fig. 3a)*. This allows the shelf to be pushed forward to make room for the back.



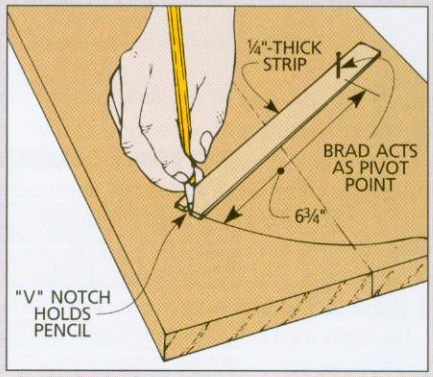




SHOP TIP ..... Beam Compass

A beam compass is a handy way to draw large arcs and circles. One can quickly be made in the shop with just a thin strip of wood.

First, cut a notch at one end to cradle the point of a pencil. Then drill a 1/16" hole along the "beam" wherever a pivot point is needed. Insert a brad in this hole and pivot the beam around it to draw the arcs.



STOPPED MOLDING GROOVE. After the tongues are cut, rout 1/4" grooves on the top and middle shelves for stop moldings to be mounted near the *front edges* of the shelves *(Fig. 4)*. (The grooves are routed now, but the moldings added later. Refer to *Fig. 14* on page 28.)

PLATE GROOVE. Next, a plate groove is routed on the same sides of these two pieces. To cut the grooves, use a 1/2" core box bit *(Fig. 5)*. Center the groove 2 1/2" from the *back edge*.

DADOES FOR DIVIDERS. To complete the shelves, stopped dadoes are routed for the three dividers (D) that are mounted between the middle and bottom shelves.

To locate these dadoes, start with the middle dado. First, measure the distance between the shoulders on the ends of the shelves and mark a line centered on this distance *(Fig. 6)*.

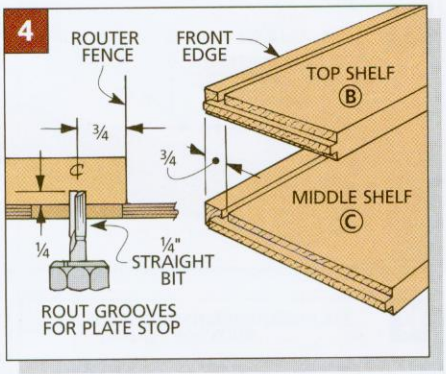
Then to determine the location of the other two dadoes, I had to do a little math. (In order to get equal spacing between the dividers, the dadoes do not lay out in equal increments.)

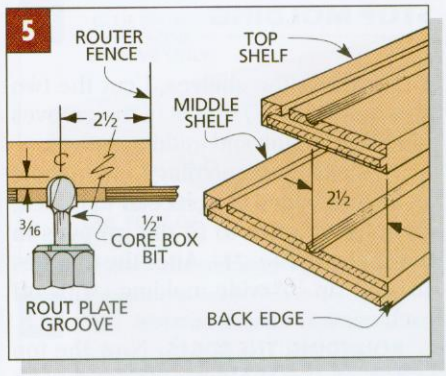
To get the right spacing, take the distance between the shoulders of the shelf (this should be 35") and divide this distance by four (to get 8 3/4").

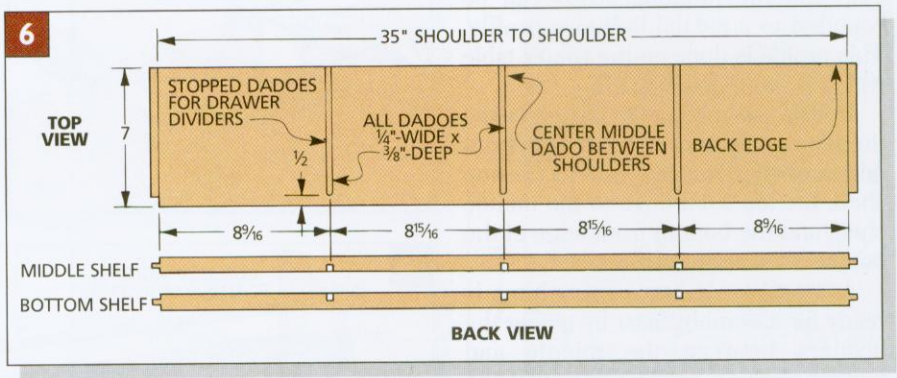
Then add one-fourth the thickness of the drawer dividers (D) to this distance. (I divided 3/4" by 4 to get 3/16". I added this to 8 3/4" for a total of 8 15/16".)

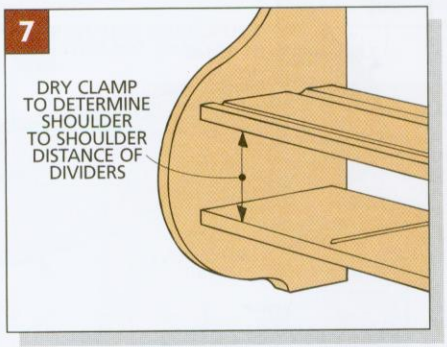
This is the distance from the *center* of the middle stopped dado to the *center* of the other two stopped dadoes *(Fig. 6)*. (Note that the remaining distance is only 8 9/16" from the middle of these dadoes to the shoulders at the ends of the shelves. This is the correct distance to get equal spacing.)

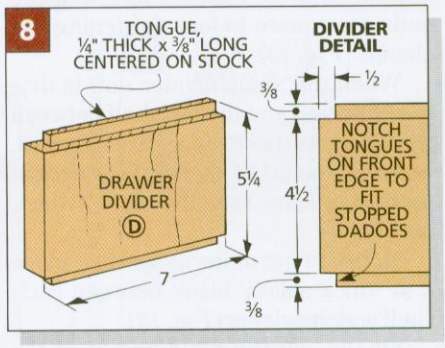
After marking the centerlines of the three dadoes, clamp the two shelves together (back-to-back) and use the same procedure as before to rout the dadoes.

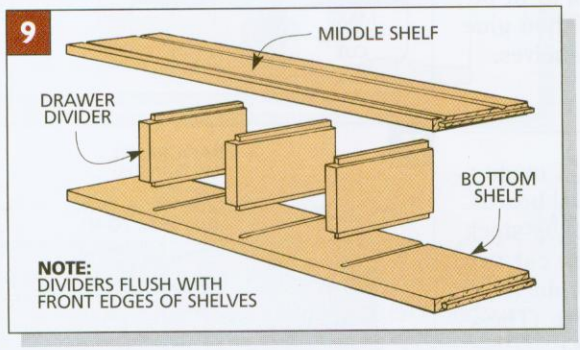


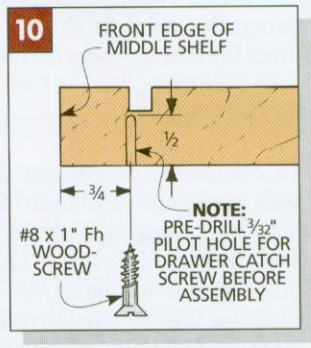












DRAWER DIVIDERS

After the dadoes are routed, the three drawer dividers (D) can be cut to fit. Note: The dividers are mounted so the grain runs vertically *(Fig. 8)*.

DETERMINING THE LENGTH. To determine the length (height) of the drawer dividers, first dry clamp the middle and bottom shelves to the side pieces. Then measure the distance between the two shelves to get the shoulder-to-shoulder distance of the dividers *(Fig. 7)*.

To this measurement, add the depth of the two dadoes to allow for the tongues on the dividers. (In my case, this came to a length of 5 1/4".) Now cut the dividers to this length and the same width as the shelves (7") *(Fig. 8)*.

CUTTING THE TONGUES. Next, cut tongues centered on both ends to fit the dadoes in the shelves.

Then notch the front edge of each tongue to fit the stopped dado so the front edge of the divider rests flush with the front edge of the shelves *(Fig. 9)*.

DRAWER CATCH HOLES. Drawer catches are added to the bottom of the middle shelf *after* assembly (refer to *Fig. 30*), but pilot holes for these catches have to be drilled *now (Fig. 10)*. If you don't drill them now, you can't fit the drill between the shelves later. Each hole is centered on a drawer opening, 3/4" back from the front edge.

STOP MOLDING

To complete the shelves, I cut the two stop moldings (E) that fit in the grooves routed in the top and middle shelves.

To make these moldings, cut rabbets on all four edges of a piece of ¾" stock, creating tongues to fit the grooves in the shelves *(Fig. 11)*. After the tongues are cut, rip ¾"-wide molding strips off each edge.

ROUNDING THE EDGES. Now the top edges of the molding strips can be rounded to a partial bullnose profile. This profile is done on the router table with a ⅜" roundover bit *(Fig. 11a)*.

Before assembling the pieces, I used the same setup to round over both front edges of the side pieces and the top shelf, the top front edge of the middle shelf, and the bottom front edge of the bottom shelf *(Fig. 14a)*.

ASSEMBLY. At last, everything is ready for assembly. Start by gluing the dividers between the middle and bottom shelves, making sure that the ends are square before tightening the clamps *(Fig. 12)*.

When the shelf/divider unit is dry, glue this unit and the top shelf between the sides. As these pieces are clamped, be sure to push the shelves forward just enough to leave room for the ½"-thick back panel.

Note: To get uniform spacing, place a ½"-thick spacer block between each shelf and the clamp *(Fig. 13)*.

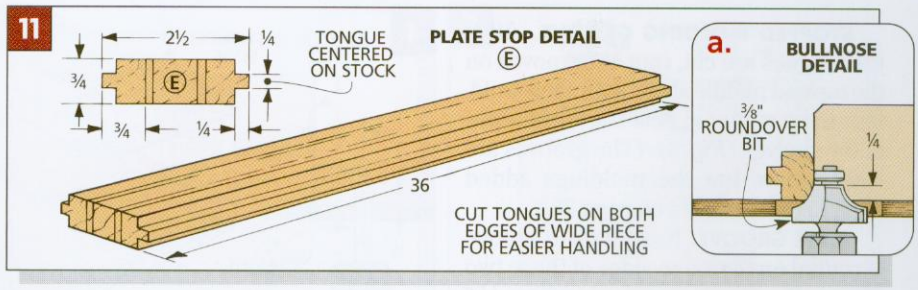
Finally, cut the moldings to fit between the sides *(Fig. 14)*. Then glue them into the grooves in the shelves.

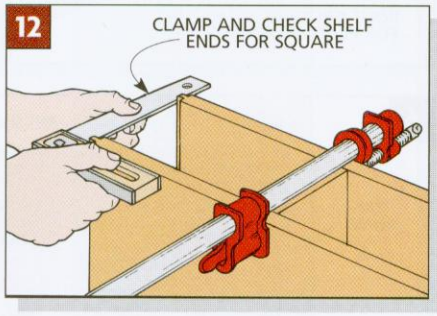
BACK PANEL

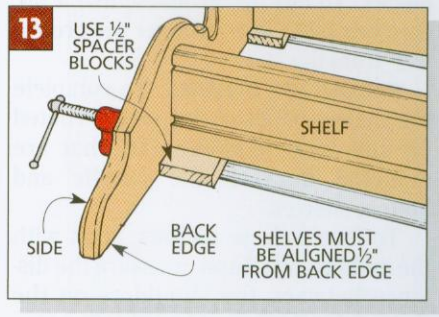
To complete the cupboard, I made a back panel out of 10 individual boards. Start by cutting eight pieces of ½" stock 3½" wide by 32" long. Then cut two more pieces an extra ⅛" wide (3⅝" wide) for the two outside pieces. (These pieces are trimmed to fit later.)

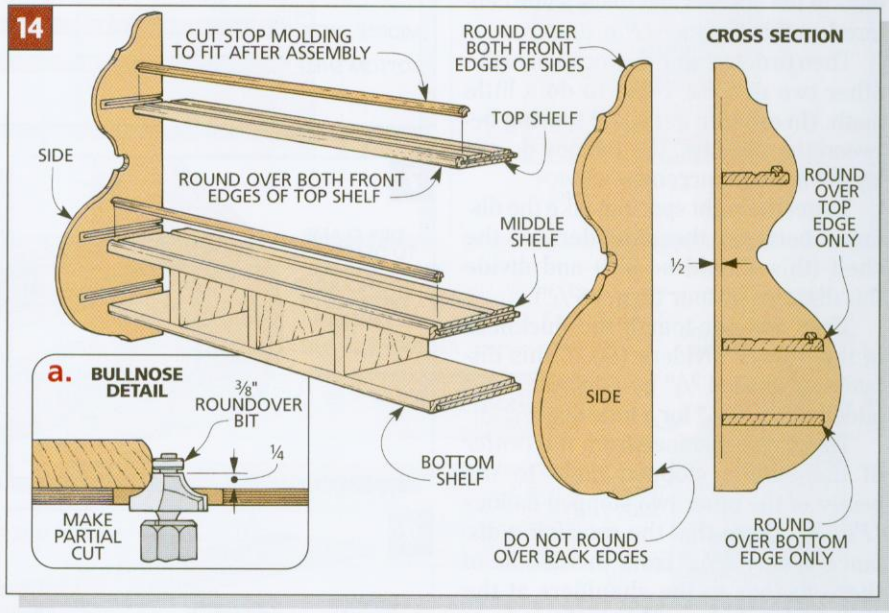
CHAMFER & GROOVE EDGES. Next, rout a 1/16" chamfer on both edges of the face (front) side of the first eight pieces, but only *one* edge of the two outside pieces *(Fig. 16)*.

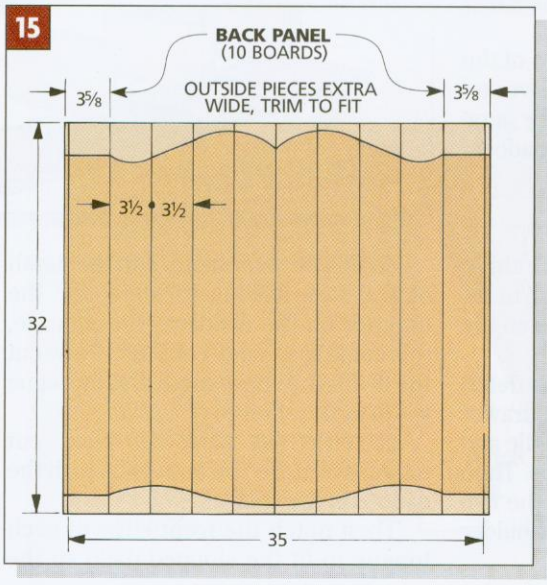
All of these back pieces are joined together with splines. To do this, first cut a ⅛"-wide groove centered on both edges of each piece *(Fig. 17)*. (On the two outside pieces, cut the groove only in the edges with the chamfer.)

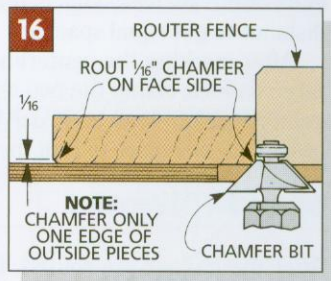


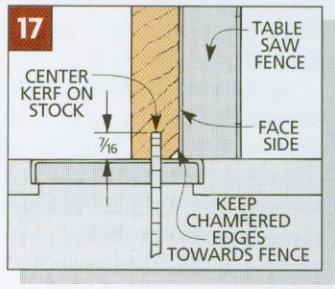












SPLINES. Now, rip 1/8"-thick splines (G) off the edge of a piece of 3/4"-thick stock *(Fig. 18)*.

Then glue each spline into *only one groove* of each back piece *(Fig. 19)*.

Note: Since the boards are unsupported at the top and bottom, the splines keep the faces of the boards flush — preventing them from twisting. However, they're glued into only one groove to allow for expansion and contraction (see Shop Tip box below).

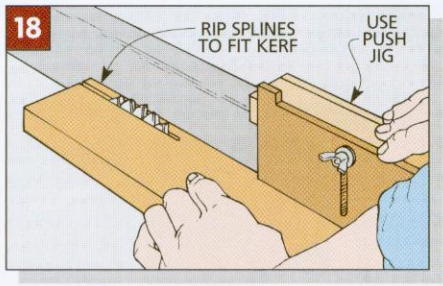
CUT BACK TO FIT. Now, place the back pieces between the two sides. The combined width should be too wide to fit, so trim the two outside pieces until they fit between the sides.

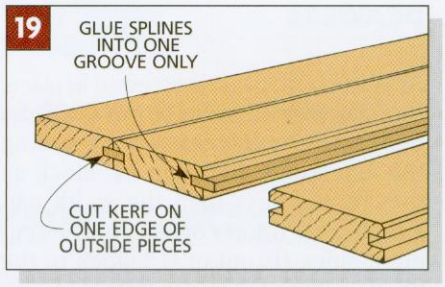
TEMPLATES. To complete the back panel, curves are cut on the top and bottom edges *(Fig. 22)*. To cut the curves, I made two templates. Tape a piece of poster board to the edge of the workbench and draw a 6"-radius and a 3 1/4"-radius arc to form the top profile *(Fig. 20)*. (Actually this is only half of the profile. Just flip the template over to trace the other half.)

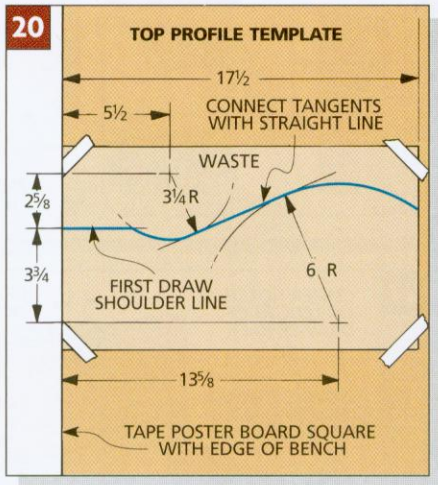
Follow the same procedure to draw a 26"-radius and a 10"-radius arc for the profile on the bottom edge *(Fig. 21)*.

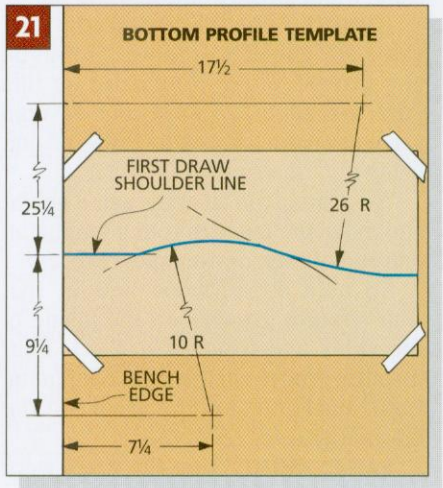
CUT THE PROFILE. Now clamp the back panel pieces together and use the templates to mark the profiles. After they're marked, cut the edges to shape with a sabre saw. Then sand the edges smooth and rout a 1/16" chamfer on the top and bottom face (front) edges.

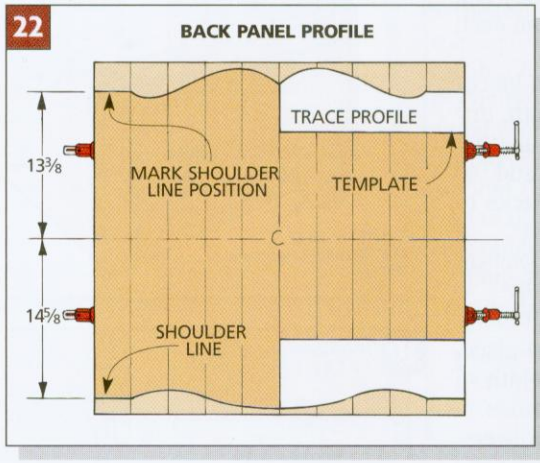
ATTACH THE BACK. The back panel pieces can now be screwed down (see box below). Drill countersunk pilot holes centered on each back piece, then screw the pieces in place *(Fig. 23)*.

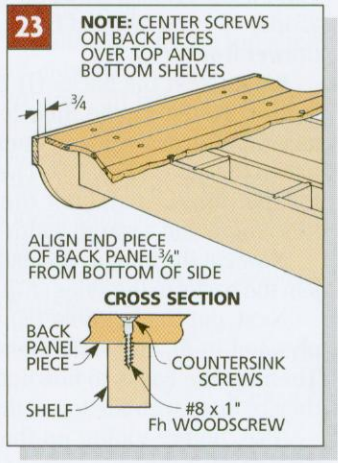












SHOP TIP ..... *Wood Movement*

Every time you use solid wood for a project, you have to be aware of wood movement — the expansion and contraction of wood during seasonal changes in humidity.

When the humidity is high, wood absorbs moisture from the air and expands. Then when the humidity is low, wood releases moisture and contracts.

How much does wood move? As a general rule of thumb you can count on kiln-dried wood (at about 7% moisture content) moving about 1/8" per 12" in width, or 1%.

Movement was a consideration when I designed the back of the cupboard. I was concerned with the wood expanding and buckling the pieces at each joint.

I built this project in the summer, so the wood was already at its widest on the expansion/contraction cycle. As I mounted the boards, I pushed them together with light pressure. However, if I had built this project in the winter, I would have laid out the boards to allow for summertime expansion.

Using the 1% rule of thumb, there should be about a 1/32"-gap between each 3 1/2"-wide board. The easiest way to gauge this gap is with playing cards. The combined thickness of three playing cards is within a few thousandths of 1/32".

As the boards are mounted, place three cards between each of the joints. This should provide adequate spacing for the wood to swell.

DRAWERS

After the back panel is screwed in place, the last step is to build the drawers. Start work on the drawers by cutting the four fronts (H) from $^3/_4$" stock so they're $^1/_{16}$" less than the width and length of the drawer openings. Then cut eight sides (I) out of $^1/_2$" stock to the same width as the fronts and $6^1/_2$" long.

JOINERY. The drawer fronts and sides are joined with dovetail tongue and groove joints. (For more on this joint, see page 15.) First rout dovetail grooves on the back of the drawer front, using a $^1/_4$" dovetail bit *(Fig. 25)*.

Next, keep the bit at the same height and move the fence to rout a tongue on one end of each drawer side *(Fig. 26)*.

To hold the plywood bottom (K), rout straight grooves on the inside of the sides and front *(Fig. 24a)*. Rout through grooves in the sides. But in the front, start and stop the groove at the dovetail grooves *(Fig. 24)*.

RAISED FRONT. After the joints were cut, I used a raised panel bit (Sears No. 25465) to cut a beveled border on each drawer front *(Fig. 28)*.

BACK. Next the backs (J) can be cut to size. To determine their length, dry assemble a drawer and measure between the sides *(Fig. 27)*. Then add $^1/_2$" for the tongues and cut the backs to this length and a rough width of 4".

Now cut the tongue and dado joints to join the backs to the sides *(Fig. 29)*.

Next, cut the bottoms (K) out of $^1/_4$" plywood to fit, and slide them in place. Then cut the backs to finished width so they're flush with the top of the sides.

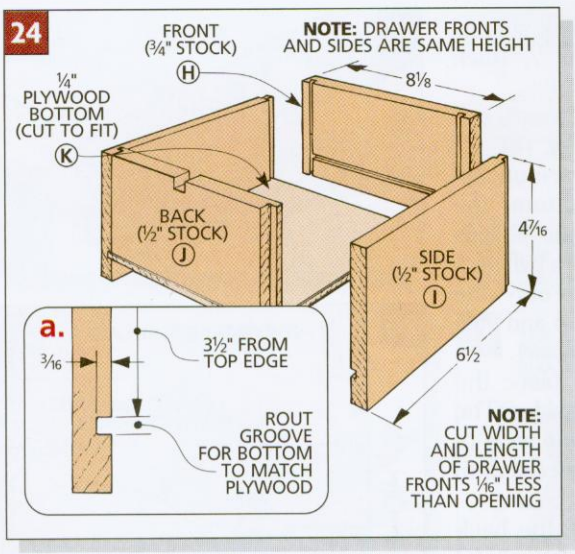
Also, before gluing up the drawers, cut a notch on the top edge of the backs for the drawer catches *(Fig. 27)*.

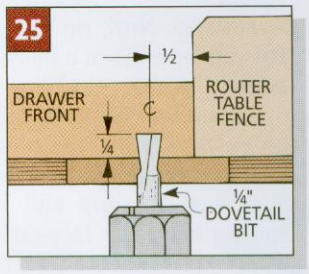
DRAWER CATCHES. The drawer catches are simply small wooden turn buttons that keep the drawer from pulling out too far *(Fig. 30)*. Mount them to the bottom of the middle shelf.

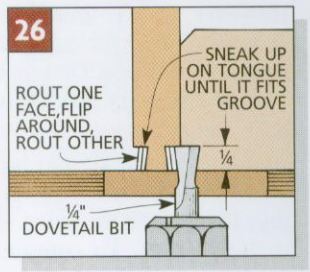
DRAWER GUIDES. To make the drawer guides, rip eight $^3/_4$"-wide pieces from scrap just thick enough so that each drawer fits when the guides are glued in place. These guides also act as drawer front stops *(Fig. 33)*.

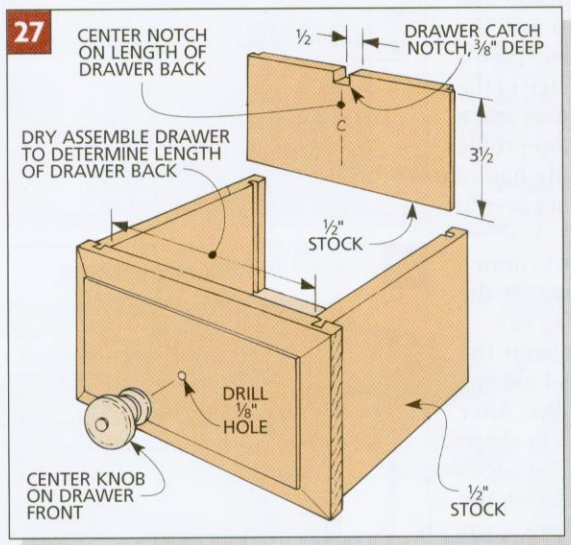
HANGERS. Finally, to hang the cupboard, drill holes on the back and mount hangers over the holes *(Fig. 31)*.

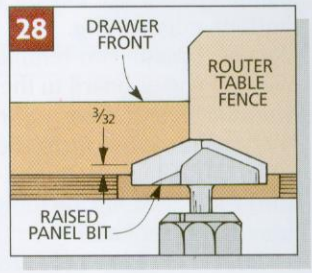
FINISH. To finish the cupboard, I used a light walnut oil stain and topped it with two coats of tung oil. ■

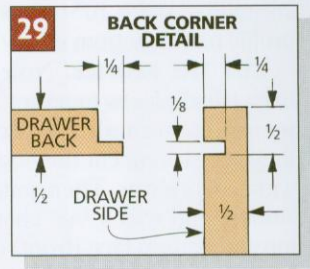


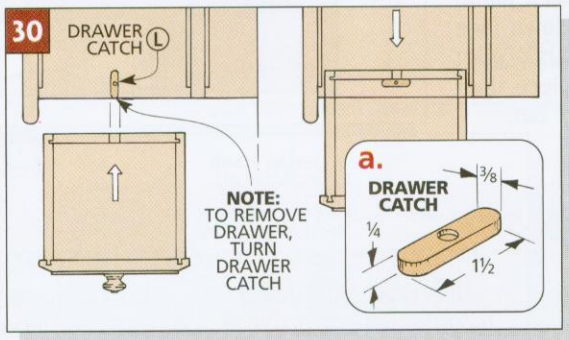


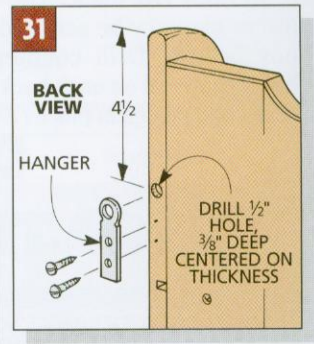


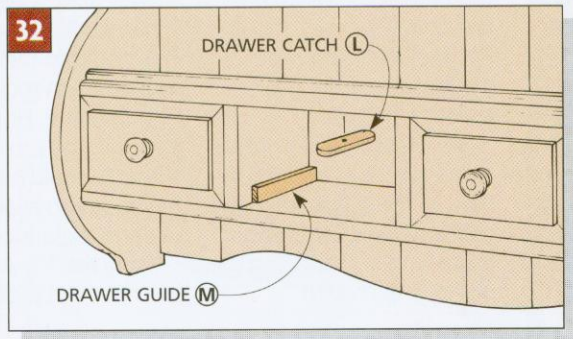


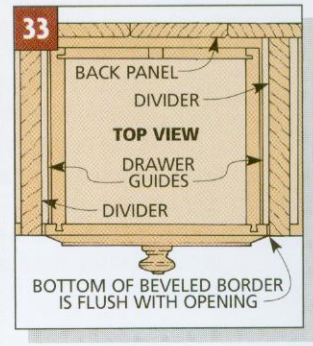






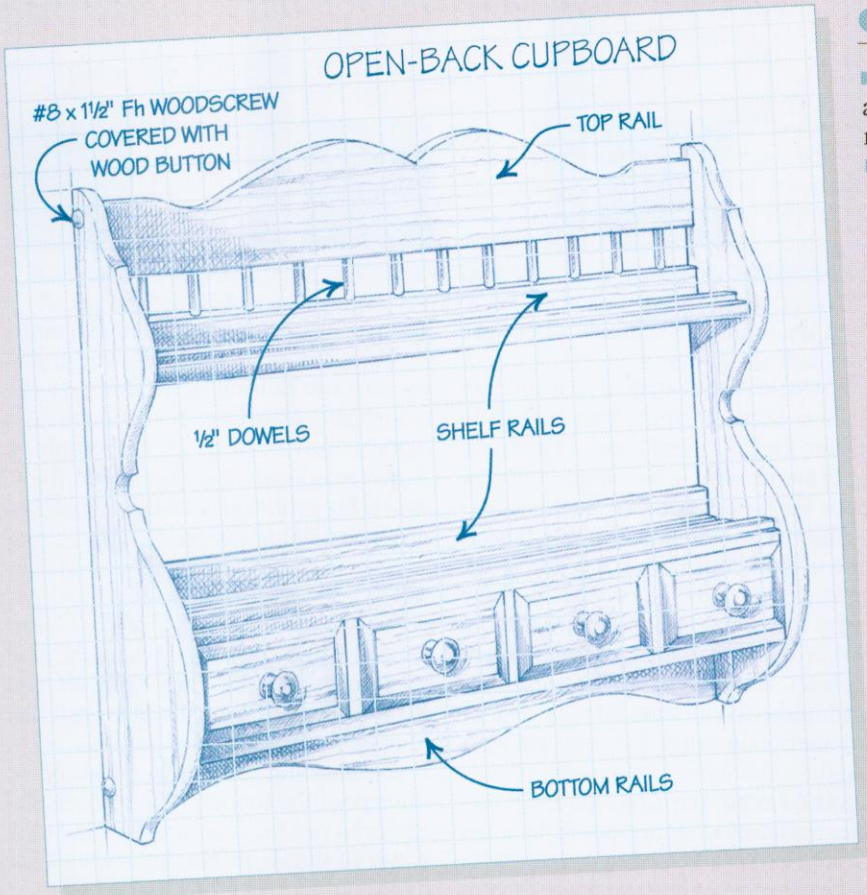






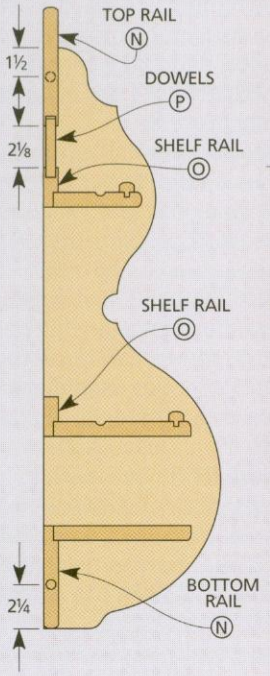
DESIGNER'S NOTEBOOK

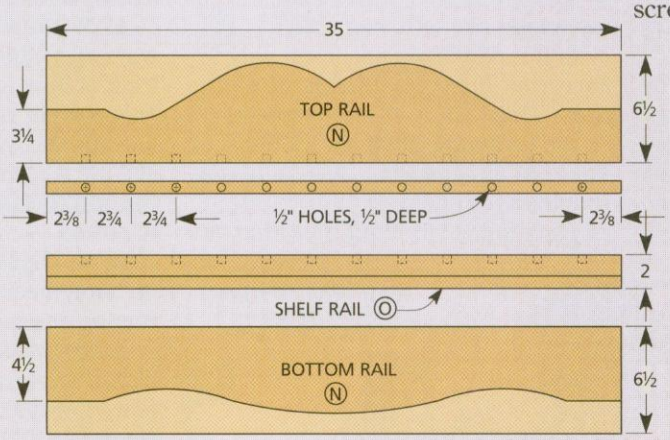
Opening up the back of the Wall Cupboard and adding short dowels as a decorative accent creates a completely different look while retaining the overall shape.

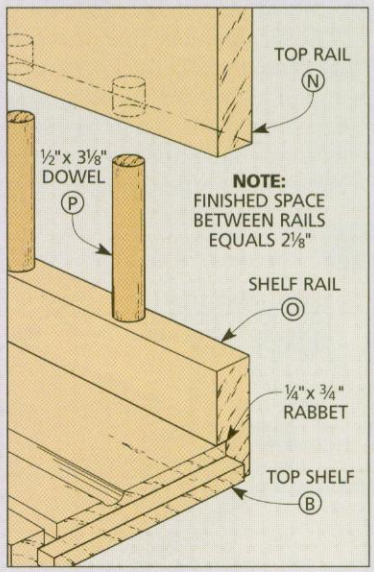


CONSTRUCTION NOTES:

- Constructing this open-back version starts after the top shelf and drawer unit are already glued to the sides (refer to page 28).
- Begin by cutting blanks for the top and bottom rails (N). The bottom rail has a ¼" x ¾" rabbet along its top edge.
- Cut the profiles on these rails (N) the same as on the top and bottom of the solid back pieces (F) (refer to *Figs. 20 and 21*, page 29).
- Two rabbeted shelf rails (O) also need to be made for this version. The top shelf rail has holes drilled in it to accept dowels.
- Align the ends of the top rail and the top shelf rail and lay out the ½" dowel holes in both pieces at the same time. This way the holes will line up.
- Glue the rabbeted edge of each shelf rail to the top or middle shelf.
- Insert ½" dowels (P) into the top shelf rail, but do *not* glue them in.
- Position the top rail onto the dowels (again, no glue) and screw it into place with counterbored screws.
- Glue the rabbeted edge of the bottom rail to the bottom shelf and screw it from the outside as well.
- Plug all screw holes with ⅜" wooden screw hole buttons.







CHANGES TO MATERIALS AND HARDWARE

OPEN-BACK WALL CUPBOARD:

F	Bk. Panel Pieces (10)	Not needed
G	Splines	Not needed
N	Top/Bottom Rails (2)	¾ x 6½ -35
O	Shelf Rails (2)	¾ x 2 - 35
P	Dowels (12)	½ x 3⅛

HARDWARE:

(4) No. 8 x 1½" Fh woodscrews
(4) ⅜" screw hole buttons

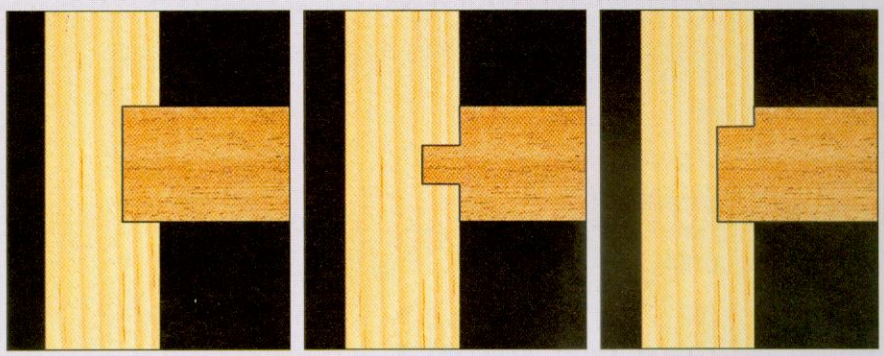
JOINERY . . . . . Tongue & Dado

It's one of the most frequently used joints in woodworking, and nobody agrees what to call it. The joint I'm referring to is a tongue and groove, or a tongue and dado, or a stub tenon and dado. The name changes depending on how it's cut on the workpieces.

For example, it's called a tongue and groove joint when it's used to join two boards edge to edge.

But when this same joint is used to join a shelf to the side of a cabinet, the names change. The groove is now a dado because it's cut across the grain. The tongue might be called a tenon because it's cut on the end rather than the edge.

No matter what you call it, this joint is very handy in cabinet work.Most frequently it's used to join shelves to cabinet sides, or to join the sides to the top and bottom. It can also be used to construct drawers.



FULL THROUGH DADO | TONGUE AND DADO | BARE-FACED TONGUE

JOINERY OPTIONS

In all of these applications, what you're doing is cutting a tongue (or a tenon) to fit in a dado.

FULL THROUGH DADO. But why use a tongue and dado at all? If you're joining shelves to the sides of a cabinet, why not save time and cut the dado to width to match the thickness of the shelves; see "Full Through Dado" photo above. This way you wouldn't have the extra step of cutting a tongue to fit the dado.

The problem is that there can be slight variations in thickness across the width of a shelf, or it's warped slightly. Then the dado is cut to fit the thickest part of the shelf, or it's cut a little too wide to accommodate the warp. So when the joint is assembled, there are noticeable gaps.

TONGUE AND DADO. To produce a cleaner joint, I often cut the dado thinner than the thickness of the shelf; see "Tongue and Dado" photo. Any variations are then hidden inside the joint.

Another way to improve the appearance of this joint is to cut *stopped* dadoes. If the dado is run all the way across the cabinet side, you will see the joint on the front edge of the cabinet. However, if the dado is stopped ½" or so from the front edge, it has a cleaner appearance because the joint isn't exposed.

BARE-FACED TONGUE. There's one more variation on this joint. If the shelf is going to be subjected to considerable weight, the tongue can be made thicker for greater strength.

In this case, the dado is cut only ⅛" narrower than the thickness of the shelf. Then a *bare-faced* tongue is cut on the end of the shelf. (A "Bare-Faced Tongue" is one that has only one shoulder; see photo above.)

Just to add to the confusion, this variation is also called a rabbet/dado joint.

This joint is commonly used to join the top and bottom of a cabinet to the sides, and also to join the back of a drawer to the sides. (See example in *Fig. 29* on page 30.) In both of these cases, the rabbet is cut a little deeper to produce a thinner tongue.

CUT THE DADOES

Once the basic configuration of the joint is determined, the next decision to make is which part to cut first, the tongue or the dado.

I've found it's easier to sneak up on the size of the tongue (it's exposed and easier to get to) than it is to adjust the width of the dado. So, I start with the dado, and then cut the tongue to fit.

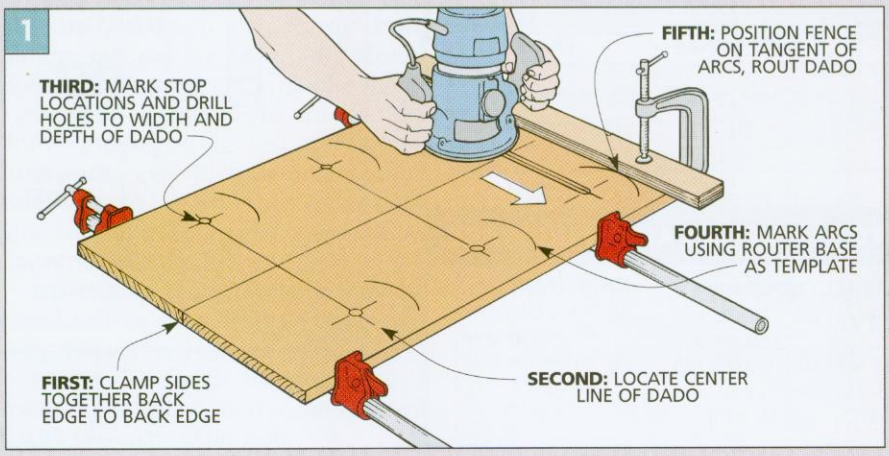
STOPPED DADO. There are a lot of ways to go about cutting a dado, but the trick is how to cut stopped dadoes on *both* cabinet sides, and make sure they line up exactly. To do this, I use a router and the following procedure.

First, I clamp the two cabinet sides together — back edge-to-back edge *(Fig. 1)*. Then mating dadoes can be cut in both pieces at the same time by routing one pass across the boards.

POSITIONING FENCE. The critical part of this procedure is positioning the fence to guide the router. I work off the centerline of the dado. For example, on the wall cupboard the top dado is centered 7¾" down from the top edge.

To position the fence, one method is to mark off a distance equal to one-half the diameter of the router's base. If a router with a 6"-dia. base is used, the fence is positioned 3" from the center line of the dado.

This method usually works fine, but



I've noticed at times the dado has been as much as 1/16" off where it should be.

The problem is that the collet that holds the bit is supposed to be centered on the router base. But this is rarely the case. If it's not centered, the distance from the edge of the base to the bit can vary. This means the position of the groove depends on which "edge" of the router base you hold against the fence.

After getting frustrated with this approach, I came up with a more accurate procedure.

Clamp the boards edge-to-edge as before, and mark the points where the dado must stop from the front edge of the cabinet's side piece *(Fig. 1)*.

At these points, drill a stop hole the same diameter as the width of the dado. (On the wall cupboard, I drilled a 1/4"-dia. hole, 3/8" deep.)

Now here's the trick. Mount a 1/4" straight bit in the router and position the bit *in* one of the stop holes. Then hold the router in the same position it will be during routing and mark a partial arc to indicate the circumference of the base *(Fig. 1)*. Do the same at the other stop hole.

Then, using these two arcs, align the fence and clamp it in place. To rout the dado, place the router bit in one of the stop holes and rout to the other hole.

Note: This brings up the question of which direction to move the router along the fence. I like to think of the direction I would move the router if I were routing *all the way around* the fence. I always move counterclockwise. Then the direction of the bit will help pull the router in tight against the fence.

CUT THE TONGUES

After the dadoes are routed in the cabinet's sides, the tongues can be cut on the ends of the shelves. There are actually two problems here.

The tongues have to be cut so they fit snugly in the dadoes. But since tongues are cut on *both* ends of the shelf, the other critical measurement is the distance between the shoulder of the tongue on one end and the shoulder on the other end.

To end up with the correct shoulder-to-shoulder length, cut the shelf to length allowing for the length of the tongues on each end. Then, as the tongues are cut to fit the dado, also be sure to check the shoulder-to-shoulder distance between the tongues.

ROUTER TABLE. If I'm working with shelves made of plywood, I use a router table to cut the tongues. (Plywood seems to chip out less when cut with a router than with a saw blade.)

To set up for the cut, I use a straight router bit that's larger in diameter than the length of the tongue. That is, if the tongue is 1/4" long, I use a 1/2" or 3/4" straight bit on the router table.

Then it's just a matter of adjusting the fence for the length of tongue you want, and raising the bit to cut a rabbet on each face of the shelf. (It's usually best to raise the bit in increments, sneaking up on the thickness of the tongue until it fits snugly in the dado.)

DADO BLADE METHOD. If the shelf is solid wood (rather than plywood), I usually cut the tongue on a table saw or radial arm saw using a dado blade.

TABLE SAW. To use the dado blade on the table saw, attach an auxiliary wooden fence to the table saw's metal fence. Then move the wooden fence over the dado blade *(Fig. 2)*. Turn on the motor and raise the blade into the fence to cut a relief.

Then turn off the motor and adjust the blade height to cut rabbets on both faces to produce the tongues.

RADIAL ARM SAW. On the radial arm saw, the process is very similar. Just clamp a stop block to the fence and adjust its position so the dado blade will cut a tongue to the exact length needed *(Fig. 3)*.

TRIM THE TONGUES

As mentioned above, I usually cut stopped dadoes in the cabinet side. This means the front corner of the tongue has to be trimmed to fit the dado.

It's tempting here to use a hand saw to cut down the shoulders and form a notch. But a saw (even a fine dovetail saw) makes a ragged cut. I prefer to use a chisel to get a nice smooth shoulder.

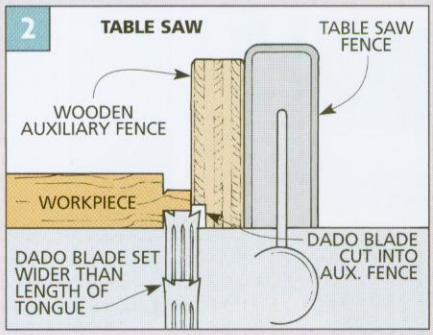
MARK SHOULDER. First I mark the shoulder on the tongue by holding the back of a chisel against one rabbet and roll it halfway over the top of the tongue *(Fig. 4)*. Then I position it on the other rabbet and roll the other side.

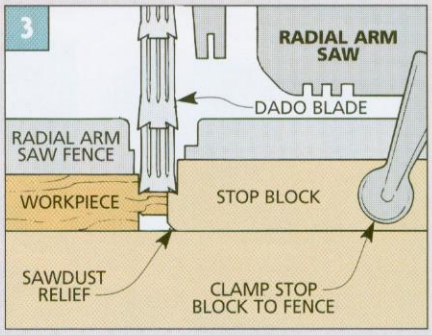
When the top has been marked, hold the chisel in this mark and press down firmly to mark the shoulder line. Don't use a mallet yet. It's better to use hand pressure to carefully mark the shoulder line and carve out a small notch. This small notch sets the shoulder line as it will be seen on the front of the shelf.

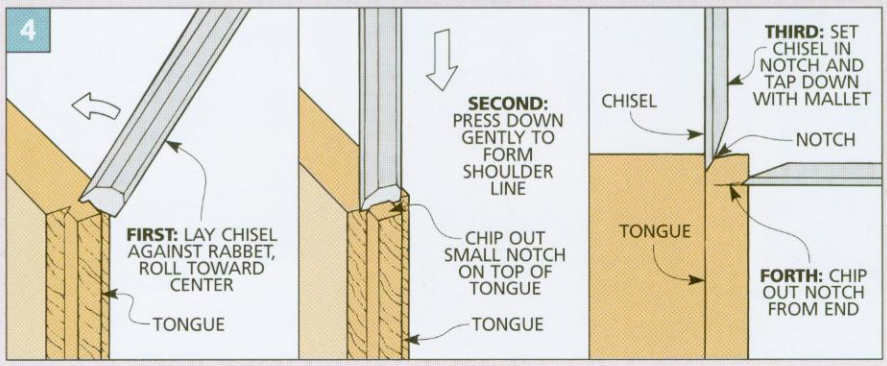
CUT DOWN SHOULDER. Once this line is set, it's just a matter of using the chisel and a mallet to chip away a larger notch to fit the stopped dado.

Note: One thing about the size of the notch. It doesn't have to be cut so the notch fits snugly against the front of the stopped dado. In fact, it can be cut back an extra 1/8" or 1/4".

All of the alignment should be done off the back edge because it's easier to get to during assembly.







Stacking Storage

Perfect for a shop, garage, or dorm room, these interlocking "crates" are quick to build and can be arranged any number of ways — as shelves, a simple entertainment center, or a sturdy work table.

At first look, these storage racks might remind you of the old wooden packing crates farmers used for shipping fruits and vegetables.

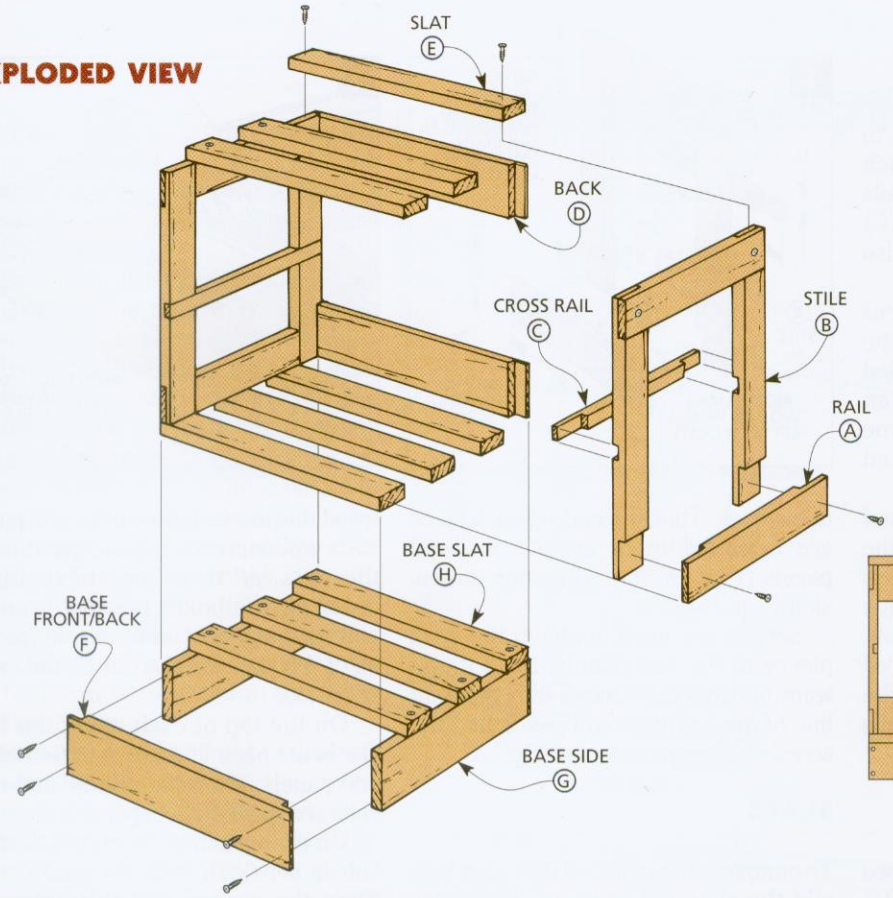
But look a little closer. The most intriguing thing about the design is the way these "crates" stack together. The slats on the top of one crate interlock neatly and securely with the slats on the bottom of the crate above.

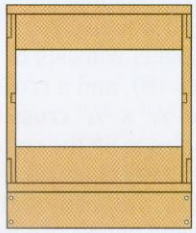
Aside from this stacking feature, the crates have other advantages. They're simple to build and don't require much in the way of materials. You can add more units as you need them. And a built-in "handle" makes them easy to move around.

Finally, they're modular so they can be arranged in a wide variety of configurations. This makes them great for shop storage, or for use in a college dormitory room. (You can even add a top to make a work surface; see page 37.)

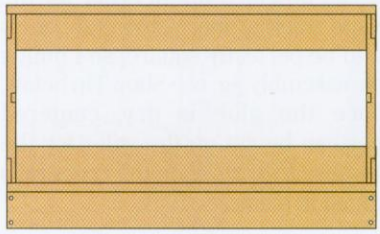
SIZES. I used pine to build two sizes of crates — a small crate 15½" long and a larger one 31" long. You can make the crates any size you want by simply changing the length of the slats and the back pieces.

EXPLODED VIEW





SMALL CRATE AND BASE
CRATE :15½H x 15½W x 12¾D
BASE: 3¾H x 15½W x 13D



LARGE CRATE AND BASE
CRATE :15½H x 31W x 12¾D
BASE: 3¾H x 31W x 13D

MATERIALS LIST

FOR ONE SMALL CRATE & BASE

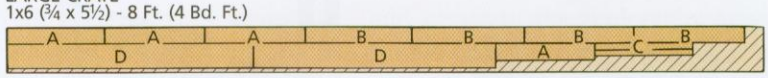
WOOD

A	Rails (4)	¾ x 2 - 12½
B	Stiles (4)	¾ x 2 - 14
C	Cross Rails (2)	¾ x ¾ - 12½
D	Backs (2)	¾ x 3 - 15½
E	Slats (6)	¾ x 2 - 15½
F	Base Front/Back (2)	¾ x 3 - 15½
G	Base Sides (2)	¾ x 3 - 12½
H	Base Slats (3)	¾ x 2 - 15½

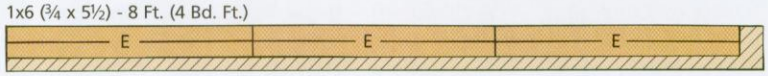
HARDWARE SUPPLIES
(8) No. 8 x ⅝" Fh woodscrews
(34) No. 8 x 1¼" Fh woodscrews

CUTTING DIAGRAM

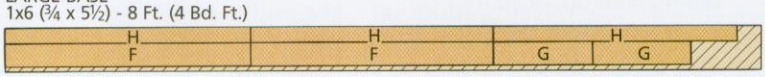
LARGE CRATE
1x6 (¾ x 5½) - 8 Ft. (4 Bd. Ft.)



1x6 (¾ x 5½) - 8 Ft. (4 Bd. Ft.)



LARGE BASE
1x6 (¾ x 5½) - 8 Ft. (4 Bd. Ft.)



Note: If crates are being stacked, only one base (parts F, G, H) is needed per stack.

MATERIALS LIST

FOR ONE LARGE CRATE & BASE

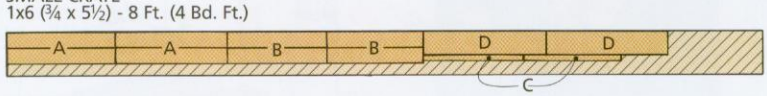
WOOD

A	Rails (4)	¾ x 2 - 12½
B	Stiles (4)	¾ x 2 - 14
C	Cross Rails (2)	¾ x ¾ - 12½
D	Backs (2)	¾ x 3 - 31
E	Slats (6)	¾ x 2 - 31
F	Base Front/Back (2)	¾ x 3 - 31
G	Base Sides (2)	¾ x 3 - 12½
H	Base Slats (3)	¾ x 2 - 31

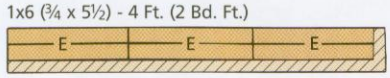
HARDWARE SUPPLIES
(8) No. 8 x ⅝" Fh woodscrews
(34) No. 8 x 1¼" Fh woodscrews

CUTTING DIAGRAM

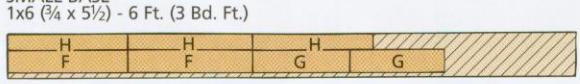
SMALL CRATE
1x6 (¾ x 5½) - 8 Ft. (4 Bd. Ft.)



1x6 (¾ x 5½) - 4 Ft. (2 Bd. Ft.)



SMALL BASE
1x6 (¾ x 5½) - 6 Ft. (3 Bd. Ft.)



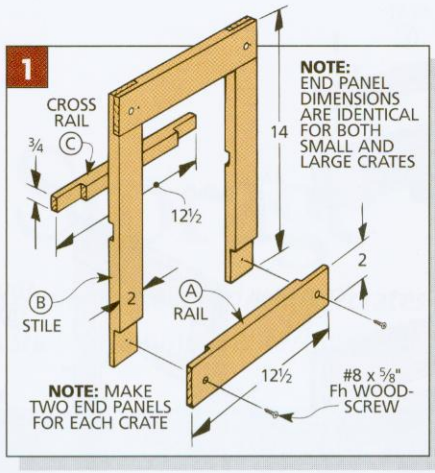
END PANELS

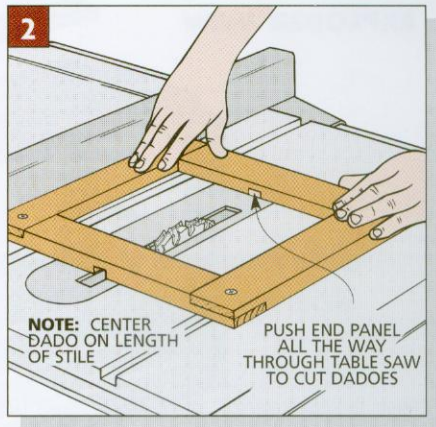
The first step in building the crates is to make the end panels from ¾"-thick stock. Each panel consists of two rails (A), two stiles (B), and a cross rail (C) *(Fig. 1)*. The ¾" x ¾" cross rails also serve as handles to lift the crates.

CUT HALF LAPS. Once all the pieces are cut to size, you can begin on the joinery. The end panels are assembled with half lap joints. Cut the half laps on the ends of all the pieces to the same width as the matching pieces (2") and half the thickness of the stock (⅜").

With the half laps cut, the rails and stiles can be glued up. In order for the crates to stack properly, the end panels need to be perfectly square, so I built a simple assembly jig; see Shop Tip below.

Once the glue is dry, centered dadoes can be cut on the stiles for the cross rails *(Fig. 2)*. Then the cross rails are glued in place.





BACK

The end panels are connected by two identical back pieces. These backs (D) are just a couple of 3"-wide pieces of ¾"-thick stock. Then the ends of each piece are rabbeted to fit around the end panels *(Fig. 3)*. For large crate dimensions, see *Fig. 3b*.

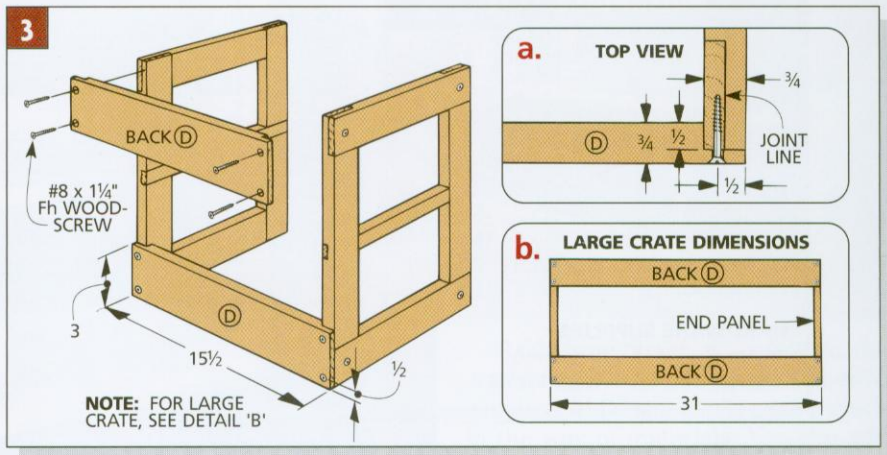
Screws are used to attach the back pieces to the end panels. But I didn't want to drive the screws into the joint line of the half laps, so I positioned the screws ½" from the ends *(Fig. 3a)*.

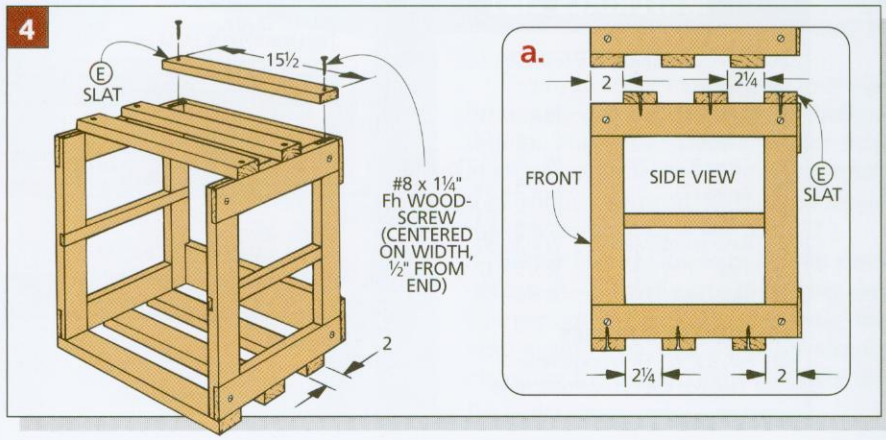
SLATS

To complete the crate, all that's left is to add the slats (E) *(Fig. 4)*. These are nothing more than 2"-wide pieces of wood that are fastened to the end panels with woodscrews (again, positioning the slats ½" from the ends). But in order for the boxes to stack properly, you need to pay careful attention to how all of the slats are spaced on the crates *(Fig. 4a)*.

On the top of each crate, the front slat is set back 2" from the front of the end panels. Then the second and third slats are spaced 2¼" apart.

On the bottom of the crates, the front slat is set flush with the end panels. Then the second and third slats are attached, again spaced 2¼" apart.

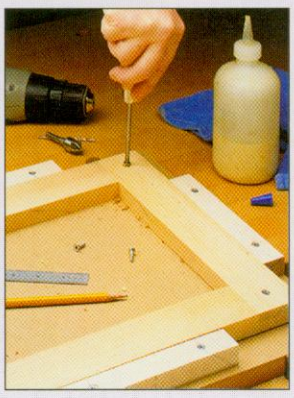




SHOP TIP
Assembly Jig

To keep the panels square during glue-up, build a jig by screwing four cleats to a base. (I used a square to position the cleats.)

While the panel is in the jig, insert a screw in each corner. Then the panel can be removed immediately.



BASE

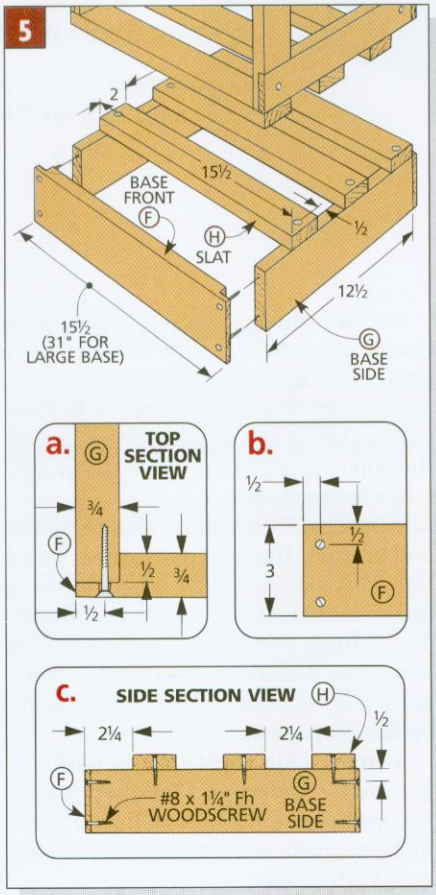
To lift the crates up off the floor a few inches, I built a base. It's just an open box with three slats across the top. And it uses the same interlocking feature found on the crates.

The base is also similar to the crates in that it can be built in a small size (15½" wide) or a large size (31" wide).

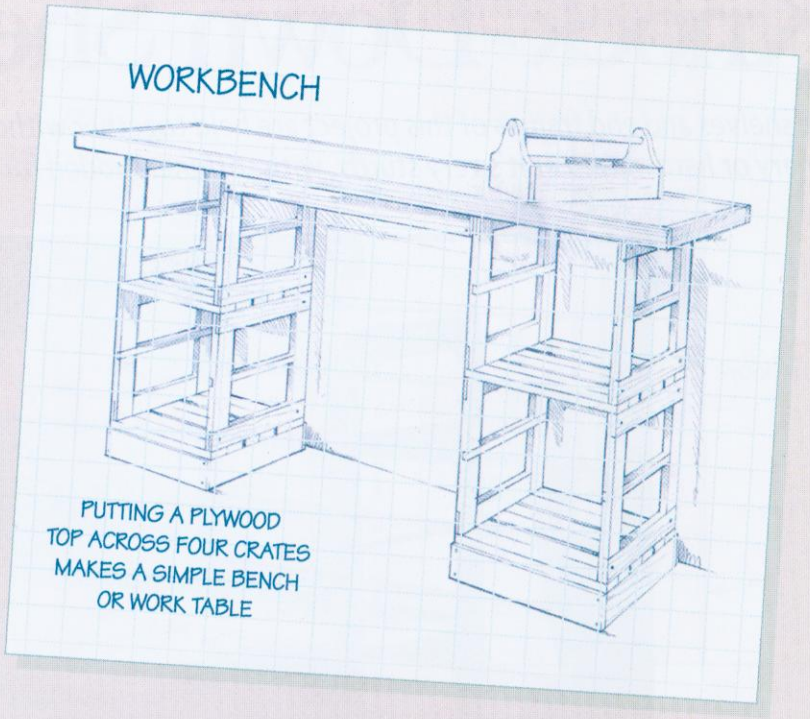
CUT PIECES. Start by cutting the front and back pieces of the base (F) to size (3" wide and to the same length as the backs of the crates) *(Fig. 5)*. Then cut rabbets on both ends of these pieces to accept the sides *(Fig. 5a)*. The front and back pieces of the base end up identical to the backs of the crates.

Next, the base sides (G) are cut 3" wide and to the same length as the crate rails (12½") *(Fig. 5)*. Then the front and back can be screwed to the sides; see Figs. 5a and 5b.

MOUNT SLATS. The front of the base projects slightly (¼") from the crates. To create this projection, the first slat is set back 2¼" from the front of the base. Then the other two slats are spaced 2¼" apart *(Fig. 5c)*. ■



DESIGNER'S NOTEBOOK



CONSTRUCTION NOTES:

■ To add a work surface across two sets of crates, first cut a piece of ¾" plywood 14½" wide and 70½" long.

■ Glue and nail ¾" x 1½" edging around the plywood top. The edging is joined at the corners with butt joints (with the long sides running by); see drawing below. Set the nails and fill the holes with wood putty. When the putty dries, sand it smooth.

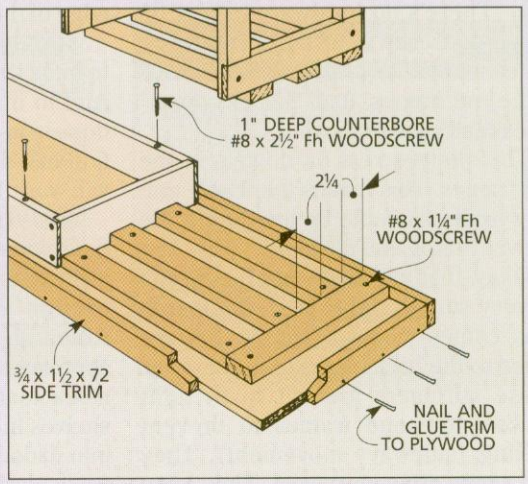
■ To fill the area between the two stacks, build a base unit as shown at left — but without any of the slats. Construct this large base filler unit with 31"-long fronts and backs.

■ Screw the base filler unit to the underside of the plywood top with six counterbored screws. Center the filler unit on the length of the plywood top and tight against the inside face of the back edging strip.

■ To help keep the plywood top from shifting, add cleats to the underside; see drawing. You will need eight ¾"-thick by 2"-wide cleats. Cut six of the cleats 15½" long and two cleats 12¾" long to use as end cleats.

■ Glue and screw the cleats to the bottom of the plywood as shown in the drawing below.

■ When the plywood top is placed on top of the crates, the cleats and the filler unit trap the crates in position.



Knock-Down Shelf Unit

The shelves and end frames of this project are held together without using any permanent joinery or hardware. Yet it's very sturdy, with stiffeners added for support.

The primary design feature of this shelf unit is one you can't see. There's no hardware except fifteen woodscrews. In fact, there's no permanent joinery holding the shelves to the end frames. It all "knocks down" for easy storage or moving.

The shelves rest on dowels in the end frames. This makes the whole unit easy to disassemble by just lifting the shelves off the end dowels.

Okay, that makes it easy, but it can't be very sturdy, right? Well, the sturdiness comes from stiffeners that are added to the back edges of the shelves. These stiffeners are cut to fit tight between the end frames to prevent racking (sideways movement). They also serve other purposes. They keep the shelves from bowing under weight, and they work well as back stops for books so they don't slide off the back edge of the shelf.

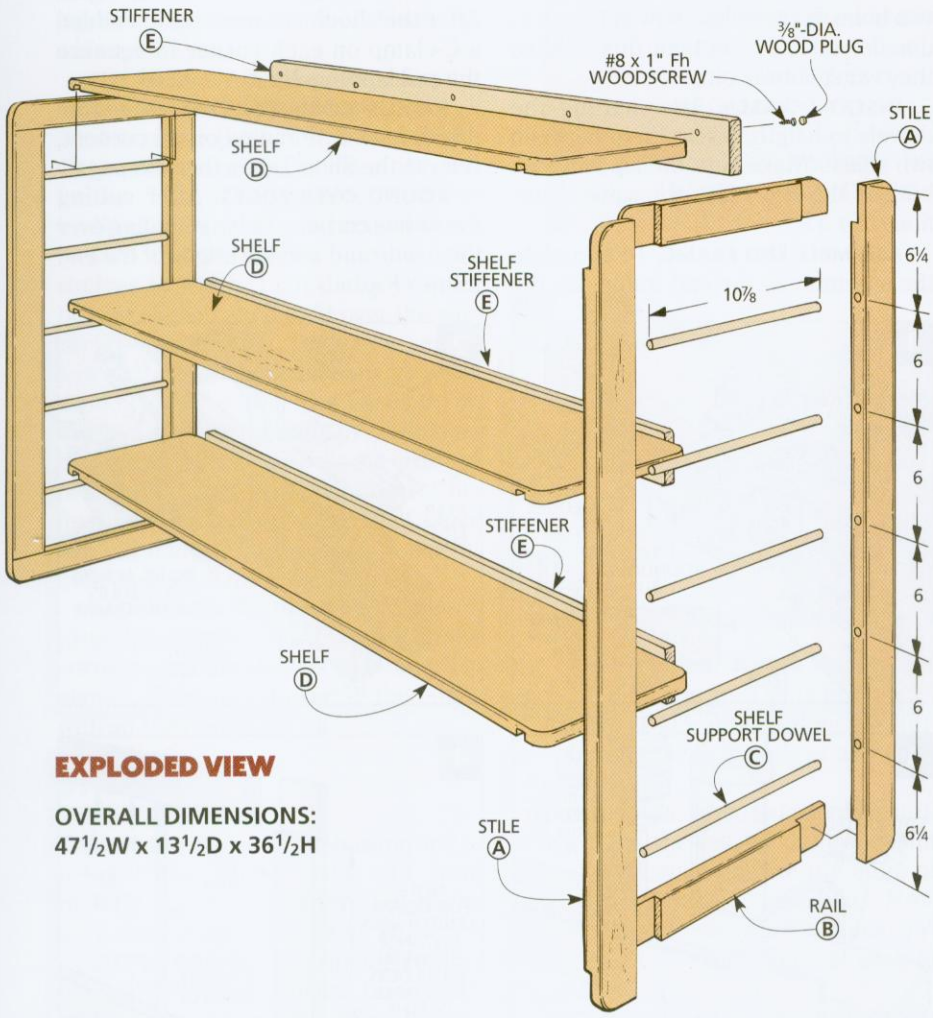
MATERIALS. I used $\frac{3}{4}$"-thick red oak to build the shelves and the end frames. And to match these parts, I used oak dowels in the end frames. (If you can't find oak dowels, any hardwood dowels will work.)

SHELVES. One of the first considerations when buying the lumber for a project like this is getting stock that's wide enough for the shelves ($9\frac{1}{2}$" wide). Although that might be the easiest approach, it may not be the best. Wide stock tends to warp easily. Since the shelves in this project are not mounted into dadoes in the end frames, they are particularly susceptible to warp as time goes on.

So, for this project I glued up a couple of narrower strips to make each shelf. The different grain patterns in each strip will help prevent warp. (You will notice in the Cutting Diagram on the opposite page that I have shown two strips for each shelf.)

CORNERS. There's one feature on the end frames that's typical on a lot of knock-down furniture projects — a radius is cut on each corner to soften it. To cut these radii, I used a method that produces a uniform radius on every corner. Check out this procedure in the tip box on page 41.

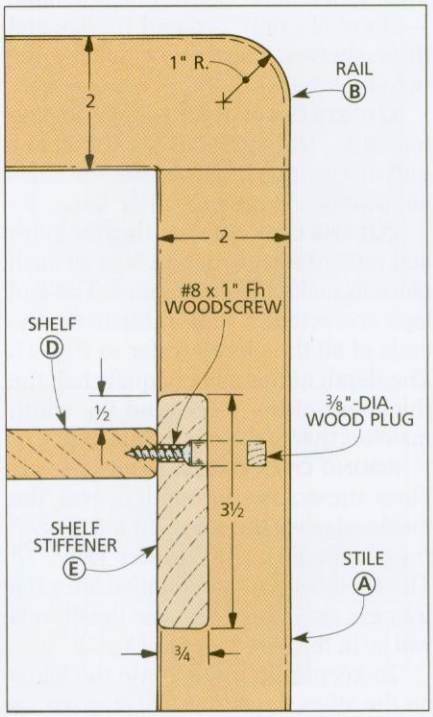
FINISH. This shelf unit is likely to take some abuse, so I finished it with two coats of a durable satin polyurethane varnish, sanding lightly between each of the coats.



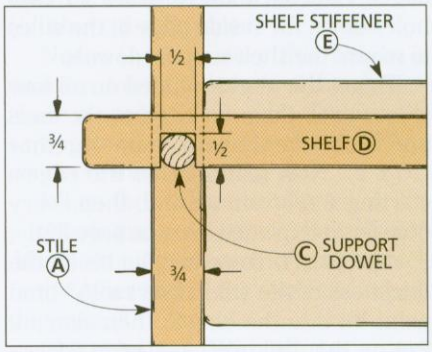
EXPLODED VIEW

OVERALL DIMENSIONS:
47 1/2W x 13 1/2D x 36 1/2H

CORNER/STIFFENER



SHELF/DOWEL



CUTTING DIAGRAM

3/4 x 7 1/2 - 96 (5 Bd. Ft.)

A	B	E
A	B	E
A	B	

3/4 x 4 - 96 (2.6 Bd. Ft.)

A	B	E

3/4 x 5 1/2 - 96 (Three Boards @ 3.6 Bd. Ft. Each)

D	D
D	D
D	D

MATERIALS LIST

WOOD

A	Stiles (4)	3/4 x 2 - 36 1/2
B	Rails (4)	3/4 x 2 - 13 1/2
C	Sup. Dowels (10)	1/2 x 10 7/8
D	Shelves (3)	3/4 x 9 7/16 - 47 1/2
E	Shelf Stiffeners (3)	3/4 x 3 1/2 - 44 1/4

HARDWARE

(15) No. 8 x 1" Fh woodscrews
(15) 3/8"-dia. wood plugs

STILES AND RAILS

This shelf unit is relatively easy to build — there are only two end frames and three shelves. I started by making the two end frames.

CUT STILES & RAILS. Begin by ripping four stiles (A) and four rails (B) all to a uniform width of 2". Then cut the stiles 36½" long and the rails 13½" long.

CUT END LAPS. After cutting the stiles and rails to size, I cut end laps on each piece to make the end frames. The end laps are actually wide rabbets on the ends of all the pieces (refer to *Fig. 4*). The depth of the rabbet equals half the thickness of the piece, and the width matches that of the mating piece (2").

ROUND OVER EDGES. Before assembling the frame, I rounded over the inside edges of the stiles (A) using a ⅛" roundover bit in the router *(Fig. 1)*. These edges can't be rounded after the frame is assembled because the dowels will be in the way (refer to *Fig. 5*).

To keep from routing into the joints on the stiles, I made pencil stop marks 2½" from each end *(Fig. 1)*.

LAY OUT HOLES. After rounding the edges, I laid out marks to drill a series of holes down the inside edge of the stiles to mount the shelf support dowels.

To get the marks aligned on all four stiles, stack them on edge so the ends are flush, then clamp them together *(Fig. 2)*. Now mark across the edges, starting 6¼" from an end, then every 6" (refer to Exploded View on page 39).

CENTER BIT. To center the bit on the thickness of the stile, insert a ½" brad point bit into the chuck, then clamp a 2x4 on the drill press table for a fence *(Fig. 3)*. Now put the outside face of a stile against the fence. With the drill press off, lower the bit so the bit's point makes a mark in the wood. Flip the stile around, so the other face is against the fence and lower the bit again. If the point on the bit doesn't exactly enter the first mark, adjust the fence and try again until you only make one mark.

DRILL HOLES. Once the bit is centered, drill five holes ¾" deep into the *inside* edge of each stile.

END FRAME ASSEMBLY

After drilling all of the holes for the support dowels, the next steps are to cut the dowels and then assemble the end frame units.

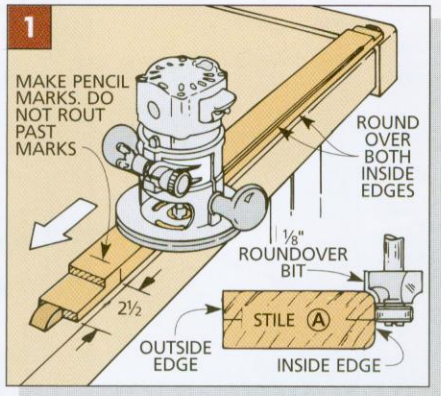
CUT SHELF SUPPORT DOWELS. First, I cut the shelf support dowels (C) to length. To determine the length, measure the distance between the shoulders of the rails (9½") *(Fig. 4)*. Then add to this measurement the depths of two holes in the stiles. Now cut ten ½"-dia. dowels ⅛" less than this total so they won't bottom out.

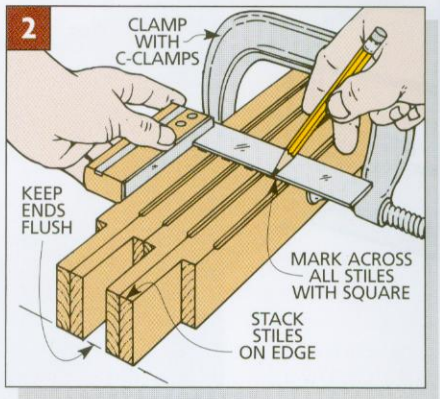
INSERT DOWELS. After cutting the dowels to length, insert them between two stiles. (Make sure the lap joints on both of the stiles face the same direction *(Fig. 4)*.

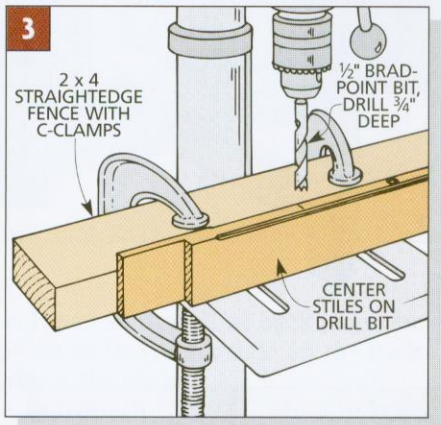
ASSEMBLE END FRAME. To complete the assembly of the end frame, lay the stile assembly flat across two pipe clamps so the end laps face up *(Fig. 5)*. Next apply glue to the end laps on the rails and clamp them to the end laps on the stiles using three pipe clamps to pull the shoulders tight, as shown in *Fig. 5*. After the shoulders were tight, I added a C-clamp on each corner to squeeze the end laps together.

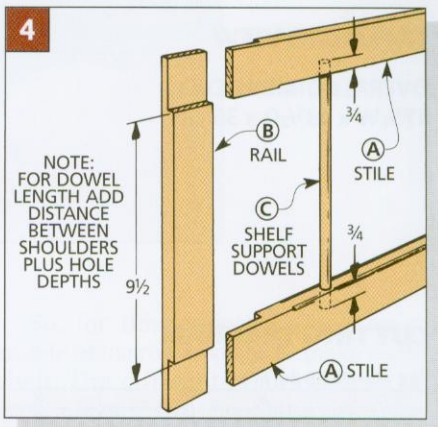
RADIUS CORNERS. Once the glue dried, I cut a 1" radius on all corners, refer to the Shop Tip on the next page.

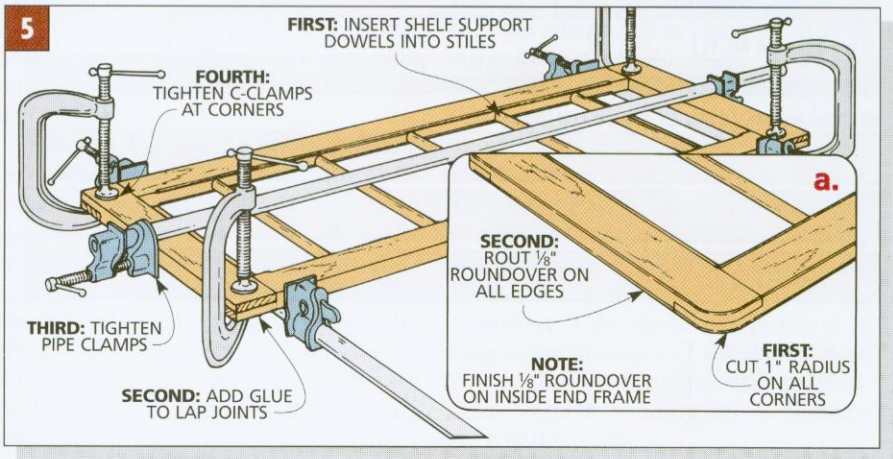
ROUND OVER EDGES. After cutting the radius corners, finish rounding over the inside and outside edges of the end frame *(Fig. 5a)*.











SHELVES

With the end frames finished, work can begin on the three adjustable shelves (D). To prevent the shelves from warping, I edge-glued two boards together to make each shelf blank 11" wide by 48" long.

CUT TO SIZE. After the glue dries, cut the shelves to a finished length of 47½". To determine the width, measure the distance between the inside of the end frames. Then cut the shelves 1/16" less to allow for expansion and contraction.

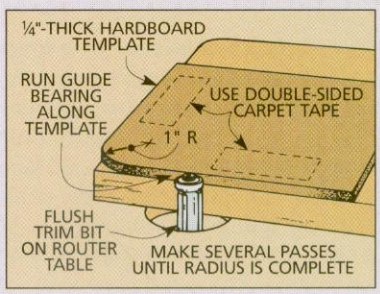
CUT DADOES. After cutting the shelves to width, I cut dadoes on the bottom of each shelf to fit over the support dowels *(Fig. 6)*. To do this, set the fence 1⅛" from the inside of a ½"-wide dado blade *(Fig. 6a)*. Now sneak up on the final depth of the dado by raising the blade and making a pass on a scrap piece until a shelf support dowel fits flush with the bottom of the shelf. Once set, cut dadoes on the bottom face at both ends of all three shelves.

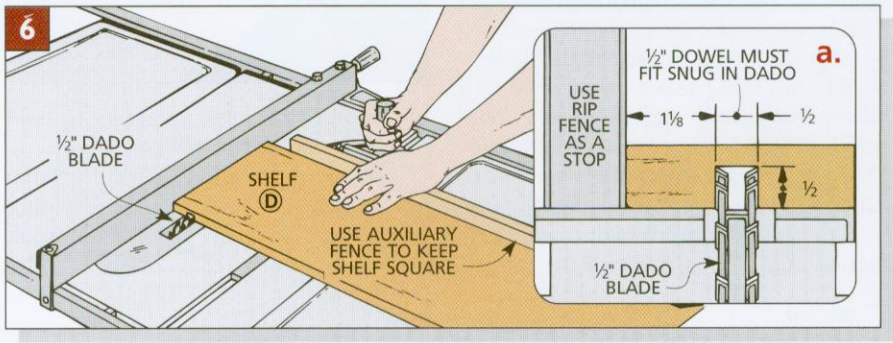
RADIUS AND ROUND OVER. To complete the shelves, cut a 1" radius on the corners of all the shelves (see Shop Tip above). Then round over all the edges with an 1/8" roundover bit.

SHOP TIP . . . . . Radius Cutting

One way to round consistent corners is with a template and flush trim router bit. Make the template from hardboard with a 1" radius on one corner. Cut the radius oversize, and *carefully* clean to the line using a disc sander.

To use the template, stick it on the workpiece with carpet tape. Then cut the radius in several passes.





STIFFENERS

To keep the shelves from bowing and to prevent the whole shelf unit from racking, I added stiffeners (E) to the back edge of each shelf *(Fig. 7)*.

CUT TO SIZE. Start by ripping enough stock 3½" wide to make three stiffeners. To determine the length, assemble the unit, and measure the distance between the end frames along the shelves. Cut the stiffeners to length by starting a little long, then sneak up on the finished length. Check the fit after each cut until you get a snug fit.

ROUND EDGES. After cutting the stiffeners, round over the edges and ends *(Fig. 7a)*.

DRILL HOLES. Next, to fasten the stiffeners to the shelves, lay out a series of holes 7/8" down from the top edge of each stiffener *(Figs. 7 and 7a)*. Now drill 3/8"-dia. counterbore holes 1/4" deep, then 3/16" shank holes at each of the marks.

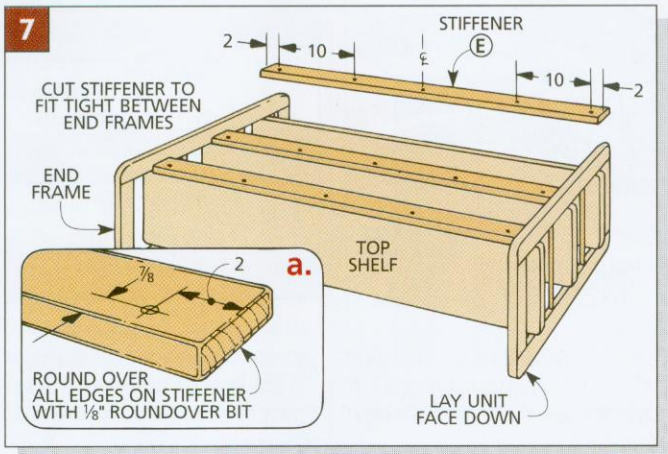
FASTEN STIFFENER. After drilling the holes, the stiffener can be screwed to the shelf. I found the easiest way to do this was to lay the front of the unit down flat *(Fig. 7)*.

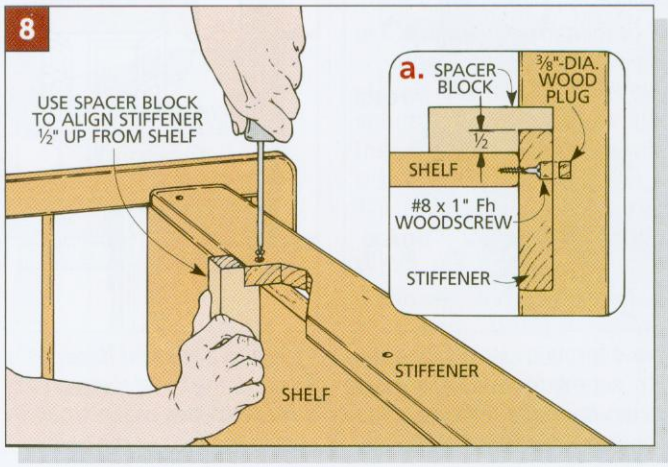
To provide a "back lip" for the shelves, position each stiffener so it's ½" above the top face of the shelf.

Note: To make sure this height is uniform down the length of the shelf, I made a spacer block out of a piece of scrap. Just cut a ½" notch out of one corner of the block *(Fig. 8)*.

When the stiffener is aligned, drill a pilot hole and screw down the stiffener. After fastening, move the spacer block to the other end of the shelf and repeat the procedure.

INSERT PLUGS. With all the screws down tight, I glued wood plugs into the holes in the stiffeners, and trimmed them off flush *(Fig. 8a)*. ■





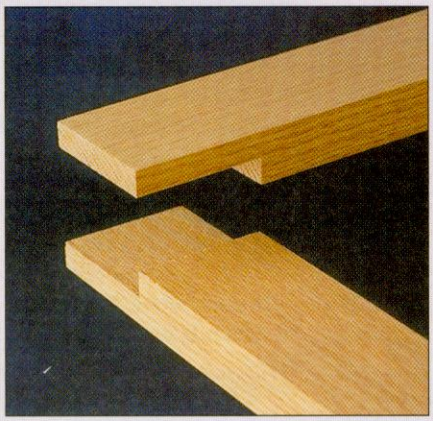
JOINERY . . . . . End Laps

There's a common belief that cutting a half lap is easy, certainly much easier than cutting a mortise and tenon joint. But what you're actually doing when you make a half lap (or end lap as it's called if it joins the ends of two boards) is cutting two tenons.

The tenons you're cutting are barefaced tenons. That is, there's only one shoulder — the other face is "bare" (no shoulder). And, just as with tenons, there are two ways to go about cutting a half lap.

One method is to use a dado blade to make multiple passes on the end of a workpiece; see below. The other method involves two cuts: a shoulder cut, and then a face cut that's made with the aid of a tenon jig; see opposite page.

Which is easier? Which produces a better joint? The quality of the joint is



based on two things: its ability to hold together, and its overall appearance.

The second method (using the tenon jig) wins in both cases. The adjoining faces of the half laps are much smoother using this method. The smooth surfaces provide a stronger glue joint, and produce a cleaner appearance without gaps around the edges of the joint.

But the other method (making multiple passes over a dado blade) is faster to set up. And its quality is not too bad.

Both methods begin by cutting the workpieces to size. Typically you're cutting stiles (vertical pieces) and rails (horizontal pieces). Rip all of the pieces to final width first. Next, cut them all to final length.

Then no matter what method you use, you'll also need some test pieces. The object is to cut two half laps in the test pieces that are exactly one-half the thickness of the stock. With both methods, this is achieved through trial and error — by gradually sneaking up on the cuts on the test pieces.

MULTIPLE PASS METHOD

One of the fastest ways to set up for cutting half lap joints is to make multiple passes over a dado blade.

SET RIP FENCE. To set up the cut, mount a dado blade in the saw. Then I use the rip fence as a stop to establish the position of the shoulder on the workpiece. Use one of the mating pieces as a gauge to adjust the fence until the edge of the workpiece is aligned with the *outside* edge of the blade *(Step 1)*.

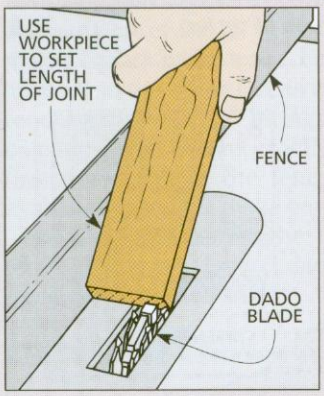
SET DEPTH OF CUT. Next, set the height of the dado blade so it's just a little bit less than half the thickness of the workpiece *(Step 2)*.

MAKE MULTIPLE PASSES. Now it's a matter of making test cuts to sneak up on the final depth of cut. While guiding the test piece with the miter gauge, make the first cut with the end of the piece against the rip fence *(Step 2)*. This establishes the shoulder. Then continue to remove the rest of the material out to the end of the piece.

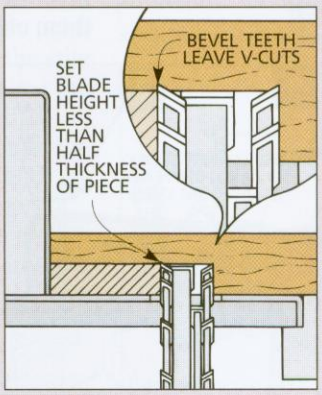
The only problem is the quality of the cut surface. When you use a stack dado set you can get a series of small V-shaped kerfs in the cuts that show on the edges *(Step 2)*.

How do you get rid of the small V-cuts? After making the initial passes, I hold the cut face over the dado blade and slide it right to left, while moving it forward and back with the aid of the miter gauge *(Step 3)*.

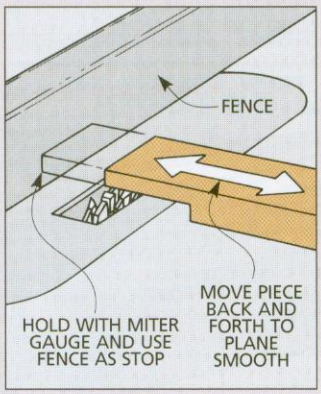
To complete the joint, make passes on the ends of *two* test pieces and check the fit. Then gradually raise the blade (deepening the cut) until the outside surfaces of the two pieces are flush *(Step 4)*.



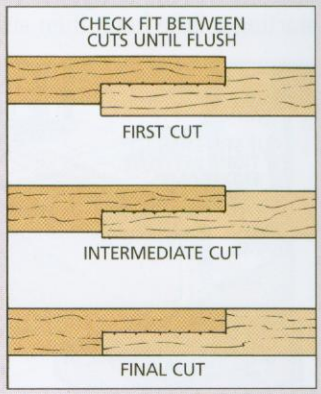
1 *Mount a dado blade and set the fence as a stop. Use a workpiece to set the distance between the fence and blade.*



2 *When a stacked dado set is used, the bevel teeth on the outside blades make small V-cuts in the face of the half lap.*



3 *To remove the V-cuts, slide the workpiece right and left over the blade while pushing it forward and back.*



4 *Make repeated passes over the end of two test pieces. then check the fit until the outside surfaces are flush.*

CUTTING END LAPS WITH A TENON JIG

The best way to get smooth surfaces on the faces of an end lap joint is to use a tenon jig. This produces a joint with a better appearance and smooth faces for a stronger gluing surface.

CUT THE SHOULDER. To cut an end lap with this method, first you have to make a shoulder cut. This sets the length of the joint from the end of the workpiece.

To make the shoulder cut on the stiles, use a rail to set the rip fence as a stop. Set the fence so the distance between the fence and the *outside* edge of the blade equals the width of the rail *(Step 1)*.

Next, I raise the blade so it's about 1/16" less than half the thickness of the stock. (I set up the cut like this so the points of the blade don't cut too deep into the workpiece. Since it's easy to cut too deep, I set the initial cuts a little shallow and clean up the cut later.)

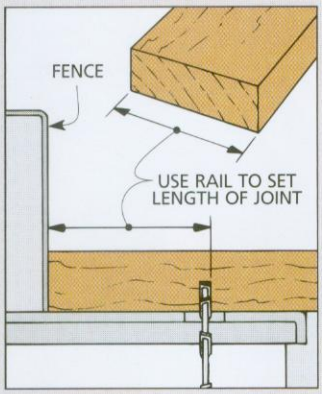
Now make a shoulder cut in all the rails and stiles. And also make shoulder cuts in a couple of test pieces.

CUT THE FACE. The face cut is made with the aid of a tenon jig (see the plans below). First, raise the blade so it cuts into the shoulder cut *(Step 2)*. I set the blade a hair less than the top surface of the shoulder cut so the points of the teeth don't cut into the shoulder.

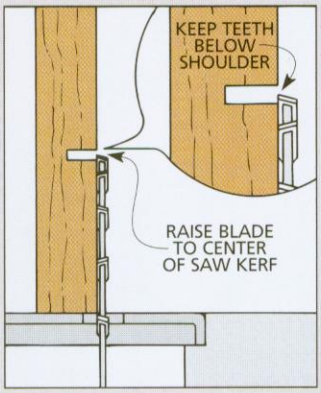
Now mount a test piece in the jig *(Step 3)*. Adjust the rip fence so the jig is in position to make a face cut that's a little more than half the thickness of the stock. Then I sneak up on the fit moving the fence (and jig) a hair at a time.

To check the progress, make the same cut in two test pieces, and then hold them together. Keep moving the fence until the outside surfaces of the two test pieces are flush. When the test pieces fit, make the cuts on the stiles and rails.

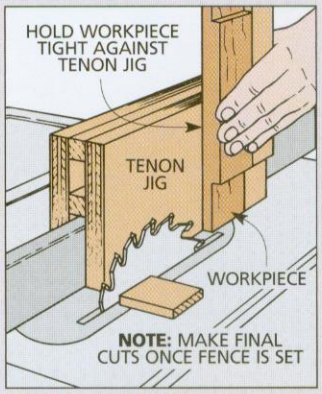
REMOVE CORNER. Now there will be a little corner at the shoulder of the end lap. Use a chisel to cut it out *(Step 4)*.



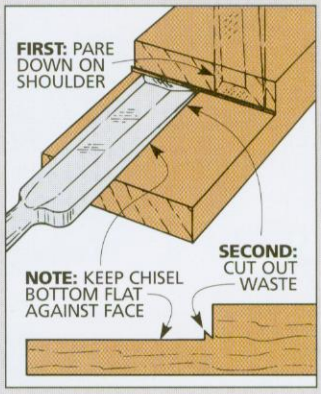
1 *Set fence to cut shoulder equal to width of rail. Set blade height 1/16" less than half the thickness of the stock.*



2 *For the face cut, set the height of the blade so the highest point cuts about halfway into the shoulder cut.*



3 *Hold the workpiece in the tenon jig. Then gradually move the fence until the blade cuts half the thickness.*



4 *The settings described in Steps 1 and 2 leave a small corner in the shoulder that's removed with a sharp chisel.*

SHOP-BUILT TENON CUTTING JIG

The jig I use to make the face cut for an end lap is the same one I use for cutting tenons. Its whole purpose is to hold the workpiece vertical.

The jig shown here is designed to straddle a rip fence. This holds it in position and also provides a way to adjust its position in relation to the saw blade.

CUT PIECES. The jig consists of two faces held together with cross pieces. There's also a vertical stop at the end of the jig.

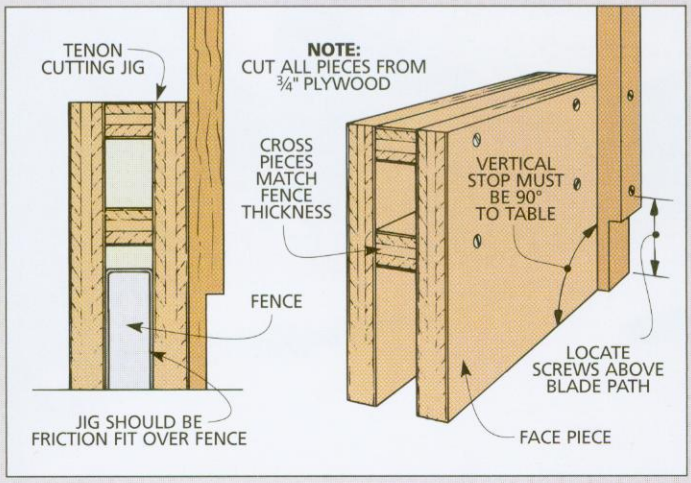
To make the tenon jig, first rip two cross pieces from 3/4" plywood to width to match the thickness of your rip fence. This width is fairly critical because you want a good friction fit against the fence when the face pieces are added. If the pieces are a hair too narrow, the jig will bind on the rip fence.

If the cross pieces are too wide, the jig will be loose on the fence. Then it's difficult to adjust when sneaking up on the face cut.

ADD SHIMS. How do you get it perfect? I try to get the pieces right on the money. But if I'm off, I try to err by making them a little narrow. Then I shim out with paper or old playing cards.

After cutting the cross pieces, cut the face pieces about 6" by 12". Screw all these pieces together and test the fit over the fence. Then add shims if necessary.

ADD VERTICAL STOP. When the jig slides easily but firmly, add a stop on the back end. As this stop is added, check that it's vertical to the saw table. And make sure the screws are above the path of the blade.

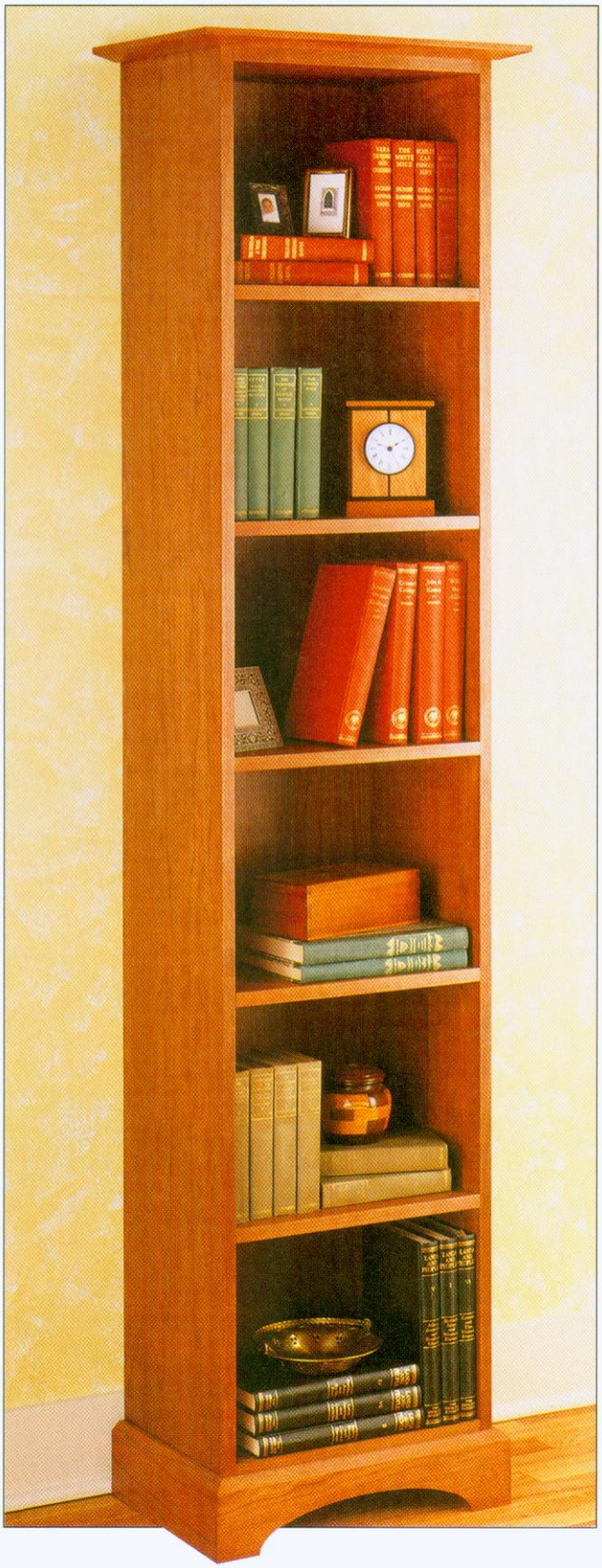


BOOKCASES

What could be simpler than a bookcase? Just shelves, sides, and a top, right? In fact, there's a lot more to building a good bookcase than you might think. Choosing realistic dimensions and selecting the right materials can be critical. And books are heavy, placing great strain on joints and horizontal surfaces.

Here are a trio of bookcase projects that range from a space-saving upright model to a full-size version with classic architectural touches. Each one incorporates interesting design and construction features. You'll also find a variety of joinery techniques that will expand your woodworking abilities and optional designs that let you make your own bookcases really special.

Tower Bookcase



Sometimes smaller can actually be better. The narrow design of this bookcase means it will fit just about anywhere. And if you prefer a shorter version, we'll show you how to make a plant stand or a smaller bookcase with a frame and panel or solid top.

Who couldn't use a little more storage space around their home? Especially when you don't have to sacrifice a lot of floor space to get it. That's the idea behind the simple design of this tower bookcase.

It takes up less than two square feet of floor space because everything is stored vertically. Yet the six shelves (four of them adjustable) can store or display a variety of items.

FEATURES. One neat thing about the adjustable shelves is how they're held in the case. Dowel pins fit into grooves on the ends of the shelves. So when the shelves are installed, the dowel pins are completely hidden.

There are a couple of other features I like about this bookcase. First of all, it's mobile. The compact size and light weight make it easy to move the bookcase anywhere extra storage space is needed.

Second, this is an easy project to customize to fit your needs. Need a plant stand or just a shorter bookcase with a solid top? In the Designer's Notebook on pages 52 and 53 you'll learn how to make it shorter and build three different designs for the top.

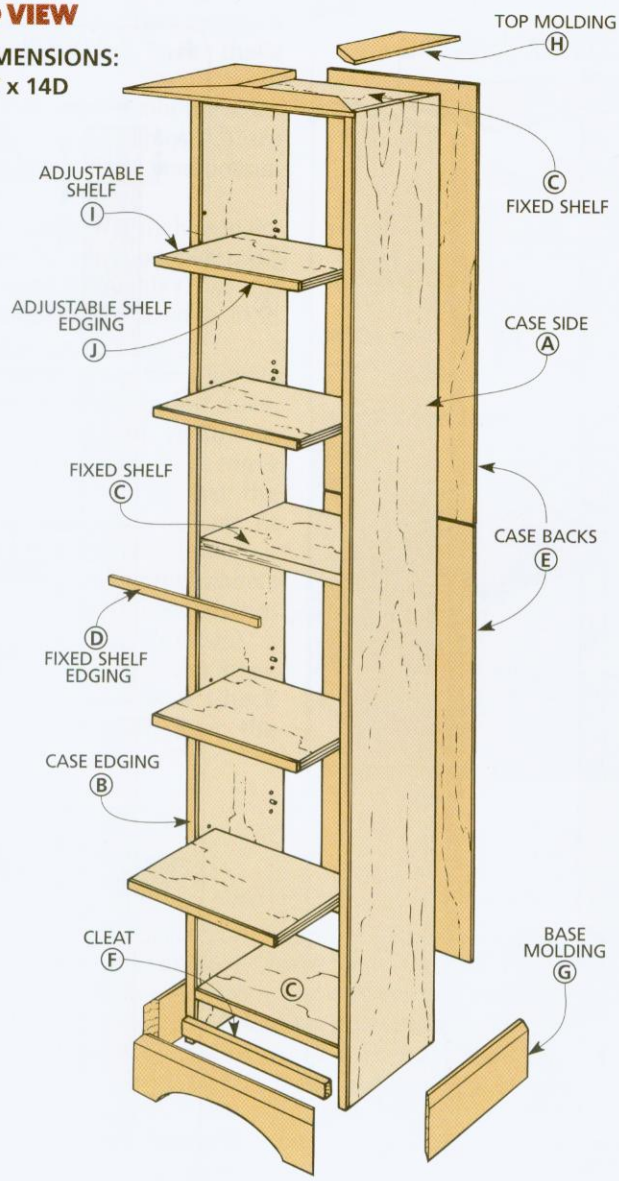
JOINERY. No matter whether you build the tall or the short version of this bookcase, tongue and groove joints are all that are needed to hold the case together. And building the top and bottom molding and attaching them to the case is just as straightforward.

WOOD. I built the sides and shelves of this bookcase from $\frac{3}{4}$" cherry plywood (one 4x8 sheet is more than enough for these parts). The back of the bookcase is made from a half sheet of $\frac{1}{4}$" cherry plywood. The sides and shelves are all edged with solid cherry. (See the Shop Tip box with some tips on trimming the edging flush on page 49.)

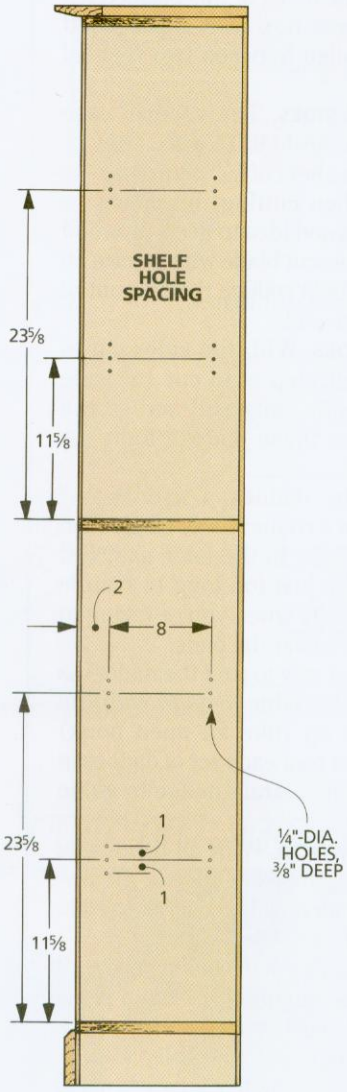
FINISH. I used a deep cherry stain for this project. Once the stain dried, I topped it off with two coats of satin polyurethane.

EXPLODED VIEW

OVERALL DIMENSIONS:
77 3/8H x 20W x 14D



SIDE VIEW



MATERIALS LIST

WOOD

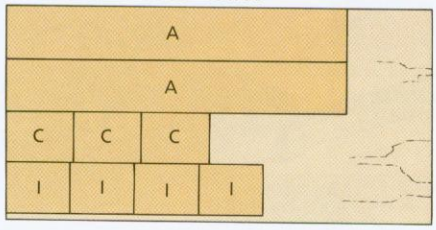
A	Case Sides (2)	3/4 ply - 11 3/4 x 76 5/8
B	Case Edging (2)	3/4 x 1/4 - 76 5/8
C	Fixed Shelves (3)	3/4 ply - 11 1/2 x 15 1/4
D	Shelf Edging (3)	3/4 x 1/4 - 14 1/2
E	Case Backs (2)	1/4 ply - 15 1/2 x 36 3/8
F	Cleat (1)	3/4 x 1 1/4 - 14 1/2
G	Base Molding (1)	3/4 x 4 - 45 rough
H	Top Molding (1)	3/4 x 3 1/2 - 50 rough
I	Adj. Shelves (4)	3/4 ply - 11 1/2 x 14 7/16
J	Shelf Edging (4)	3/4 x 1/4 - 14 7/16

HARDWARE SUPPLIES

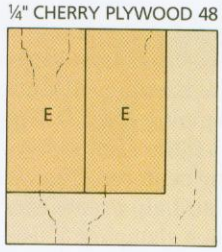
(36) No. 16 x 5/8" brads
(6) No. 8 x 1 1/4" Fh woodscrews
(1) 1/4" x 18" birch/maple dowel
(6) 3/8" cherry flat-top plugs

CUTTING DIAGRAM

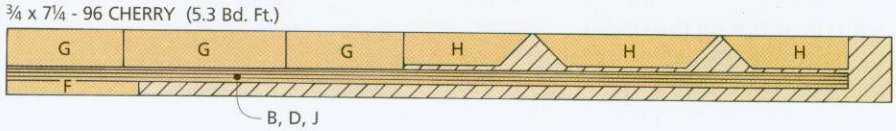
3/4" CHERRY PLYWOOD 48 x 96



1/4" CHERRY PLYWOOD 48 x 48



3/4 x 7 1/4 - 96 CHERRY (5.3 Bd. Ft.)



CASE

The case is the heart of this project. It's just an upright box with three fixed shelves installed between two vertical sides *(Fig. 1)*.

CUT CASE SIDES. The vertical case sides (A) are first cut to size. They're ripped from a sheet of 3/4" plywood.

Note: When cutting the pieces to length, it's a good idea to use a plywood blade or a crosscut blade with at least 50 teeth. It will help reduce the amount of chipout on the ends.

CUT DADOES. With the sides cut to size, the next step is to cut 1/4"-wide dadoes at both ends and across the middle. Later these dadoes hold the fixed shelves.

To cut the dadoes, I used a 1/4" straight bit in a router. I was tempted to use a dado blade in the table saw. But the pieces are just too long to handle easily. Especially when you're trying to cut the dadoes near the ends.

The easiest way to rout the dadoes is to lay the sides edge-to-edge with the inside faces up (like an open book) *(Fig. 2)*. Then rout each set of dadoes in one pass using a straightedge to guide the router.

EDGE PLYWOOD. With all three sets of dadoes cut, the front edge of the plywood sides can now be covered to hide the plies and "stop" the dadoes.

To do this, I ripped two long strips of 1/4"-thick case edging (B) from a piece of 13/16"-thick hardwood stock.

Note: Whenever possible, I'll use edging strips trimmed off the edge of a piece of 13/16"-thick stock. Since that's a little thicker than the 3/4" plywood, alignment with the plywood isn't critical (refer to *Fig. 3a*). It can be trimmed flush later.

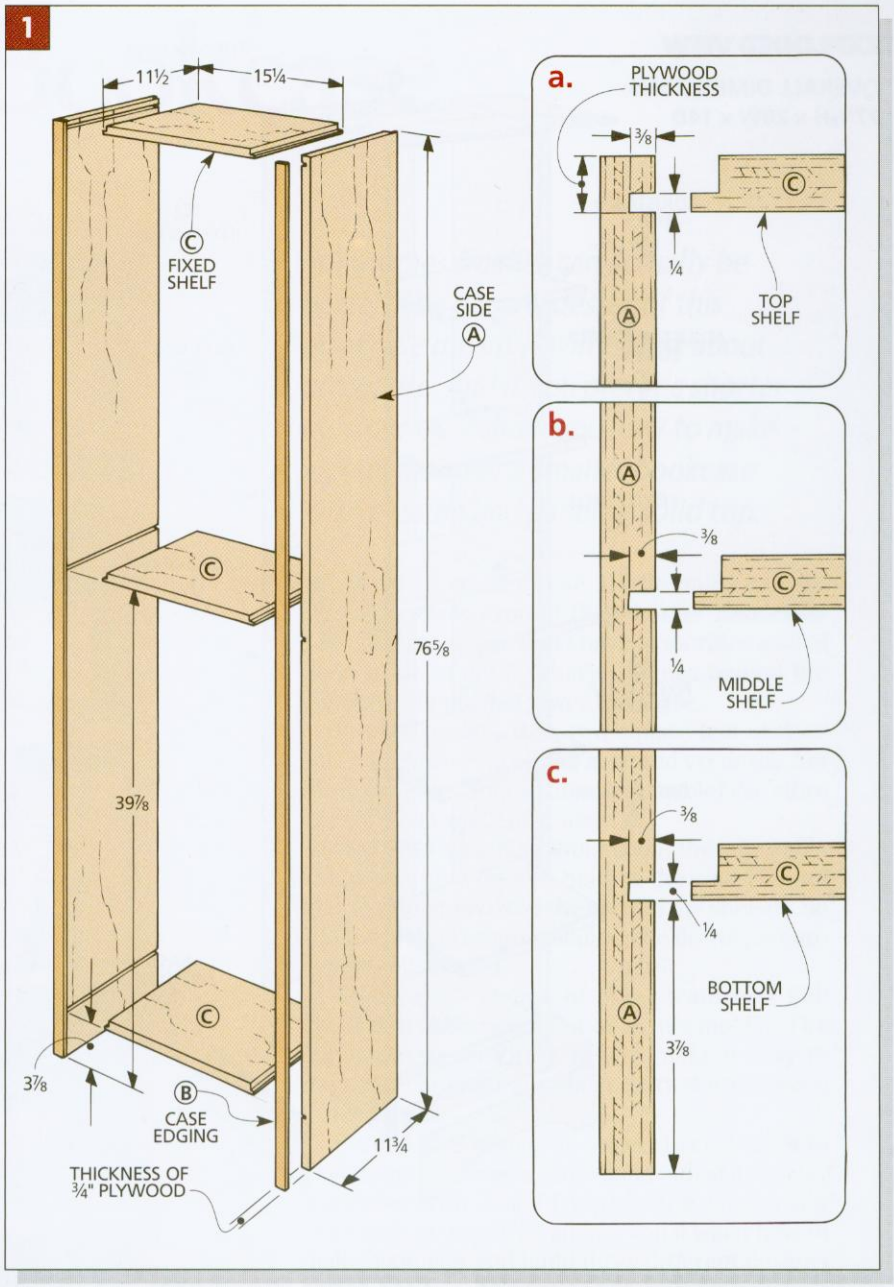
Another tip to make installing the edging a little easier is to use spacers (strips of 1/4"-thick hardboard) under the plywood when gluing *(Fig. 3)*. They raise the plywood off the clamps so you can keep the edging centered *(Fig. 3a)*.

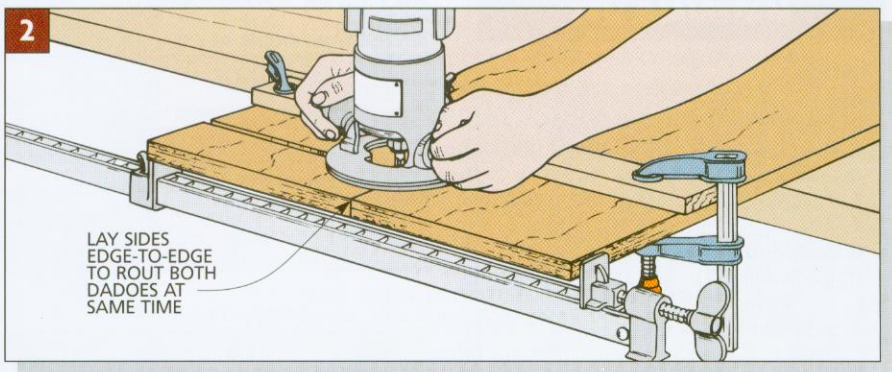
The spacers also help create more direct pressure when clamping. Raising the plywood pieces puts them in line with the screw on the clamp.

I also like to use a pressure block between the clamp head and the edging. It helps distribute the clamping pressure, so fewer clamps are needed *(Fig. 3)*. In addition it also protects the edging from getting dents and scratches from the clamp jaw.

TRIM EDGING. After the glue dries, the edging can be trimmed flush. To do this I used a router with a flush trim bit. For more on this, see the Shop Tip box on the opposite page.

CUT BACK RABBET. With the edging trimmed on the front edges of the case





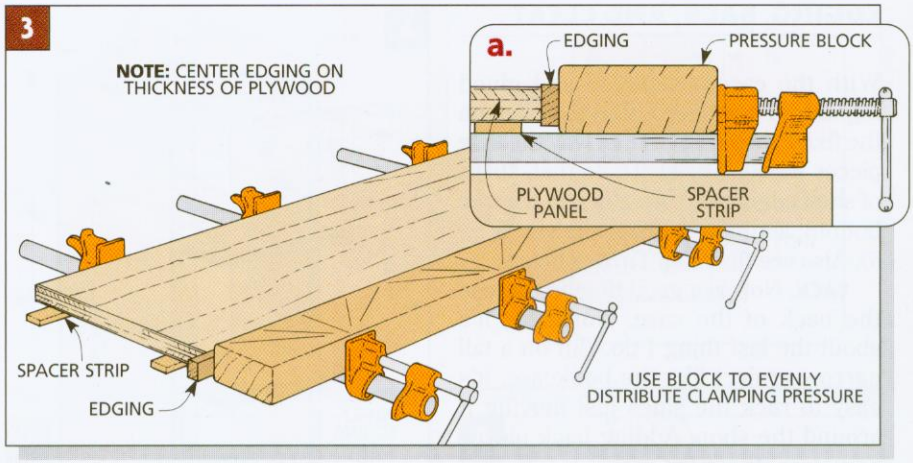
sides, a rabbet can be cut on the back edges *(Figs. 4 and 4a)*. This creates a recess for a plywood back that's installed later.

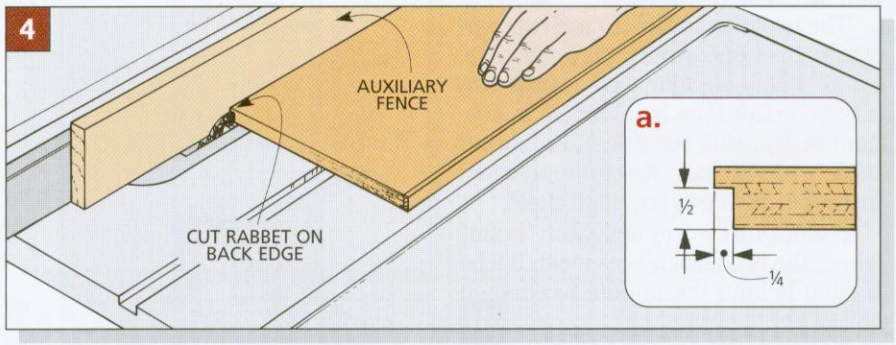
CUT FIXED SHELVES. To join the sides together, three fixed shelves (C) are glued near the top, middle, and bottom of the case *(Fig. 1)*.

I started by cutting the shelves to finished size from $^3/_4$" plywood. Next, $^1/_4$" tongues are cut on both ends *(Figs. 1a, b, c)*. These tongues are sized to fit in the dadoes cut in the side pieces.

ASSEMBLE CASE. Once the tongues on the shelves fit snugly in the sides, the case can be assembled. To do this, slide in the shelves until the front edges of the tongues butt up against the edging strips at the front of the case. At the same time the shelves should sit flush with the shoulders of the rabbets on the back of the case. (If needed, trim the shelf's back edge until it's flush.)

Finally, glue and clamp the fixed shelves between the side pieces. Check that everything is square after the clamps are tight.





SHOP TIP . . . . . Trimming Edging Flush

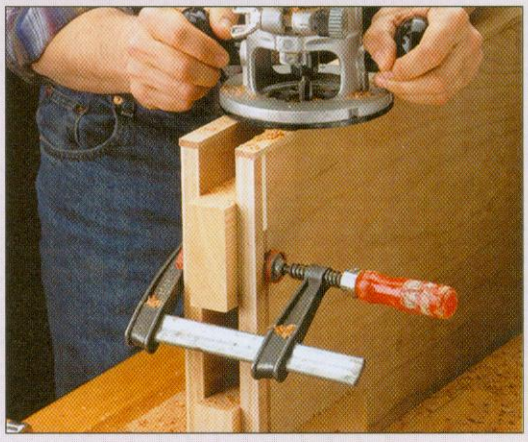
Once the edging was glued on the sides of the tower bookcase, it needed to be trimmed flush. To do this, I used a router with a flush trim bit.

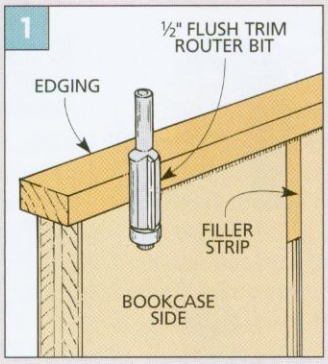
To prevent the bearing from dropping in the dadoes in the sides, I filled in each dado with a filler strip that was just thick enough to fit flush with the face of the plywood *(Fig. 1)*.

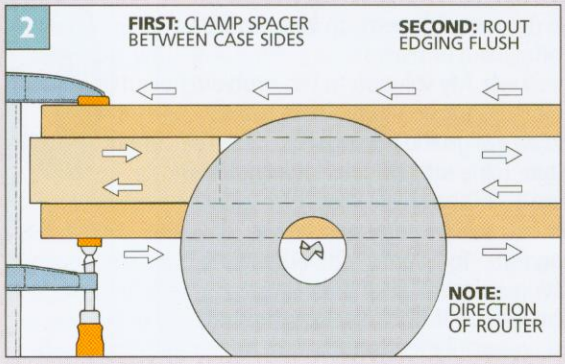
The trick to keeping the router from tipping when working on the thin edges is to clamp both side pieces together. It gives a wider surface for the router to sit on. And it lets you rout the edging on both pieces at the same time.

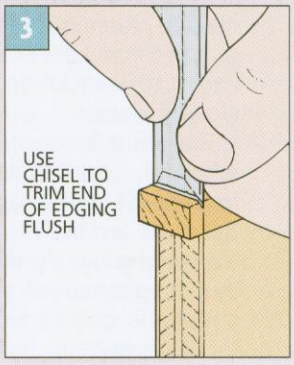
To make this work, you'll have to separate the case sides to make room for the router bit. I clamped 2x4 spacers between the sides to hold them apart and make a wide platform for the router (see photo at right and *Fig. 2*).

Finally, I trimmed the edging to length with a sharp chisel *(Fig. 3)*.









EDGING, BACK, AND CLEAT

With the case assembled and glued together, I wanted to hide the plies on the fixed shelves the same way the side pieces were covered. To do that, strips of shelf edging (D) are glued to the top, bottom, and middle fixed shelves *(Fig. 5)*. Also see the Shop Tip box below.

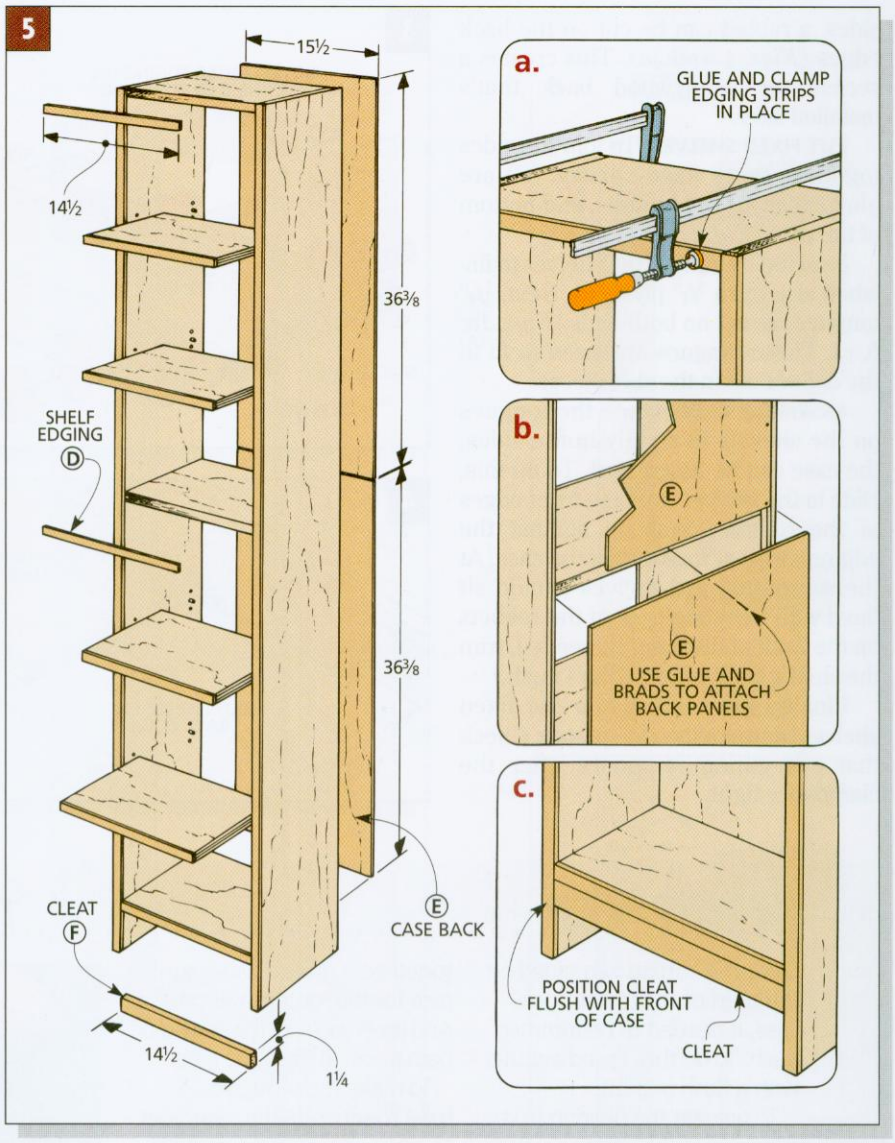
BACK. Now is a good time to enclose the back of the case. Normally, it's about the last thing I do. But on a tall narrow project like the bookcase, it's easy to rack the sides just moving it around the shop. Adding back pieces now strengthens the case.

The two case backs (E) are cut from a half sheet of ¼"-thick plywood *(Fig. 5)*. You may wonder why I used two pieces instead of just one. It's economics. By using two pieces, I could cut both from a half sheet of plywood instead of having to buy a full sheet.

Note: Don't worry about the "seam" where the two back pieces meet. It'll be hidden behind the middle fixed shelf *(Fig. 5b)*.

Now install the case backs in the rabbets cut in the case sides. To do that, I used glue and brads.

CLEAT. To complete construction of the case, a cleat (F) is attached to the bottom fixed shelf *(Fig. 5c)*. This cleat is a ¾"-thick piece of stock glued and clamped flush with the front. It's added to create more glue surface for attaching the front piece of base molding (added next).



SHOP TIP . . . . . Aligning and Clamping Edging

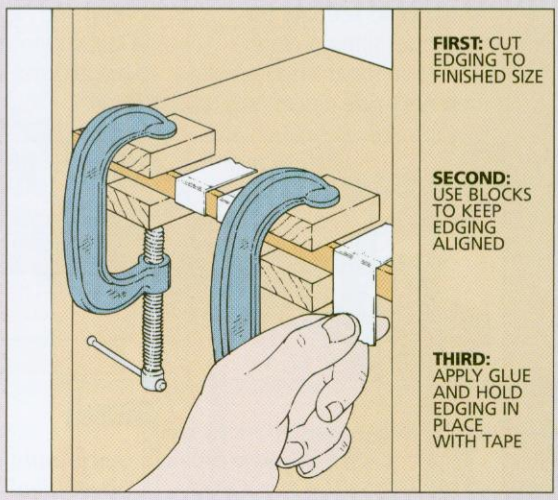
When it came time to install edging to the fixed shelves on the tower bookcase, I ended up doing things a little differently. Instead of installing oversize pieces that get trimmed flush later, I cut the edging to exact size and glued it in place.

The reason for doing things differently is the narrow edge on the shelf. It's too easy for the router and flush trim bit to tip and gouge the edging. By cutting the edging to an exact fit, only a little light sanding is needed.

One problem you run into when applying edging this way is keeping it aligned with the edge of the plywood. After the glue is applied, the edging seems to want to slide out of place.

My solution to this problem is to use scrap blocks to help align the edging. First, I clamp the scrap blocks to both sides of the shelf. They form a slot for the edging to fit into.

To "clamp" the edging in place, I'll use duct tape to pull it tight against the shelf until the glue dries.



MOLDING

With the case complete the next step is to add the decorative molding at the top and bottom.

BASE MOLDING. The easiest way to make the base molding (G) is to start with one long board and rip it to finished width *(Fig. 6)*. Next, rip or rout a 45° chamfer along one edge *(Fig. 6a)*. Now this blank can be mitered into three pieces to fit around the base.

Before attaching the base molding to the case, a half ellipse is cut in the front piece to add a decorative detail.

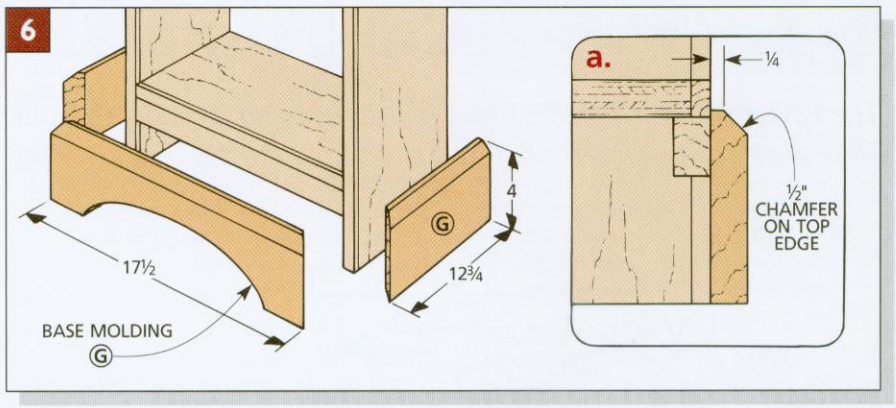
To create this shape, first enlarge the half pattern in *Fig. 7*. It isn't critical that you match the pattern exactly. But what you want to end up with is a design that looks balanced on the front piece.

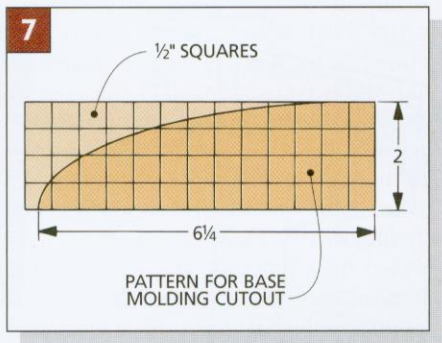
The way I went about doing that is to first find the centerline of the front piece. Then position the half pattern on one side of this line and trace around it to draw one half of the partial ellipse *(Fig. 8)*. Now by flipping the pattern over, the other half of the ellipse can be drawn next. When you're finished, the ellipse will be automatically centered.

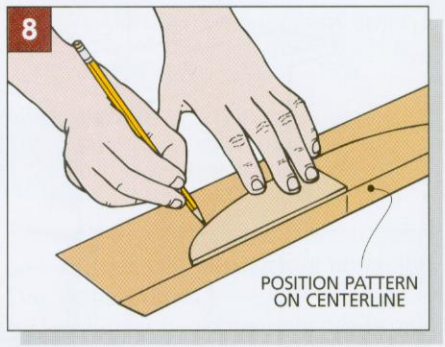
Now cut out the shape and use a drum sander to sand the ellipse smooth. Finally, all three pieces can be glued and clamped to the case.

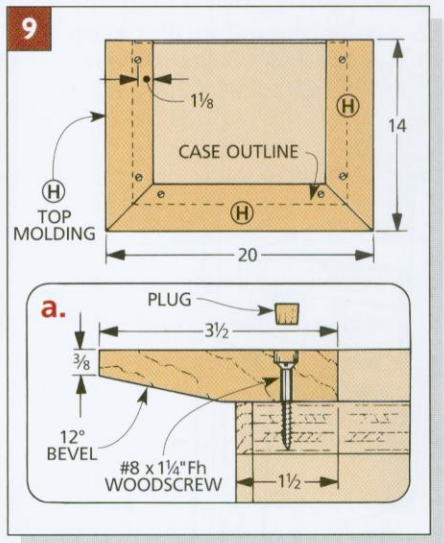
TOP MOLDING. To complete the molding for the case, top molding (H) is added next *(Fig. 9)*. This is made in much the same way as the base molding. First, a blank for all three pieces is ripped to finished width. Next, a 12° bevel can be ripped on one face *(Fig. 9a)*.

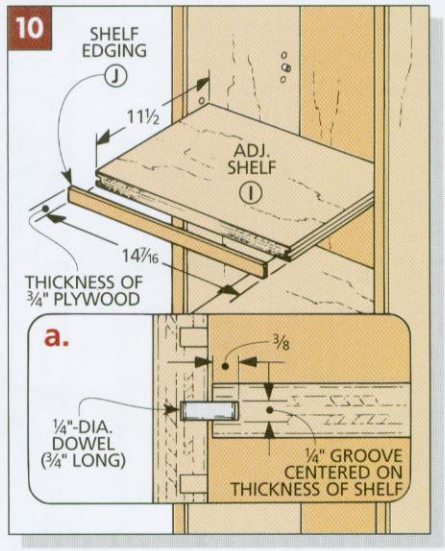
Now miter the ends of the pieces to fit around the top with a 2" overhang. Each piece can be glued and screwed in place to form a U-shaped frame to sit on top of the case. Finally, plug the screw holes to fill in the openings.











SHELVES

Now, all that's left for this bookcase is to add the rest of the shelves. So make four adjustable shelves (I) to fit inside the case *(Fig. 10)*. These shelves are the same depth as the fixed shelves (C) that hold the case together (11½"). As for their length, I cut the shelves 1/16" shorter than the opening in the case.

The only thing unusual about the adjustable shelves is the way they're held in the case. It's a system of shelf support pins that fit in holes in the case. Not too unusual. But the shelves don't rest on top of the support pins. Rather, they fit *around* the pins *(Fig. 10a)*. It's all done with a simple groove in the ends of the shelves.

To cut the ¼"-wide groove, I used a dado blade in the table saw. The grooves should be centered on the thickness so they sit level.

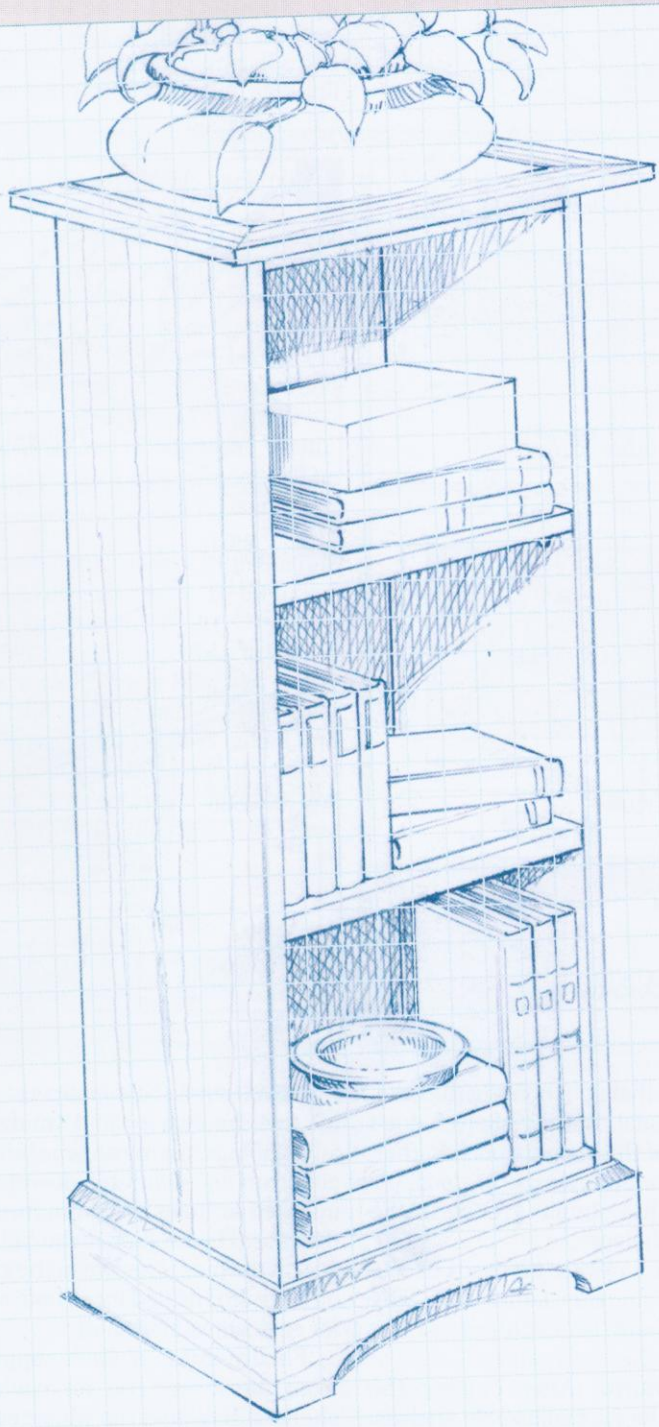
SHELF EDGING. After cutting the grooves on the four adjustable shelves, a piece of shelf edging (J) is glued and clamped to the front edge of each shelf. The edging hides the grooves as well as the plies of the plywood.

DOWEL PINS. To support the shelves in the bookcase and make them adjustable at the same time, short pins cut from ¼"-diameter dowel rod are installed in holes drilled in the sides of the case. The location of the ¼" holes to accept the pins is shown in the side view on page 45. I drilled three hole positions for each adjustable shelf.

Finally, cut four shelf support pins from the dowel rod for each of the shelves. Because the pins need to be removable, I didn't stain or finish them. Just add a coat of wax so they will be easy to pull out when changing the height of the shelves. ■

DESIGNER'S NOTEBOOK

The Tower Bookcase can be reduced in height and turned into a plant stand or just a shorter bookcase. Here are three options for building a top for a shorter case.

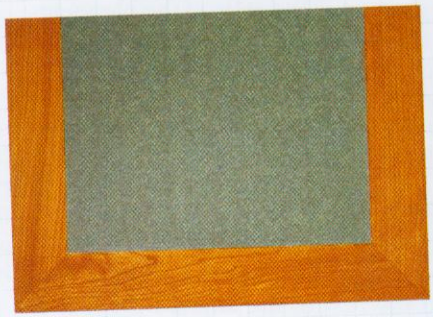


PLANT STAND OR SHORT BOOKCASE

TOP OF SHORT BOOKCASE CAN BE BUILT WITH A SOLID TOP OR A 3-SIDED FRAME AND PANEL TOP

SOLID WOOD TOP

FRAME AND PANEL TOP WITH PLYWOOD PANEL



FRAME AND PANEL TOP WITH PLASTIC LAMINATE PANEL

CONSTRUCTION NOTES:

■ To shorten the Tower Bookcase, cut the two 3/4" plywood case sides (A) and edging (B) only 40 5/8" high. That will make the overall height of the new design 41 3/8" tall. The width and depth of this short design remain the same as the original.

■ The top of the short design will "show" so make it out of a matching solid wood or use frame and panel construction.

■ If the top is to be *solid* 3/4"-thick stock, build it up by edge gluing two or three pieces (to minimize warp). Then cut the blank to finished dimensions of 14" wide by 20" long.

■ If the top is to be built with frame and *plywood* panel construction, use 3/4" hardwood plywood for the panel. Start by gluing a 1/4" strip on the back edge of an oversized plywood blank. Then cut the blank to 11 3/8" x 15 1/4".

■ If the shorter bookcase is to become a plant stand, you may want to use a frame and panel top with a *plastic laminate* panel to prevent water damage. To do this, first glue a 1/4" strip on the back edge of an oversized 3/4"-thick plywood blank. Then use contact cement to glue the plastic laminate on top of the plywood and over the top of the edging strip. Finally, cut the laminate-covered blank to 11 3/8" x 15 1/4".

■ To make the three-sided frame for a frame and panel top, cut or plane solid stock to match the thickness of the hardwood plywood or panel covered with plastic laminate. Then cut the frame pieces to a final width of 2 3/4".

■ The panel is held within the frame using tongue and groove joinery. Cut a 1/4"-wide groove centered on the thickness of the frame pieces. Then cut a matching tongue on the front and ends of the panel. (The tongue is 1/16" shorter than the depth of the groove to allow for excess glue.)

■ Rout or rip a 12° bevel on the bottom edges of the top (front and sides only) after the frame and panel are assembled.

■ The new top is attached from below with four flathead woodscrews located 1" in from each corner. They're countersunk up through the "sub-top" (fixed shelf, part C). (If using a solid wood top, drill oversize shank holes for the screws. This will allow the top to expand and contract with changes in humidity. Don't glue it down.)

■ The shorter bookcase only needs one piece of 1/4" plywood for the back. It's cut 36 3/4" long, stopping just below the new top. Then it's nailed to the sub-top, bottom fixed shelf, and side rabbets.

CHANGES TO MATERIALS AND HARDWARE

PLANT STAND/SHORT BOOKCASE

A	Case Sides (2)	3/4 ply - 11 3/4 x 40 5/8
B	Case Edging (2)	3/4 x 1/4 - 40 5/8
C	Fixed Shelves	Only Need Two
D	Fix. Shelf Edging	Only Need Two
E	Case Back (1)	1/4 ply - 15 1/2 x 36 3/4
I	Adj. Shelves	Only Need Two
J	Adj. Shelf Edging	Only Need Two

SOLID WOOD TOP

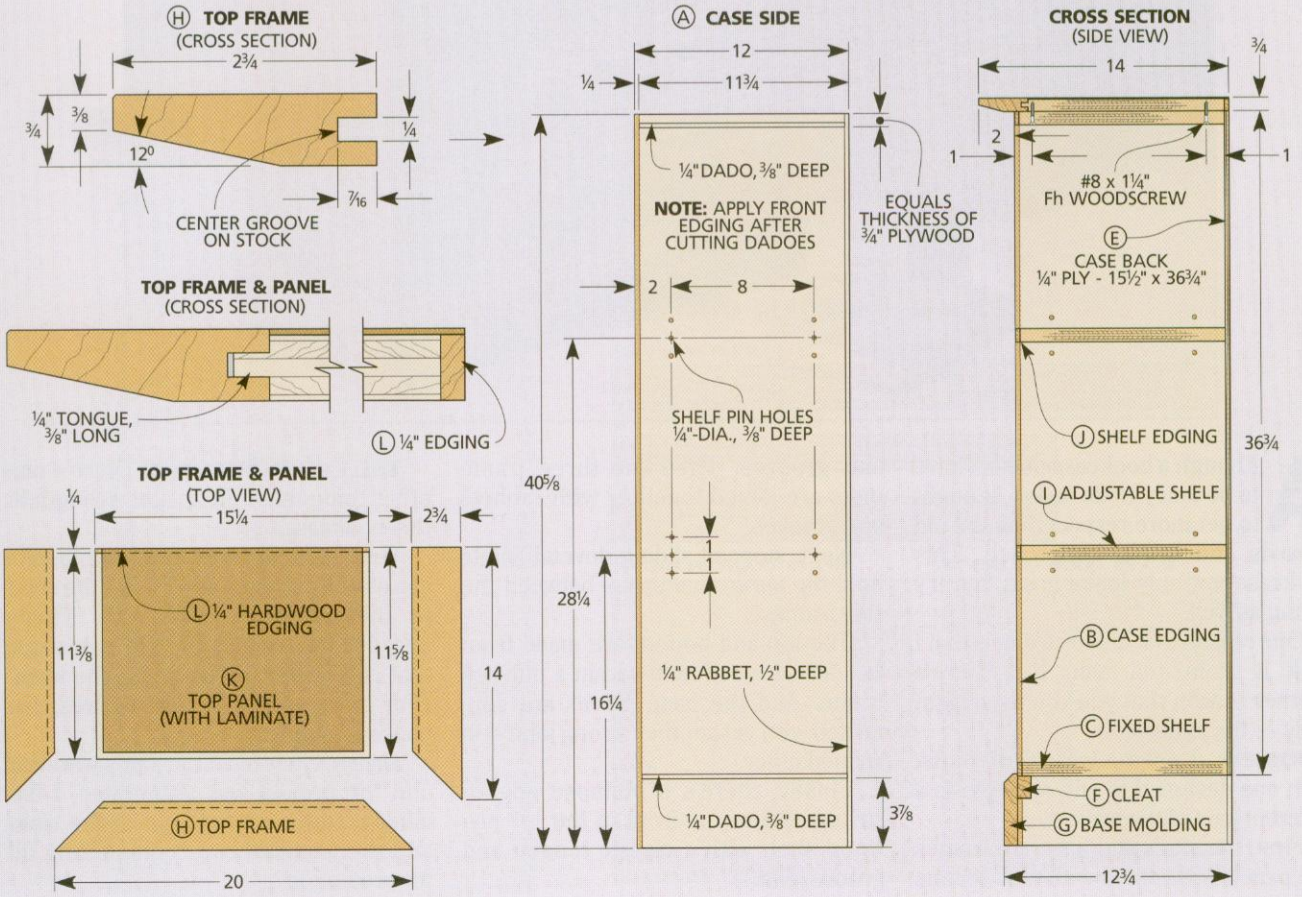
K	Solid Top (1)	3/4 x 14 - 20

FRAME AND PANEL TOP

H	Top Molding (1)	3/4 x 2 3/4 - 50 rough
L	Top Panel (1)	3/4 ply - 11 3/8 x 15 1/4
M	Back Edging (1)	3/4 x 1/4 - 15 1/4

HARDWARE

(24) No. 16 x 5/8" brads
(4) No. 8 x 1 1/4" Fh woodscrews
(1) 1/4 x 12" birch/maple dowel



Oak Bookcase

Designed with frames and plywood panels and a variety of different joinery techniques, this project offers an interesting set of challenges to any home woodworker.

Although a bookcase doesn't have to be fancy to do its job, it ought to get more respect than the old "boards and bricks" approach. This bookcase not only looks great, but it's strong as well.

One reason that it's so strong is that I built it from red oak. But there's another reason that you can't see right away — the joinery.

JOINERY. I used a variety of joints, each one designed to add strength to a different part of the project.

First, the sides and back are frames and panels assembled with stub tenons and grooves. Then the three frame units are joined together with rabbets and grooves.

Next, stopped sliding dovetail joints hold the apron that spans between the side frames.

The top and bottom are made from $\frac{3}{4}$" oak plywood held within a mitered frame. And the base pieces are connected with yet another strong joint — a splined miter.

Finally, there's a bullnose edging strip added to the front of the $\frac{3}{4}$" plywood shelf with a classic tongue and groove joint.

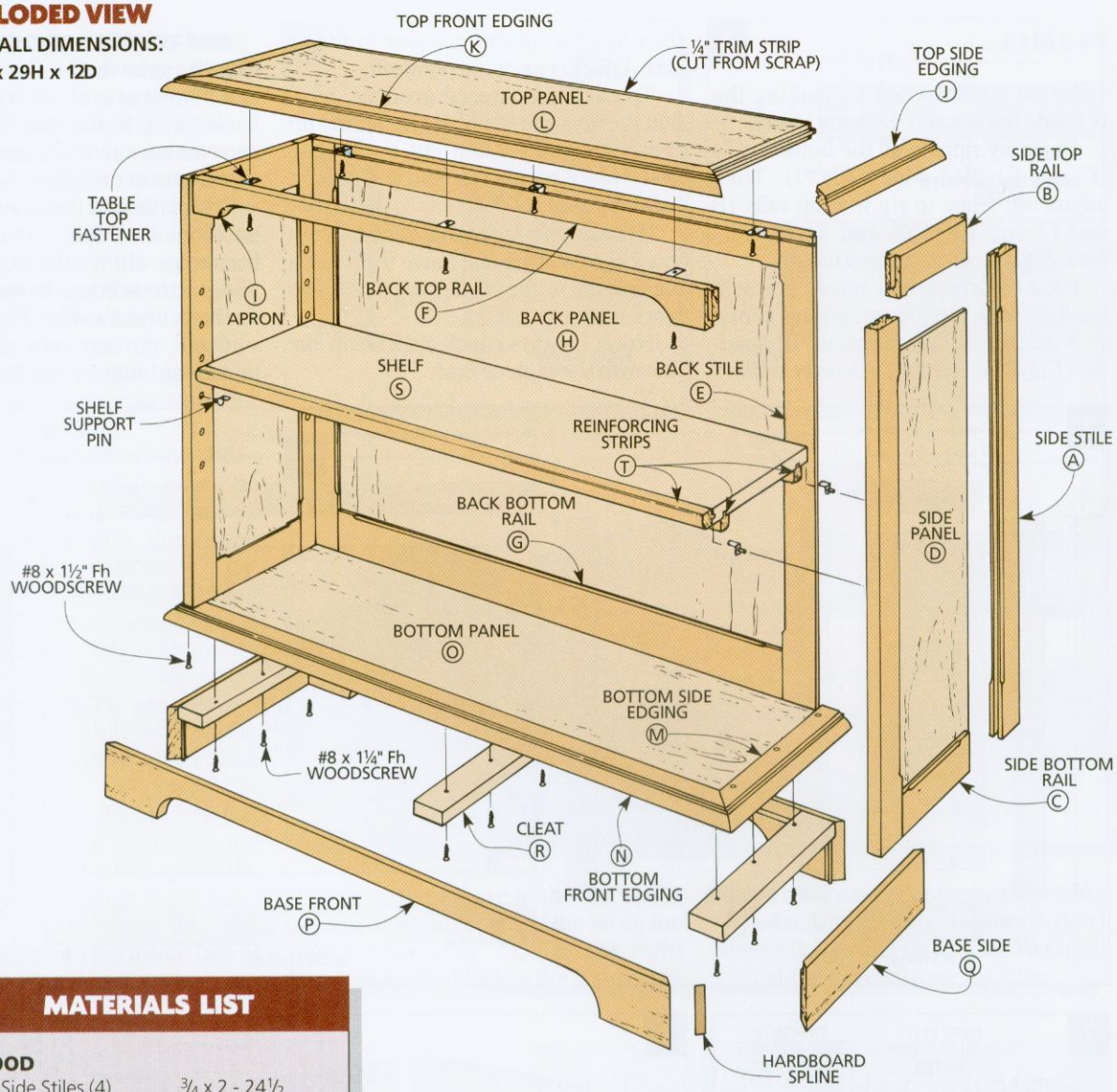
SHELF REINFORCEMENT. There's one other thing that I did to add strength to this bookcase.

Over time, shelves filled with books can start to droop. I don't think the shelf in this bookcase ever will. That's because it's reinforced with oak strips that run *under* the length of the shelf. (For more on reinforcing shelves, see pages 62 and 63.)

FINISH. Once all of the joints were cut and the project was assembled, I finished it with a coat of light brown stain and then applied two coats of tung oil for protection.

EXPLODED VIEW

OVERALL DIMENSIONS:
38W x 29H x 12D



MATERIALS LIST

WOOD

A	Side Stiles (4)	¾ x 2 - 24½
B	Side Top Rails (2)	¾ x 2 - 8
C	Side Btm. Rails (2)	¾ x 2½ - 8
D	Side Panels (2)	¼ ply - 8 x 21
E	Back Stiles (2)	¾ x 2 - 24½
F	Back Top Rail (1)	¾ x 2 - 32
G	Back Btm. Rail (1)	¾ x 2½ - 32
H	Back Panel (1)	¼ ply - 32 x 21
I	Apron (1)	¾ x 2 - 35¼
J	Top Side Edging (2)	¾ x 1¾ - 11¾
K	Top Frt. Edging (1)	¾ x 1¾ - 37½
L	Top Panel (1)	¾ ply - 10 x 34½
M	Bot. Side Edging (2)	¾ x 1¾ - 12
N	Bot. Frt. Edging (1)	¾ x 1¾ - 38
O	Bottom Panel (1)	¾ ply - 10¼ x 35
P	Base Frt./Back (2)	¾ x 3 - 37½
Q	Base Sides (2)	¾ x 3 - 11¾
R	Cleats (3)	¾ ply x 2 - 11
S	Shelf (1)	¾ ply x 9¼ - 34⅜
T	Reinforc. Strips (3)	¾ x 1 - 34⅜

HARDWARE SUPPLIES

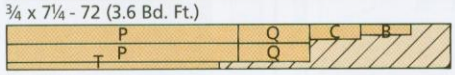
(6) Table top fasteners with ¾" Rh screws
(4) Pin style shelf supports
(6) No. 8 x 1½" Fh woodscrews
(9) No. 8 x 1¼" Fh woodscrews

CUTTING DIAGRAM

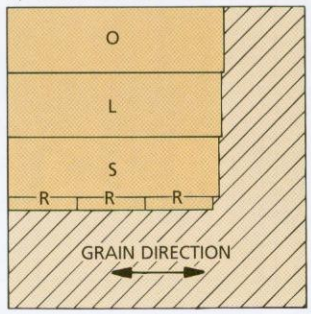
¾ x 7¼ - 96 (4.8 Bd. Ft.)

¾ x 5½ - 72 (2.8 Bd. Ft.)

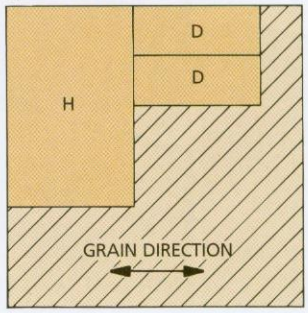
¾ x 7¼ - 72 (3.6 Bd. Ft.)



¾" OAK PLYWOOD 48 X 48



¼" OAK PLYWOOD 48 X 48



FRAMES

I started construction by making the two side frames and the back frame.

Begin by ripping all the bottom rails (C and G) 2½" wide *(Fig. 1)*. Then adjust the fence to rip the top rails (B and F) and stiles (A and E) 2" wide. Now cut the pieces to final length.

EDGE GROOVES. The pieces are held together with tongue and groove joints.

Note: The grooves accept ¼" *hardwood* plywood which is usually thinner than ¼". So cut the grooves to fit the actual thickness of the plywood.

To cut the centered grooves, position the fence so the blade is slightly off center *(Fig. 2)*. Then cut a ½"-deep kerf. Now flip it end-for-end and make a second pass.

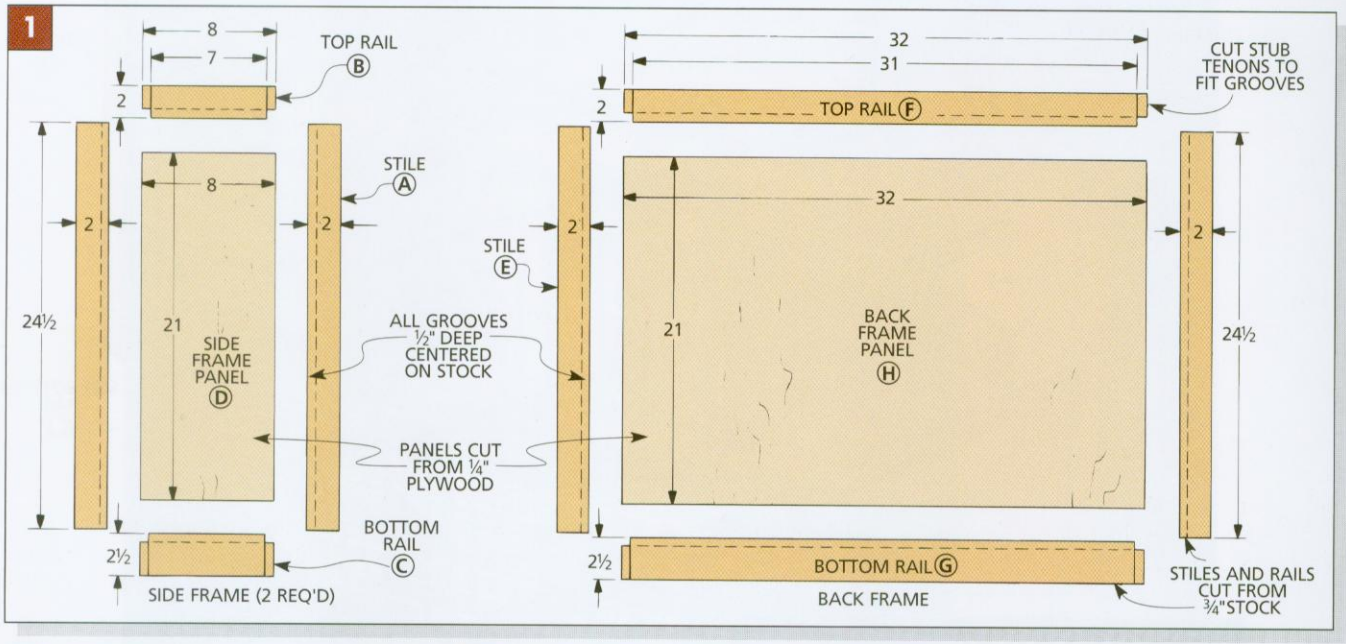
If the groove isn't quite wide enough to accept the plywood, move the fence a hair closer to the blade and make two more passes.

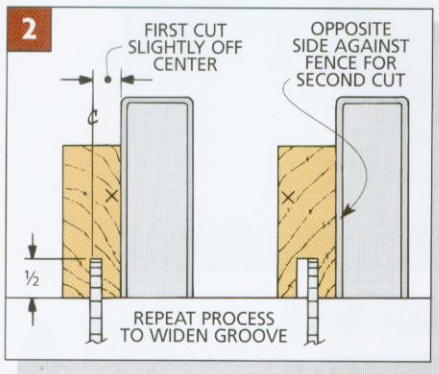
Note: I always check out a setup like this with a test piece first.

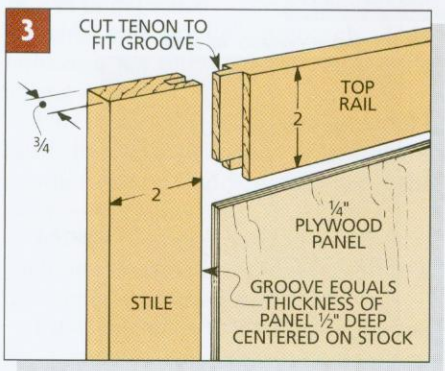
SIDE TONGUE & GROOVES. After cutting the grooves on the inside edges, another set of grooves is cut to join the back frame to the side frames. These grooves are cut on the inside face of the side frame's rear stiles (A) *(Fig. 4)*.

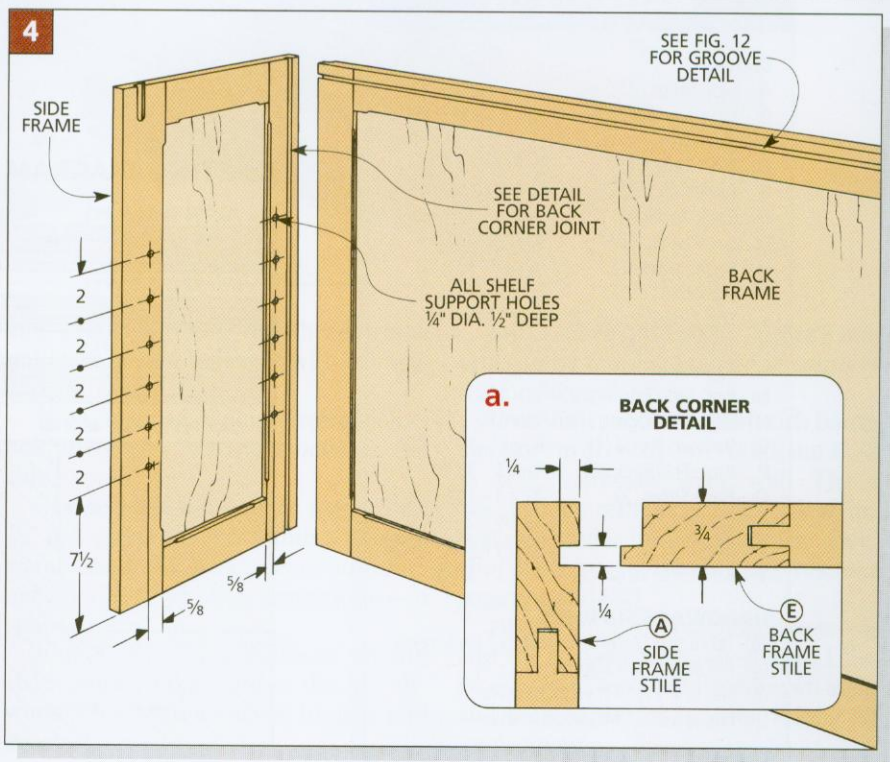
It's important that these grooves be positioned so the distance from the back edge of the stile to the far side of the groove is equal to the thickness of the back frame's stile *(Fig. 4a)*.

Once the grooves are complete, matching tongues can be made on the









back frame stiles (E). I did this by cutting a rabbet on the back edge of each stile. Sneak up on the cut until the tongue just fits the grooves *(Fig. 4a)*.

STUB TENONS. The tongues that connect the ends of the rails to the stiles are actually stub tenons that fit into the panel grooves *(Fig. 3)*. I made these with multiple passes over the saw blade.

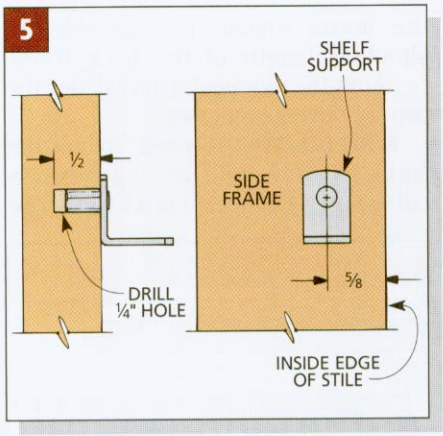
PLYWOOD PANELS. After the stub tenons are cut, dry assemble the frames and take measurements for the plywood panels. Then cut the panels to size, making sure the grain runs the height of the case *(Fig. 1)*.

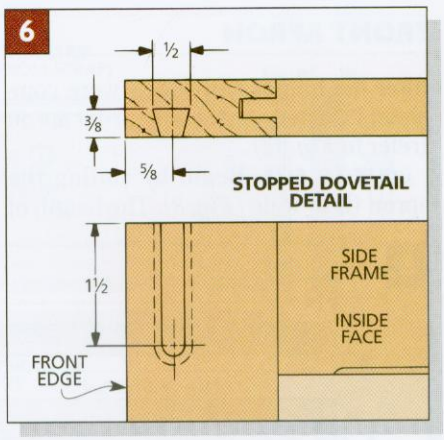
ASSEMBLY. Now each of the three frame and panel assemblies can be glued up. As I was gluing up the frames, I glued the panels into the frame grooves for maximum stability.

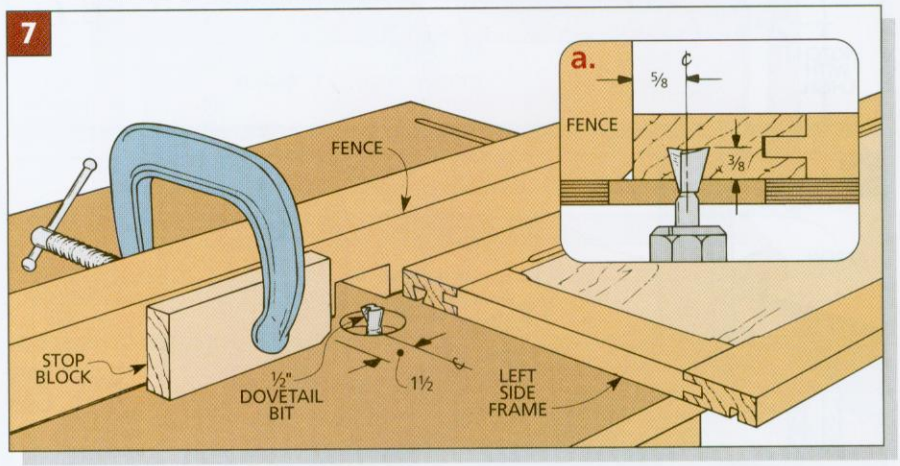
CHAMFERS. After the assemblies are dry, there are a few more steps. First, I routed 1/8"-wide decorative chamfers around the *inside* edges of the stiles and rails; see the Shop Tip box below.

SHELF HOLES. Next, drill holes for the shelf pins that support the center shelf *(Figs. 4 and 5)*.

DOVETAIL GROOVES. The last step is to rout stopped dovetail grooves in the side frames to accept a top apron (I). (This apron spans the front of the case. Refer to *Fig. 13* on page 58.) The grooves are located on the inside face of each front stile *(Fig. 6)*.







To rout the groove in the left frame, clamp a block to the left of the bit on the router table *(Fig. 7)*. For the right frame, move the block to the right of the bit and cut from the opposite direction.

Note: After making these cuts, don't change the setting on the bit. You need it to cut the dovetail tongues later.

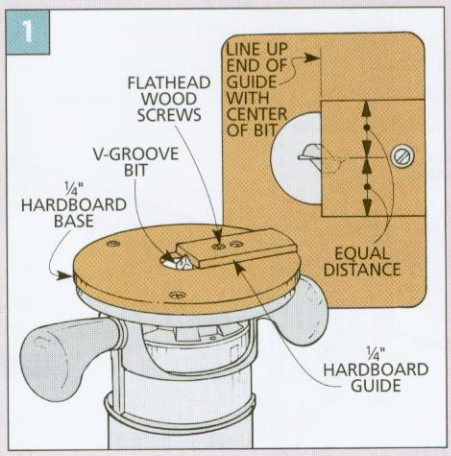
SHOP TIP . . . . . Routing Inside Chamfers

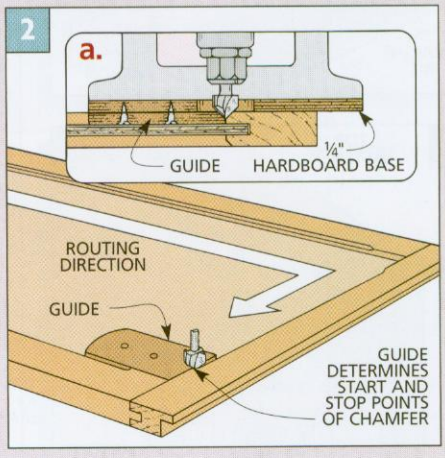
If a frame and panel are already assembled, it's difficult to rout a chamfer on the frame because the panel gets in the way of the pilot on the chamfering bit.

To deal with this problem, I used a "V-groove" bit instead. And to guide the bit, I made an auxiliary base and special 1½"-wide guide from ¼" hardboard *(Fig. 1)*.

The primary function of this guide is the same as that of the pilot on a chamfering bit. It keeps the bit a uniform distance from the edge being chamfered. But the guide also stops the chamfer a uniform distance (¾") from the corners.

To make the chamfer, just adjust the depth of the bit to cut a ⅛"-wide chamfer. The guide will maintain a uniform chamfer and stop the cut exactly ¾" from the corners *(Fig. 2)*.





FRONT APRON

After the frames and panels were complete, I started work on the front apron (refer to *Fig. 13*).

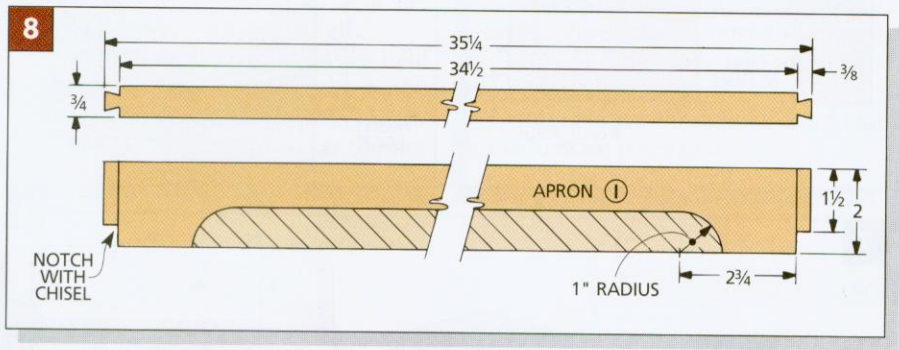
CUT TO SIZE. Begin by cutting the apron (I) 2" wide *(Fig. 8)*. The length of the apron equals the shoulder-to-shoulder length of the back frame (*without* the tongues), plus 3/4" (for the two 3/8" dovetail tongues).

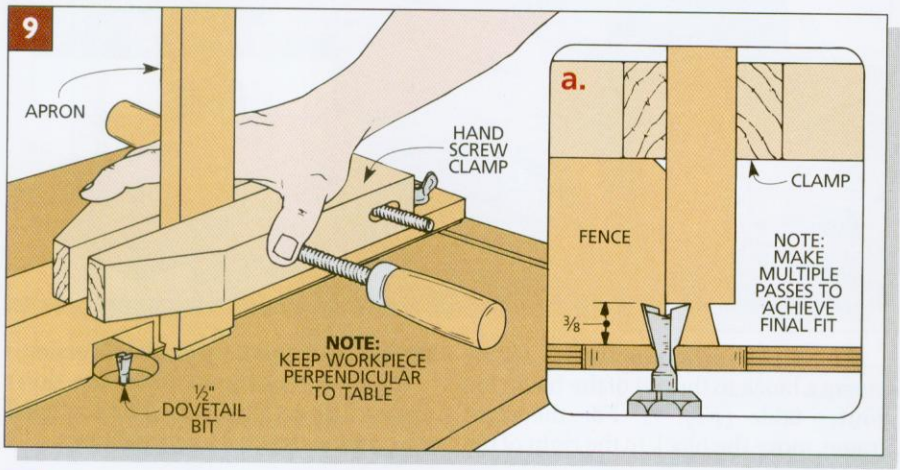
ROUT DOVETAIL TENONS. To hold the apron securely while forming the dovetail tenons, I clamped it in a hand screw clamp *(Fig. 9)*. Then I adjusted the fence to take just a little off each face to form the tenon. Now creep up on the final thickness by moving the fence and repeat the process until the tenons fit the dovetail grooves.

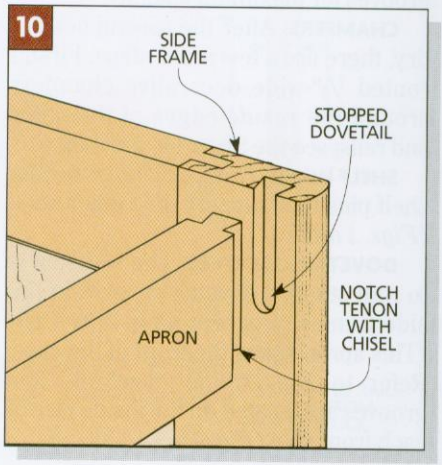
Next, trim about 1/2" off the bottom of each tenon so when it slides into the groove, the top of the apron is flush with the top of the frame *(Fig. 10)*.

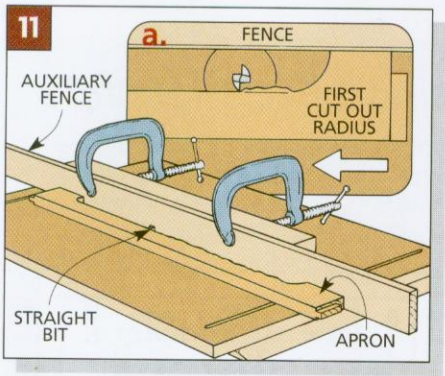
CUT PROFILE. Now the curved profile can be cut. To do this, draw a 1"-radius curve near each end *(Fig. 8)*. Then cut out the shape, staying about 1/8" outside the pencil line.

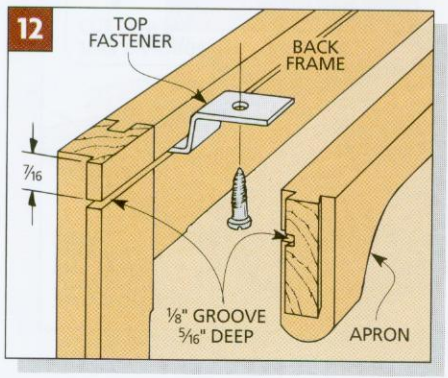
To finish up to the line, I used the router table with a long fence and a straight bit *(Fig. 11)*. Make a series of light passes until the edge is straight

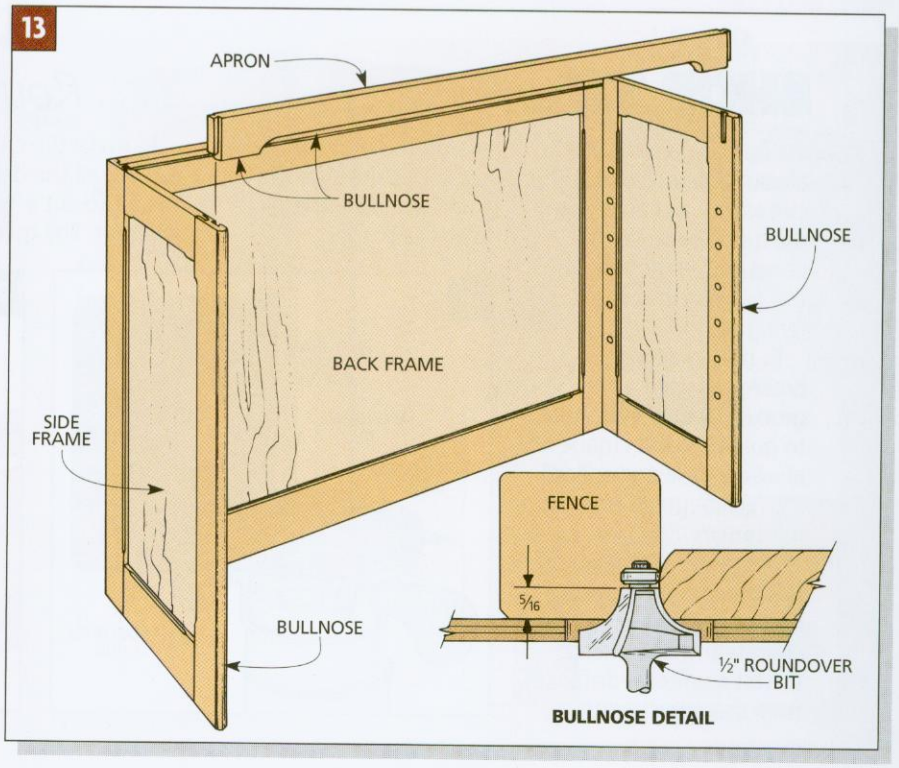












and smooth, and lines up with the rounded corners.

CUT GROOVES. Next it's time to plan ahead for fastening the top. I used stamped metal fasteners that fit into grooves. Cut the grooves along the inside edges of the apron and top rail of the back frame *(Fig. 12)*.

SOFTEN EDGES. The last step before assembling the case is softening the edges with a bullnose profile *(Detail in Fig. 13)*. Rout the front of the side frames and the bottom of the apron.

ASSEMBLE THE CASE. Finally, the case can be assembled *(Fig. 13)*. First glue the side frames to the back frame. Then add the front apron.

TOP AND BOTTOM

Once the case is assembled, the top and bottom can be made. I started by cutting the two plywood panels (L and O) to size *(Fig. 14)*.

Note: The top frame hangs over the case 3/4" on the sides and front, so it should be built 3/4" deeper and 1 1/2" wider than the outside dimensions of the assembled case. The bottom frame extends 1" over, so it should be 1" deeper and 2" wider than the case.

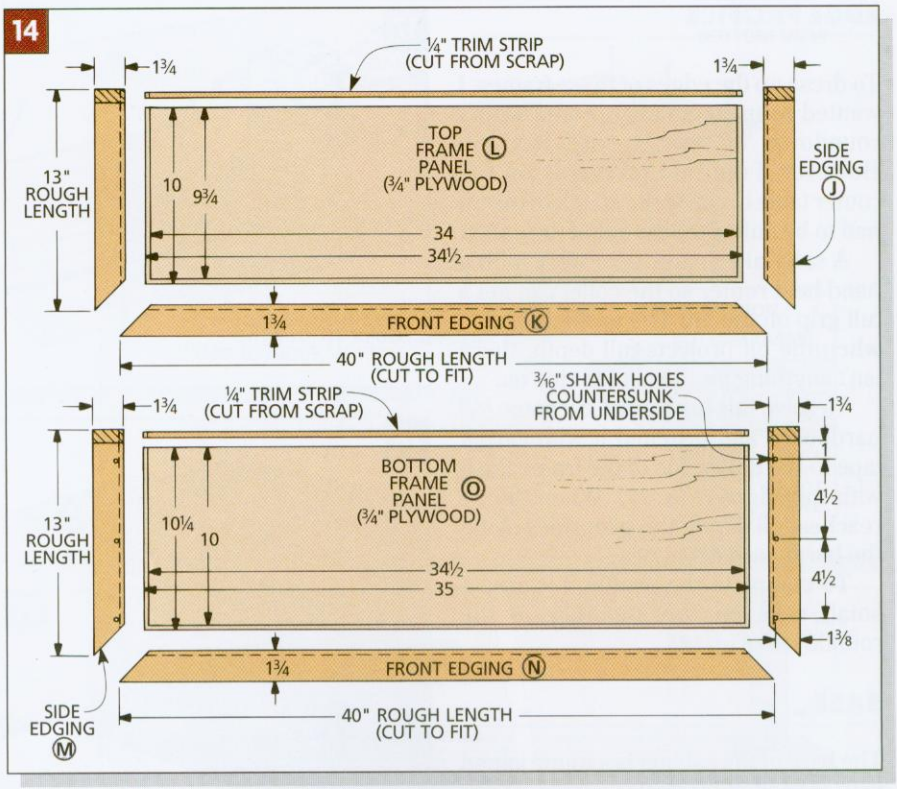
APPLY EDGING STRIP. The back edge of the plywood is covered with a 1/4"-thick trim strip. Rip this strip from 3/4" stock and glue it to the plywood.

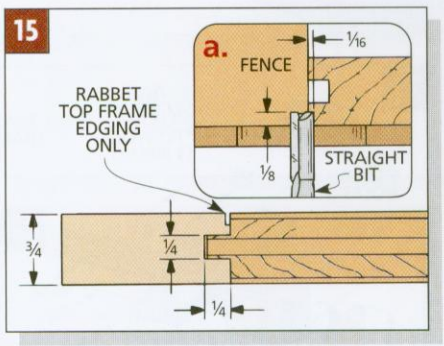
MAKE FRAMES. Next, the mitered frames can be made. Begin by ripping the pieces 1 3/4" wide *(Fig. 14)*. These pieces are joined to the plywood with tongue and groove joints. So, cut a 1/4" x 1/4" groove centered on the inside edge of all the pieces. Then form a matching tongue on the front and sides of the plywood panels by cutting rabbets on the top and bottom faces *(Fig. 15)*. (Also, note the Shop Tip box at right.).

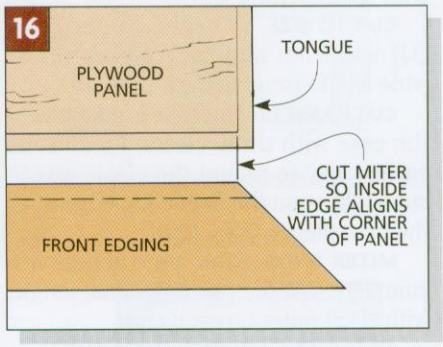
When cutting the mitered corners, I concentrated on shaving the ends of the frame's front pieces (K and N) until the inside corners fit the inside corners of the panel *(Fig. 16)*. Then I mitered the ends of the frame sides (J and M), leaving the back end a little long.

ROUT RABBETS. There's one more small step. Cut a tiny rabbet on the inside of the top frame pieces *(Fig. 15a)*. (This adds an accent line and makes the joint more forgiving than a butt joint.)

ASSEMBLE FRAMES. Now glue up the frames and panels and trim the back ends of the frame flush with the panel.





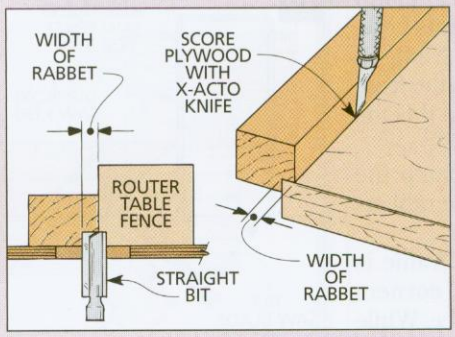


SHOP TIP . . . . . Clean Rabbets

Cutting a rabbet *across* the grain on plywood almost always results in tearout along the shoulder line. The way to eliminate this is to score the edge before routing.

The problem with scoring is locating the score line *exactly* where the edge of the rabbet will be. I solved this problem by routing an identical rabbet in a strip of scrap on the router table. The strip was then used as a guide to score the plywood.

After the rabbet is routed in the strip, just fit the strip over the end of the plywood to guide a razor blade knife while scoring. Then, flip the plywood over and rout a clean rabbet.



EDGE PROFILE

To dress up the edges of these frames, I wanted to make a fancy profile with a roundover bit and a core box bit. However, I ran into problems on the router table because the shank of the bit had to be pulled too far out of the collet.

A safer alternative is to work with a hand-held router so the collet can get a full grip on the bit. The problem is that when the bit projects full depth, there isn't anything for the pilot to ride on.

To solve this problem, I cut some 1/4" hardboard and fastened it with carpet tape to the underside of the frame flush with the edges *(Fig. 17)*. When the bit reaches full depth, the pilot rides along the hardboard *(Fig. 17a)*.

To complete the profile, I routed a small cove on the shoulder of the roundover *(Fig. 18)*.

BASE

The base of the cabinet is a frame joined with splined miter joints.

CUT TO SIZE. To begin, cut the sides (Q) and front and back pieces (P) 3" wide and to rough length *(Fig. 19)*.

CUT RABBETS. The base is attached to the case with three cleats. I found the easiest way to mount the cleats was to cut a rabbet on the inside top edge of all the base pieces *(Fig. 19a)*.

MITER ENDS. After the rabbets are complete, cut the pieces to final length with a 45° miter on each end.

Note: The length of the pieces is determined by the size of the bottom frame. The base should set back 1/4" on the front and sides and be flush on the back (refer to *Figs. 23 and 27*).

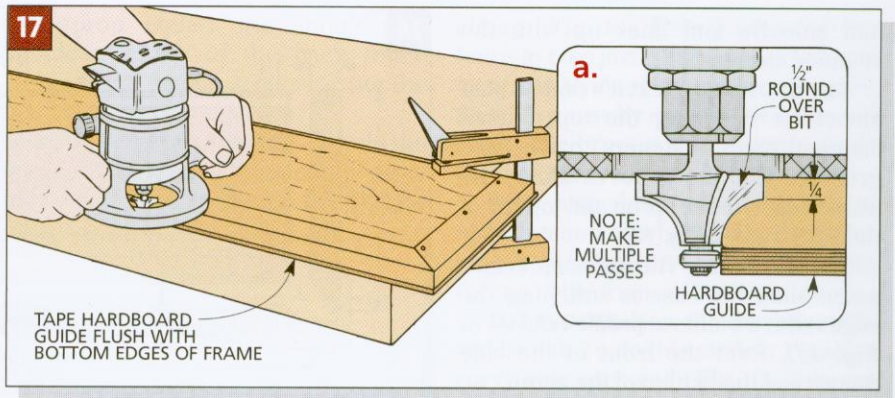
To strengthen the corners and help keep them aligned while gluing, the mitered joints are splined with strips of 1/8" hardboard. I cut the kerfs on the table saw *(Fig. 20)*.

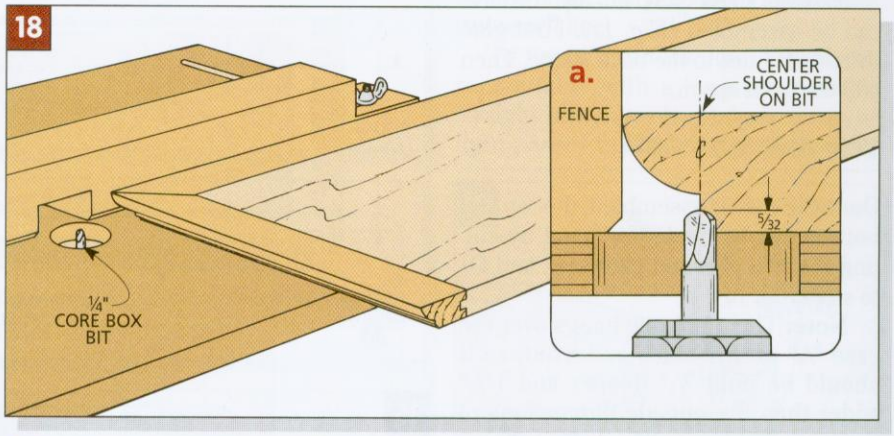
Note: If you have a biscuit (plate) joiner, you could use biscuit joints here.

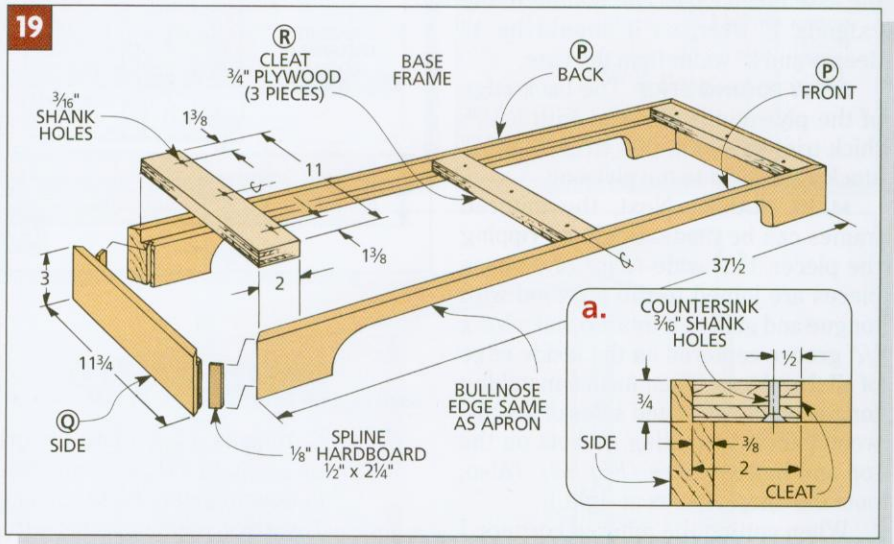
CUT BOTTOM PROFILE. Next, a curved profile can be made on the front and back pieces *(Fig. 21)*. I did this the same way as I did the apron (I).

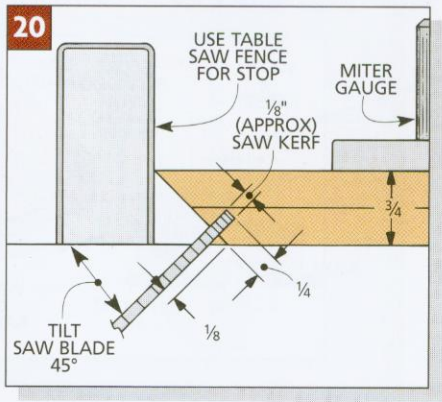
MAKE CLEATS. Now dry clamp the base and measure between the rabbets for the cleats (R) *(Fig. 19)*.

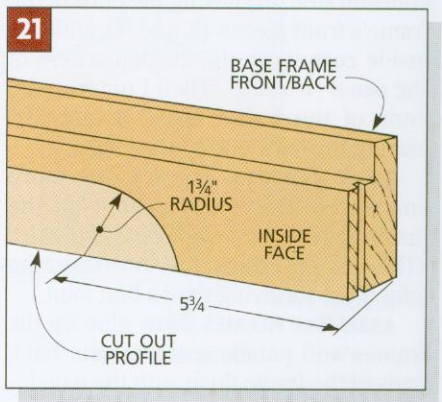
ASSEMBLE BASE. The base frame is assembled by gluing the corners together with the splines in place. While the glue is wet, glue the cleats in place.











ATTACH BOTTOM FRAME. While the base is drying, the bottom plywood frame can be fastened to the case. To do this, turn the case upside down and align the bottom frame on it *(Fig. 22)*.

Now glue and screw the bottom frame and case together.

SCREW ON BASE FRAME. To mount the base frame, drill pilot holes and drive screws through the cleats into the plywood bottom *(Fig. 23)*.

MOUNT TOP. Next, the top frame can be attached with fasteners *(Fig. 24)*. Turn over the top frame and center the case on it. Then slip the fasteners into the grooves and screw them down.

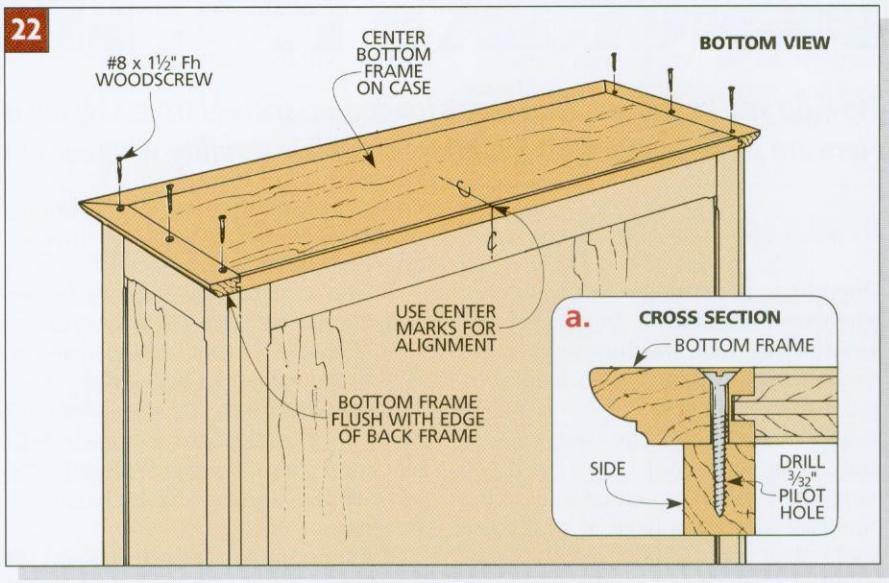
SHELF

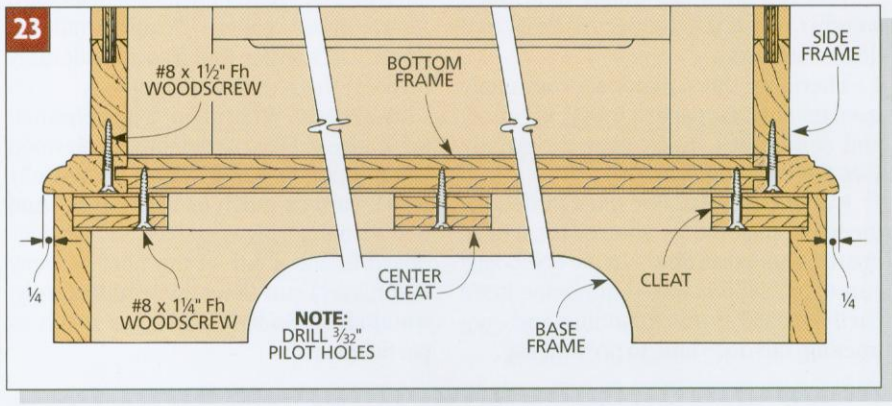
The shelf starts as a piece of plywood 10" wide and 1/8" less in length than the inside of the bookcase *(Fig. 26)*.

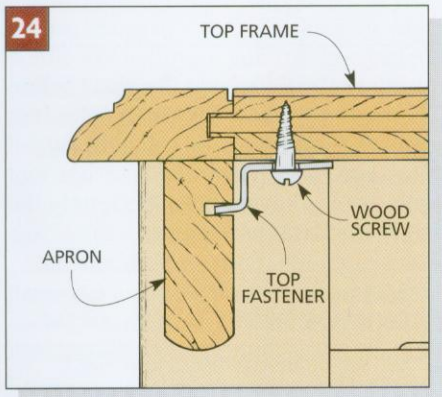
To keep the shelf from sagging, I added reinforcing strips (T) into 1/4" grooves on the front edge and bottom face *(Fig. 26)*.

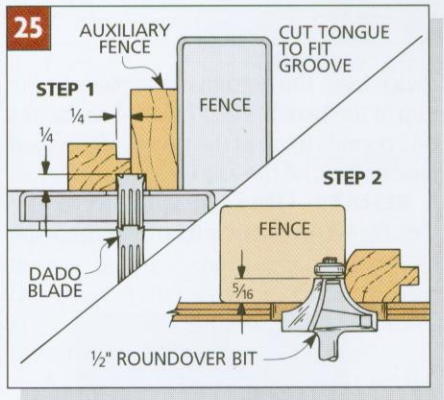
After cutting the grooves, rip 1"-wide strips and cut rabbets to produce a tongue that matches the grooves *(Step 1 in Fig. 25)*.

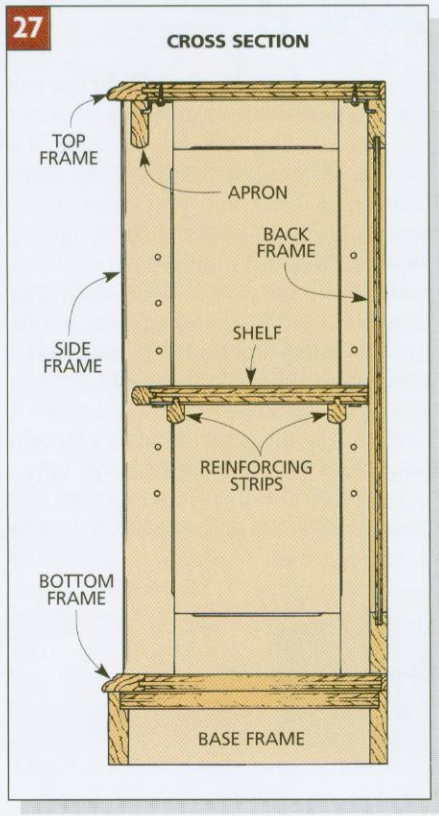
To complete the strips, rout a bullnose profile on the other edges *(Step 2)*. Finally, glue the strips in place. ■

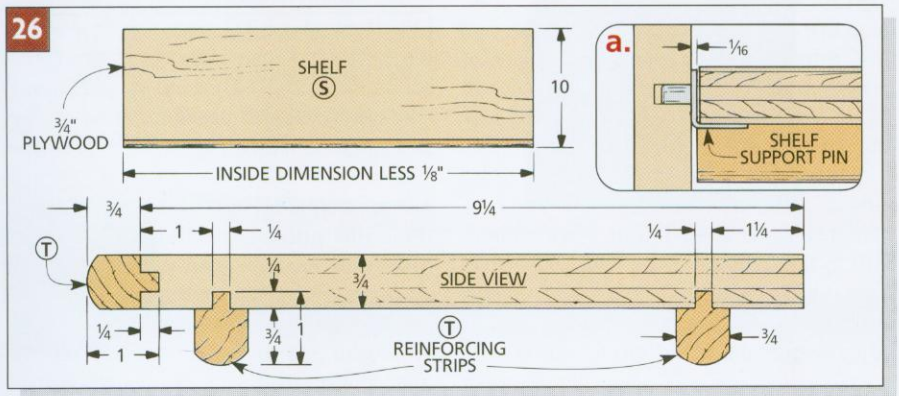












DESIGNER'S NOTEBOOK

How do you keep your bookcase's loaded-up shelves from sagging like a swayback horse? Here are some practical suggestions for adding stability where it's needed most.

SHELF MATERIALS

One of the first things we considered when we designed the bookcases featured in this book was how to keep the shelves from sagging when loaded up with a full set of books.

Books are heavy. The book you are holding weighs about 1 lb. 5 oz. If you completely filled the center shelf of the bookcase shown on page 54 with these books, they would weigh over 90 pounds.

Will the shelf sag under that much weight? Not if the proper material and design are used.

There are three materials commonly used for shelves: particleboard, plywood, and solid stock. Each sags differently (see the test results below).

PARTICLEBOARD. For most situations the worst material for shelves is particleboard. The wood fibers in particleboard run every which way. This helps keep particleboard from expanding and contracting, but does little to prevent sag.

However, particleboard may be the best choice for shelves in two cases. First, if cost is a factor, particleboard is very inexpensive. That's why most knock-down shelves you see at discount stores are particleboard (complete with fake wood grain). A second reason is that particleboard is a good flat base material for veneer.

If you decide to use particleboard for shelving, use high density particleboard (sometimes called "cabinetmaker's grade"). It's stiffer (but also considerably heavier) than "underlayment."

PLYWOOD. What about using plywood for shelves? Like particleboard, plywood is more dimensionally stable and usually won't warp as much as solid stock. And one advantage plywood has over particleboard is that some of the fibers (every other layer) run along the length of a plywood shelf. So it won't sag as much as particleboard.

But hardwood plywood is usually built up of different species of wood. The face plies may be a strong hardwood, such as oak, but the inside plies could be anything, even a softer wood like basswood.

One other disadvantage of both particleboard and plywood is the way they will sag over time. This is called "creep." Particleboard and plywood are especially susceptible to creep because of the glue used to bond the material together. Over a couple of years the glue stretches.

SOLID STOCK. If your only goal in building shelves is to prevent sag, solid stock is the best choice. All of the fibers in it run along the length, so the amount of sag should be small.

It's usually better to make shelves out of a dense hardwood like oak. The wood cell walls in most hardwoods are thick and numerous, and they tend to resist the compression and tension forces that take place within a shelf under load.

SAG TESTS

How much sag is too much? Your eye will start to see a deflection (sag) of about 1/32" per running foot. For example, if a shelf is 36" long, it shouldn't sag more than 3/32" at the center. That means a 1/16" sag would be acceptable, but a 1/8" sag would become very noticeable.

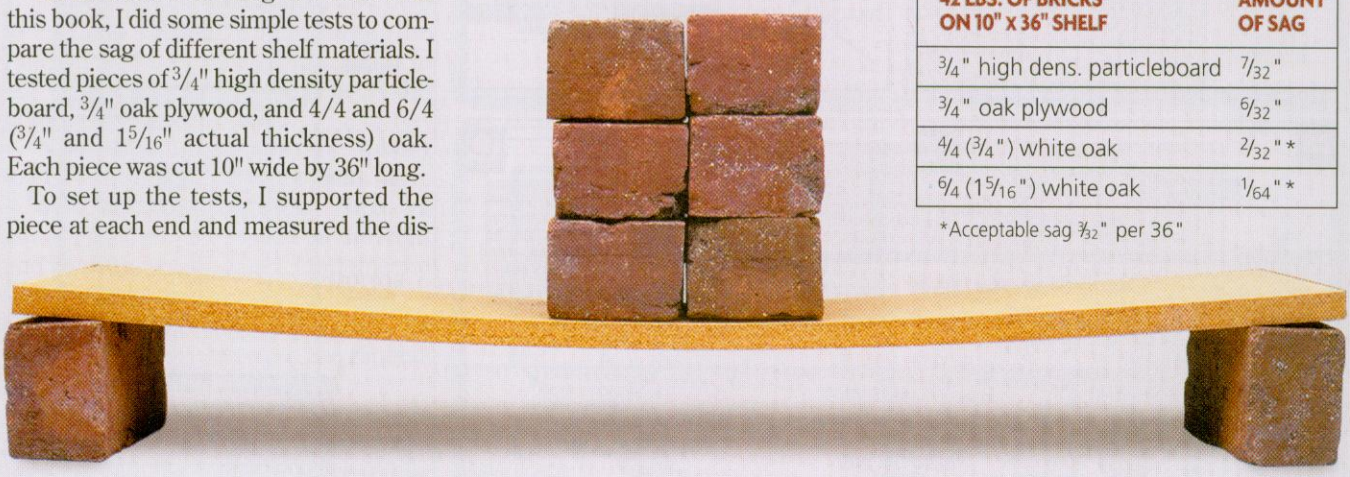
TESTS. Before building the shelves in this book, I did some simple tests to compare the sag of different shelf materials. I tested pieces of 3/4" high density particleboard, 3/4" oak plywood, and 4/4 and 6/4 (3/4" and 1 5/16" actual thickness) oak. Each piece was cut 10" wide by 36" long.

To set up the tests, I supported the piece at each end and measured the distance from the bottom of the piece to the top of the bench. Next I placed six bricks (42 pounds total) at the center of the shelf and measured the sag (see photo).

RESULTS. Okay, so what were the results? The particleboard sagged the most — about 7/32"; see the chart below. The oak plywood sagged a little less than 6/32", and the solid oak only sagged 2/32" and 1/64". Using the 1/32" per foot rule (or 3/32" over three feet), only the solid stock was acceptable.

42 LBS. OF BRICKS ON 10" X 36" SHELF	AMOUNT OF SAG
3/4" high dens. particleboard	7/32"
3/4" oak plywood	6/32"
4/4 (3/4") white oak	2/32"*
6/4 (1 5/16") white oak	1/64"*

*Acceptable sag 3/32" per 36"



RECOMMENDED SPANS

In addition to the material used to build the shelf, there are a couple of other factors you should consider when designing a shelf for a bookcase: the load you expect to put on the shelf, and how that load is distributed on the shelf. Once you know both of these factors, you can determine how great a span the shelf should be able to stretch across without sagging.

EXPECTED LOAD. A running foot of average-size books weighs about 20 pounds. So a three-foot shelf filled with average-size books would have to support about 60 pounds.

LOAD DISTRIBUTION. For the sag tests explained on the opposite page, I wanted to determine the "worst possible situation" for the distribution of the load on the shelf. So I used six bricks (42 pounds), and placed them right in the center of the shelf. However, in a normal situation the weight would be distributed over the entire shelf.

GUIDELINES. Taking all three factors (shelf material, load, and distribution) into consideration, the chart at right shows some general guidelines for the maximum span for shelves to avoid an objectionable sag.

As you can see from the chart, if you have to span more than a couple of feet, the best material to use when building a shelf is solid stock.

MAXIMUM SPAN RECOMMENDATION FOR 10"-WIDE SHELF FULL OF BOOKS	
3/4" particleboard	24"
3/4" plywood	30"
4/4 (3/4") solid stock	36"
6/4 (1 5/16") solid stock	60"

TECHNIQUES FOR REDUCING SAG

If you want to prevent shelves from sagging, solid stock is the best material to use. But there are times that plywood or particleboard might be a better choice for the overall *design* of the bookcase. That's because they aren't as likely to warp or expand and contract with changes in humidity.

Is there any way to still use these materials and reduce the sag?

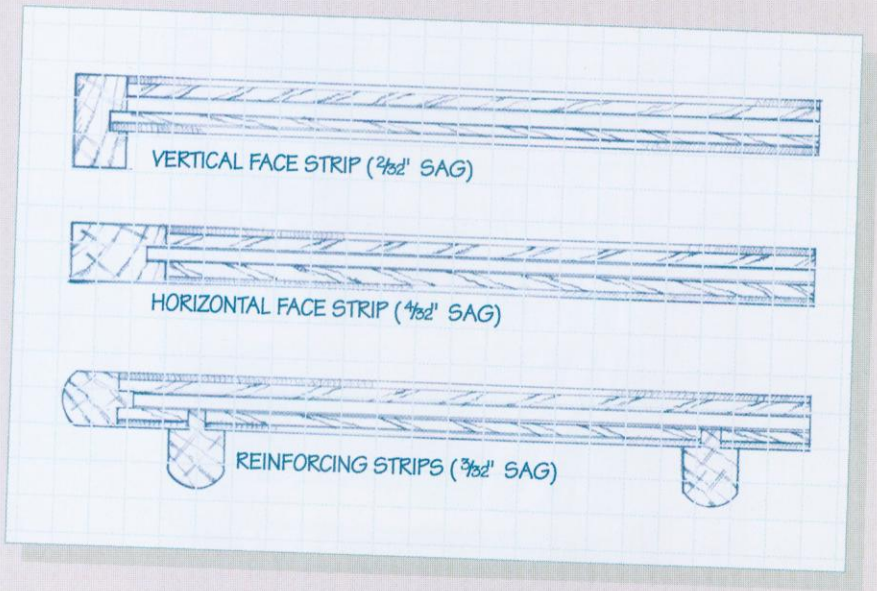
DECREASE SPAN. First, determine if there's a way to design the cabinet to decrease the span of the shelf by adding one or more center supports. If you reduce the span, you can reduce the sag. A rule of thumb is if you cut the span in half, the sag will be one eighth as much as the original.

For example, a shelf that's 36" long may sag 1/8" at the center. If it's supported so each half is 18" long, the sag on each half will be reduced to 1/64".

INCREASE THICKNESS. Another solution is to increase the thickness of the shelf. A thicker shelf will dramatically increase the shelf's rigidity. If you double the thickness, you can reduce the sag to one-eighth of the original.

One of the tests I did (shown in the chart on the opposite page) was to use a piece of 1 5/16"-thick white oak. When the bricks were piled on, the deflection was only a little over 1/64", which compares to 1/16" for 3/4" stock.

ADD REINFORCEMENT. Supporting the center of a shelf, or making the shelf thicker may not be realistic solutions to the overall design of the bookcase. A better approach to reducing sag might be to add reinforcement to the edges or under the shelf. It's common to see shelves with a face strip added to the front edge. This is not just a way to cover the edge of the plywood. Facing strips are a functional addition to the shelf — the strips are there to add stiffness.



A shelf is like a 2x4 laid flat on its side. If you lay a 2x4 flat between two end supports and add weight, it will definitely sag. But if you tip the same 2x4 up *on edge* and add the weight, there will be very little sag. The same principle applies if you add a face strip on edge to a shelf.

To test how much this helps a plywood shelf, I added a 1 1/4"-wide vertical strip of 3/4" oak stock to the front of the plywood shelf and measured the sag. Without the strip the plywood sagged 6/32". But with the vertical facing strip, it sagged only 2/32".

One problem of adding a vertical strip is the decreased shelf space. What about adding a *horizontal* face strip to the front of the plywood shelf? I added a 1 1/4"-wide strip horizontally to the front of the plywood and it sagged a little more than 4/32" (or 1/8"). That's an improvement over the plywood without a strip but not as good as the strip on edge.

I also decided to try adding some wood reinforcing strips *under* the shelf where they wouldn't show. I cut a couple pieces of 1"-wide hardwood strips (with a tongue and bullnosed face) and glued them into grooves cut into the bottom of the plywood shelf. It sagged about 3/32", and I'd consider that acceptable on a three foot long shelf. That's the design we ended up using for the oak bookcase as shown on page 61.

Classic Bookcase

Separate components and knock-down hardware make this formal cherry bookcase easy to assemble and convenient to move. And you can customize the top design to suit your taste.

I've always wanted to build a large, formal-looking bookcase. But I had visions of wrestling it around my shop when the time came to assemble and finish it.

The design of this bookcase changed all that. A simple, straightforward system breaks the project down into manageable-sized pieces that are easy to handle.

To see what's special about the design, you need to look inside. Here you'll find a "knock-down" system using bolts and nuts to hold things together. Not something you'd expect on a classic piece of furniture.

What makes this system work are the individual components used to build the bookcase. The base, sides, and top are all built as separate units. Once completed you just bolt them together.

And it's just as easy to take apart. You won't need to hire a moving crew if you get tired of it in the living room.

Another benefit to using components is being able to change the overall appearance. By building a different top assembly, the project takes on a completely new look. For example, the classic top with the oval can be replaced with a straight one (see page 72).

WOOD. A classic project requires a classic wood. And tight-grained cherry and cherry plywood, with its subtle grain pattern, is perfect. For the back panel I used $\frac{1}{4}$" cherry plywood.

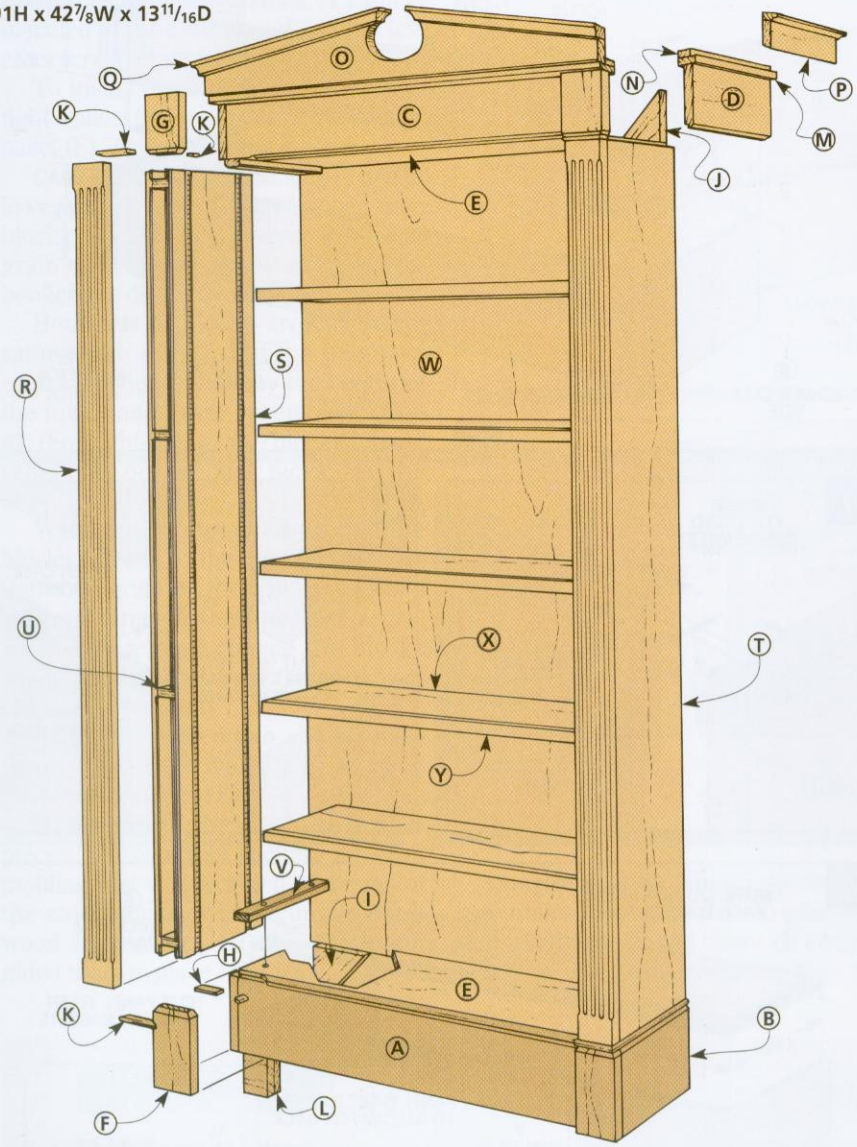
FINISH. When it came time to apply a finish I decided to use a cherry stain. I wanted the rich reddish-brown color without waiting for the aging process. And using stain would even out the color differences between the lighter sapwood and darker hardwood.

I stained with a dark red cherry gel stain. A gel stain doesn't penetrate as deep as other stains so it isn't as likely to leave dark blotches.

After the stain dried, I brushed on three coats of varnish.

EXPLODED VIEW

OVERALL DIMENSIONS:
91H x 42 7/8W x 13 11/16D



MATERIALS LIST

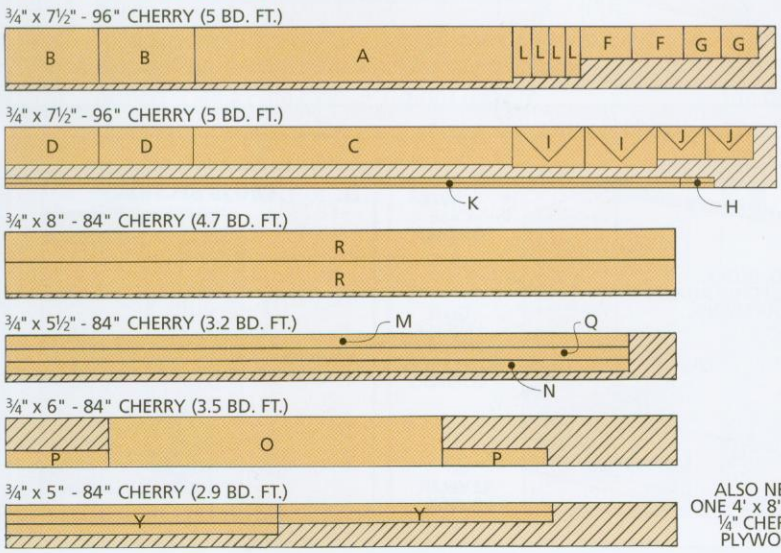
WOOD

A	Lwr. Case Frt. (1)	3/4 x 6 5/8 - 39 5/8
B	Lwr. Case Sides (2)	3/4 x 6 5/8 - 11 13/16
C	Upr. Case Frt. (1)	3/4 x 4 5/8 - 39 5/8
D	Upr. Case Sides (2)	3/4 x 4 5/8 - 11 13/16
E	Top/Btm. Panls. (2)	3/4 ply - 11 3/16 x 39 7/8
F	Lwr. Case Blks. (2)	3/4 x 3 5/8 - 6 5/8
G	Upr. Case Blks.(2)	3/4 x 3 5/8 - 4 5/8
H	Filler Pieces (4)	3/8 x 3/4 - 2 1/8
I	Lwr. Crnr. Blks. (2)	3/4 x 5 - 9 rough
J	Upr. Crnr. Blks. (2)	3/4 x 4 - 6 rough
K	Bead Molding (1)	3/8 x 5/8 - 14 feet
L	Leveler Blocks (4)	3/4 x 5 3/4 - 2 1/8
M	Top Molding (1)	3/4 x 1 3/4 - 78
N	Cleat (1)	3/4 x 1 1/4 - 78
O	Top Front (1)	3/4 x 6 - 44 rough
P	Top Sides (2)	3/4 x 3 - 14 rough
Q	Cove Molding (1)	3/4 x 1 3/8 - 78
R	Fluted Caps (2)	3/4 x 3 3/4 - 84 rough
S	Interior Panels (2)	3/4 ply - 11 1/2 x 72
T	Exterior Panels (2)	3/4 ply - 11 3/4 x 72
U	Ribs (8)	3/4 ply - 2 x 11 1/4
V	Align. Blocks (4)	3/4 ply - 1 1/2 x 11 1/4
W	Back (1)	1/4 ply - 38 1/2 x 73 1/2
X	Shelves (5)	3/4 ply - 10 1/2 x 33 15/16
Y	Trim Pieces (5)	3/4 x 1 1/4 - 33 15/16

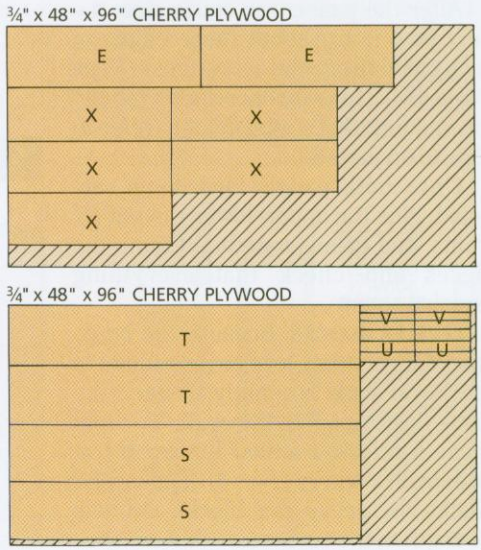
HARDWARE SUPPLIES

(68) No. 8 x 1 1/4" Fh woodscrews
(8) 1/4-20 x 3" hex head bolts
(8) 1/4" flat washers
(8) 1/4-20 T-nuts
(2) 1 1/8"-dia. levelers with T-nuts
(4) 72" shelf standard brackets (brown)
(52) Bracket nails (brown)
(20) Shelf supports (brown)

CUTTING DIAGRAM



ALSO NEED:
ONE 4' x 8' SHEET
1/4" CHERRY
PLYWOOD



UPPER & LOWER CASE

This bookcase is built in separate assemblies. Normally, I'd build them one at a time. But here, the upper and lower case assemblies are almost identical. (The upper case is 2" shorter.) Building them at the same time reduced the number of setups.

FRONT & SIDES. Both the upper and lower case assemblies start with a front and two side pieces. I began by cutting the lower case front (A) and sides (B) to finished size *(Fig. 1)*. And then I repeated the same steps to make the upper case front (C) and sides (D).

Next, I used a locking rabbet joint to hold the front and side pieces together *(Fig. 2)*. A tongue cut on the front pieces fits in a 1/4"-deep dado cut on the side pieces. The important thing here is to make the tongue fit snugly in the dado.

After cutting the tongue, I rabbeted the inside top edge of the lower case assembly and the inside bottom edge of the upper case assembly *(Fig. 3)*. These rabbets will hold a top and bottom panel which are made next.

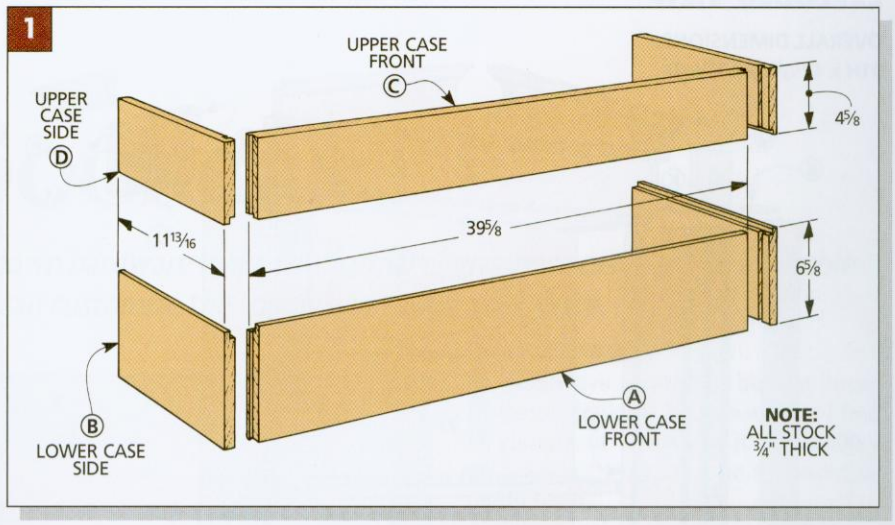
TOP/BOTTOM PANELS. To determine the length of the top/bottom panels (E), dry assemble the fronts and sides and measure the distance between the rabbets on the sides *(Fig. 4)*.

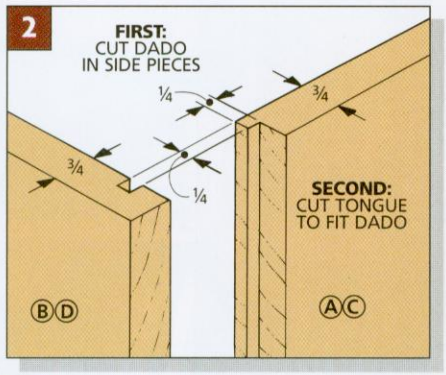
Then to determine the width, measure from the rabbet on both front pieces to the back edges of the sides. But you need to leave room for the plywood back (added later). So the width of each panel is cut so it's 1/4" short of the back edge *(Fig. 4a)*. In my case, the finished size of both top/bottom panels (E) was $11\frac{3}{16}$" x $39\frac{7}{8}$".

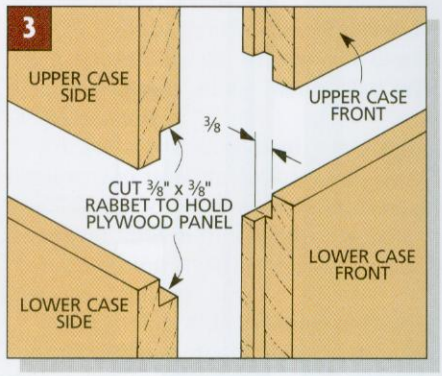
After the panels are cut to size, the next step is to rabbet three edges of each panel (front and side edges) *(Figs. 4 and 4a)*. This rabbet creates a "shelf" for molding that's added later (refer to *Fig. 10* on page 68).

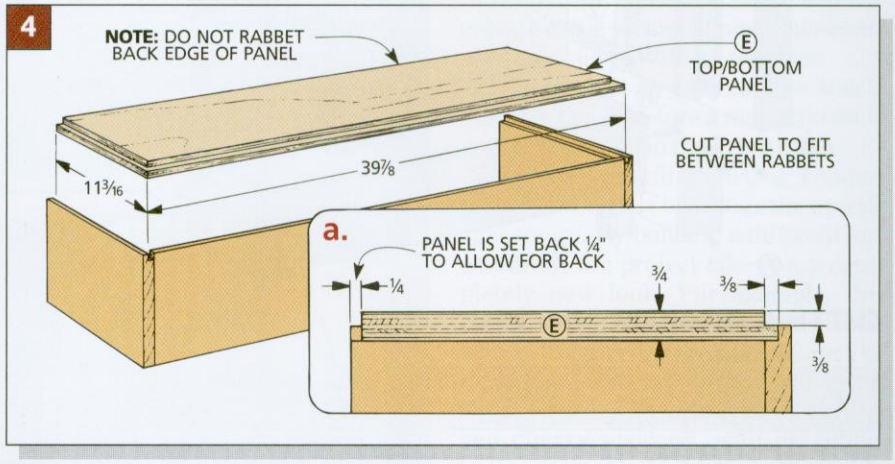
Once both panels have been rabbeted, glue the upper/lower case sides, fronts, and panels together. Clamp the pieces and check that everything remains square.

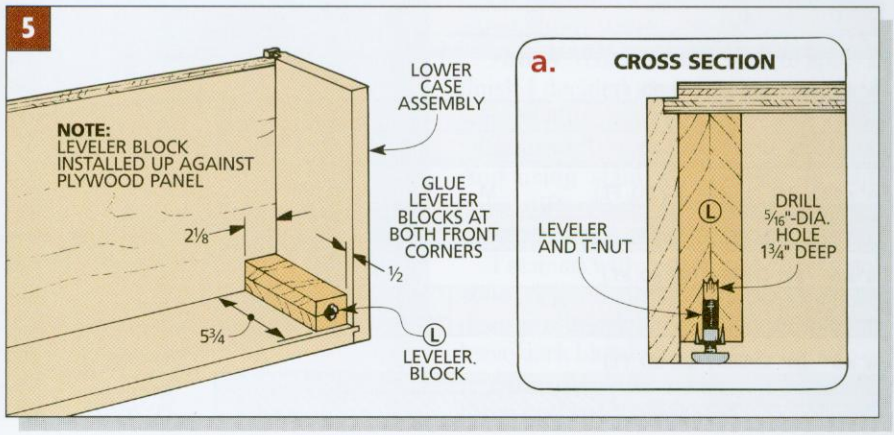
LEVELER BLOCKS. Because the bookcase stands so tall, levelers are added to the lower case assembly to keep the back tight against the wall. To hold these levelers, I added blocks (L) at both front corners *(Fig. 5)*. The leveler blocks also act as glue blocks and help strengthen the corners.











Each leveler block is glued up from two pieces of $^3/_4$"-thick stock. A T-nut is installed in the bottom end and the levelers screw into the nut *(Fig. 5a)*.

To install the blocks, position them tight against the underside of the bottom panel (E). Then glue them in place.

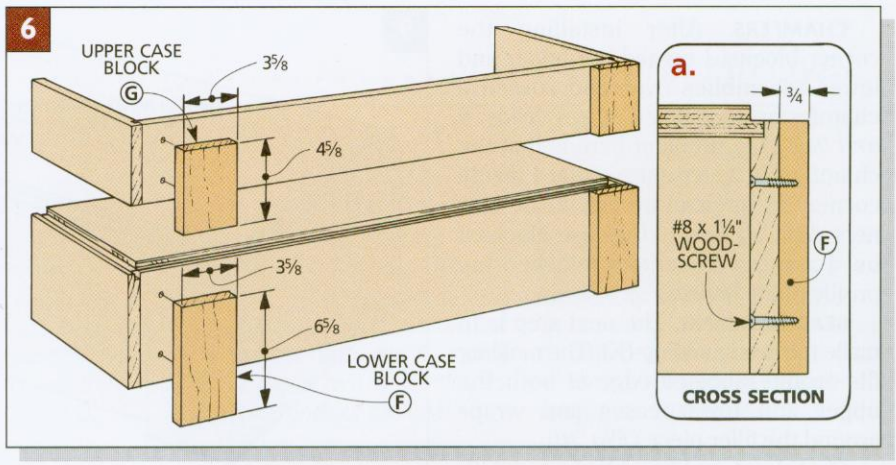
CASE BLOCKS. The next step is to add lower case blocks (F) and upper case blocks (G). The blocks cover up the end grain on the side pieces and give the bookcase a distinctive look.

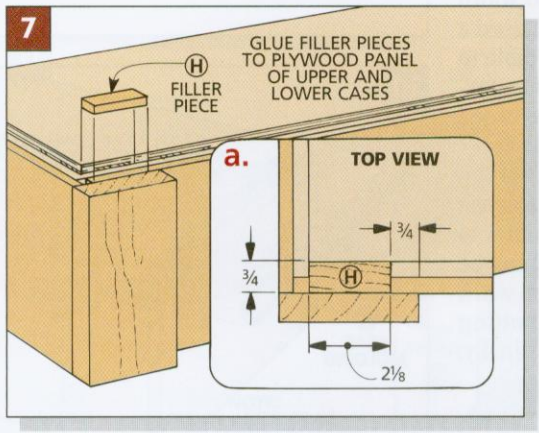
Both sets of blocks are cut to the same width ($3^5/_8$"). But the height of each set is determined by the height of the upper and lower assemblies *(Fig. 6)*. (For tight-fitting case blocks I made relief cuts on the back faces; see the Shop Tip box below.)

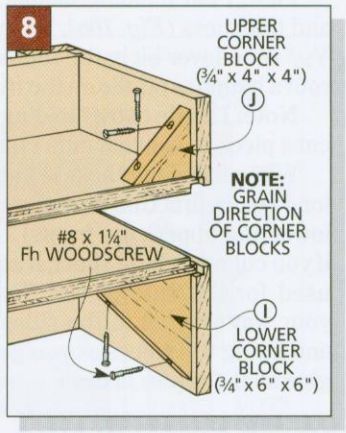
You might be tempted to glue the blocks directly to the front pieces. But the wood grain on the blocks runs in a different direction than the front pieces. So there's a good chance the blocks would "pop off" if the wood moved from changes in humidity.

Instead, I drilled two shank holes through the case fronts and screwed the blocks in place *(Fig. 6a)*.

FILLER PIECES. Next I added filler pieces. These act as backing for bead molding that will be glued to the top of the case blocks later. I cut the hardwood filler pieces (H) $^3/_8$" thick and glued them in place *(Fig. 7)*.







CORNER BLOCKS. Then I turned the assemblies around so I could glue and screw on lower (I) and upper (J) corner blocks at the back corners *(Fig. 8)*. These triangular-shaped blocks add support to each assembly.

Note: The blocks are installed flush with the back edge of the plywood.

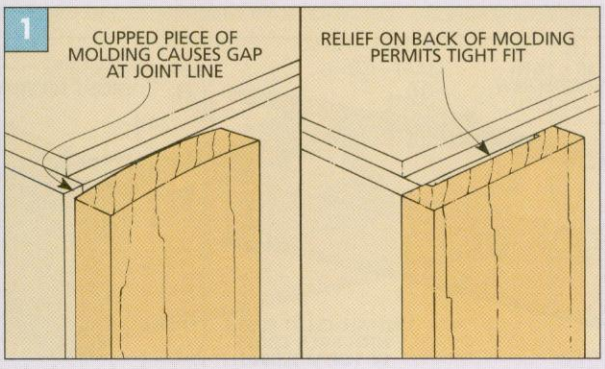
SHOP TIP ..... *Relief Cuts For A Tight Fit*

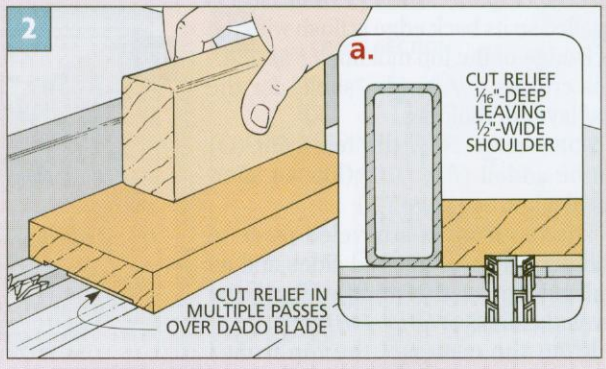
The success of a project depends on the fit of the parts. This is especially true for a piece of trim that's applied to the face of a project such as the case blocks on this bookcase.

The blocks should fit tight to the case along their edges. But if the blocks are cupped even slightly the edges *won't* fit tight *(Fig. 1)*.

This is the same problem faced by carpenters who install trim molding in houses. Their solution is to use molding that's milled with a shallow "relief" on the back side to fit up tight against a wall.

So I cut a shallow channel across the back side to create relief behind the block *(Fig. 2)*. Note: In order to avoid weakening the block, only cut the channel $^1/_{16}$" deep.





CHAMFERS. After installing the corner blocks, I turned the upper and lower assemblies over and routed a chamfer around three edges *(Figs. 9 and 9a)*. One problem here is that the chamfer bit won't cut a square inside corner. So to clean up the inside corners right up next to the case blocks, I used a sharp chisel and followed the profile of the bevel *(Fig. 9b)*.

BEAD MOLDING. The next step is to make the bead molding (K). The molding fits on the rabbeted edge of both the upper and lower cases and wraps around the filler piece *(Fig. 10)*.

First, I cut molding blanks to width and thickness *(Fig. 10a)*. Then I used a $^3/_{16}$" roundover bit in the router table to rout a bullnose profile on the front edge.

Note: I made extra molding in case I cut a piece or two that didn't quite fit.

When installing the molding, cut the long pieces first (the ones that cover the lower and upper case fronts). That way if you cut one a little short, it still can be used for the side pieces. Then work your way around to the sides, cutting and fitting the pieces as you go. Finally, glue all the pieces in place.

UPPER CASE MOLDING

At this point, the lower case assembly is done, and you can start work on the upper case. It's built in several layers.

TOP MOLDING. The first layer is the top molding (M) *(Fig. 11)*. The molding starts out as a single workpiece cut into three pieces. It's the base for the rest of the molding.

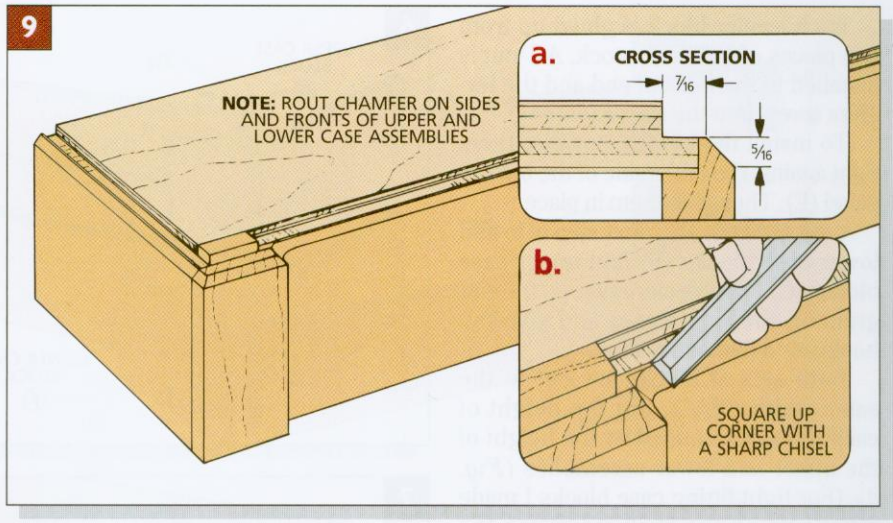
Installing the molding is pretty straightforward. Simply miter the pieces so the molding overhangs the sides and the case blocks on the front by $^1/_4$" *(Figs. 11a and 11b)*. Then glue and screw them in place.

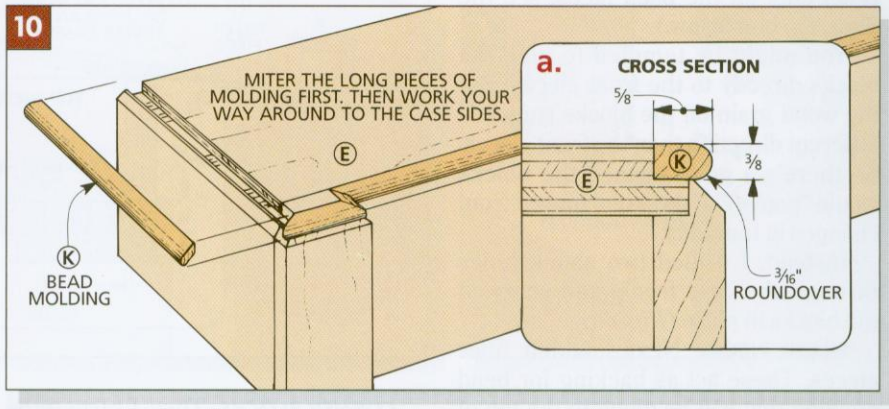
CLEAT. The next "layer" to add is the cleat (N) *(Fig. 12)*. The $1^1/_4$"-wide cleat is installed so its back edge is flush with the back edge of the top molding *(Fig. 12a)*. This creates a $^1/_2$"-wide "shelf" for the next layer of molding.

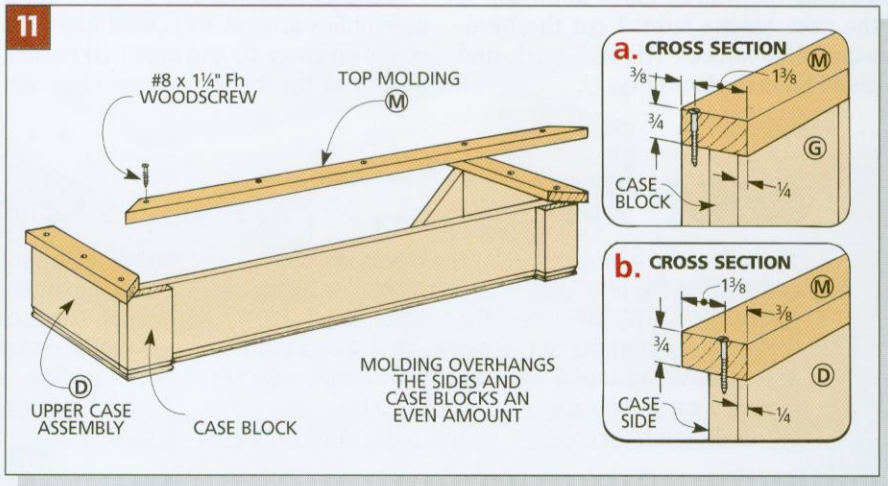
TOP FRONT. Now the top front (O) can be added *(Fig. 13)*. (For an alternate design, see page 72.)

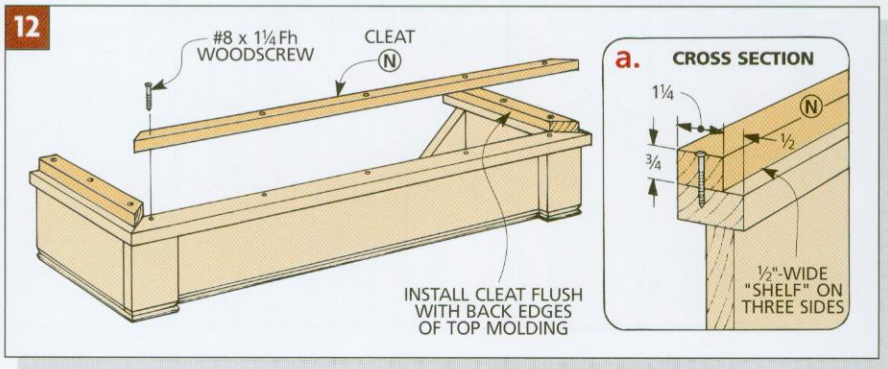
The top front is a beveled piece of molding with two tapered sides and an oval cut out of the middle. I cut the beveled ends first *(Fig. 13a)*.

From the center of the top front I drew an oval (see the Shop Tip box





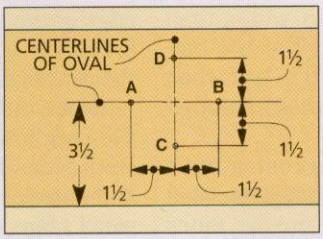




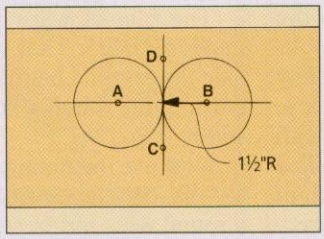
SHOP TIP ..... Drawing An Oval

You don't have to be a whiz kid in geometry to draw an oval.

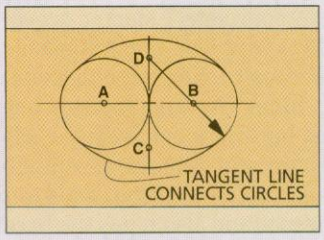
First, only four points need to be drawn. Then all you have to do is draw two circles and two arcs with a compass.



1 *From the center of the oval, measure and mark the centerpoints A, B, C, and D.*



2 *Use centerpoints A and B to draw two 3" circles to form the ends of the oval.*



3 *Use centerpoints C and D to draw arcs connecting the tangents of the circles.*

above). Then I marked the tapered cuts on each side of the oval.

I cut out the oval with a sabre saw close to the line and cleaned up to the line with a drum sander. Next, I cut the tapers and glued and clamped the top front to the cleat *(Fig. 13b)*.

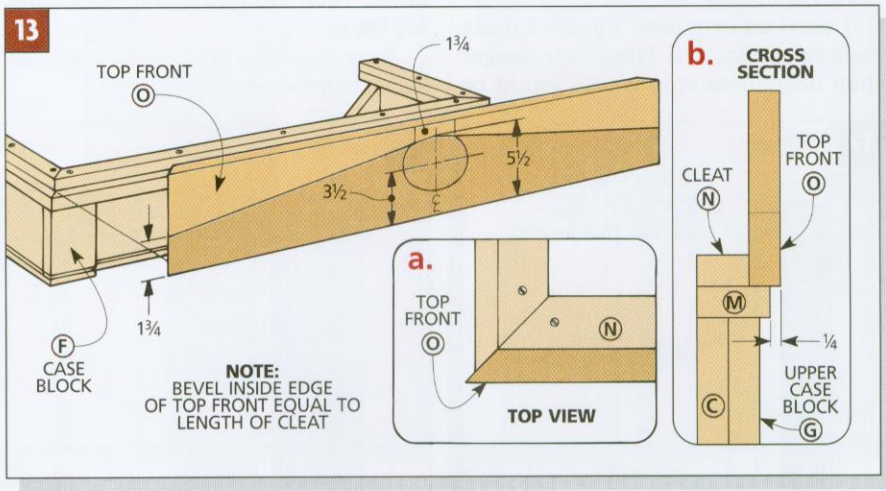
TOP SIDES. Once the top front was installed, I started work on the top sides (P) *(Fig. 14)*. The goal here is to make the sides flush with the tapered edge on the front piece *(Fig. 14a)*.

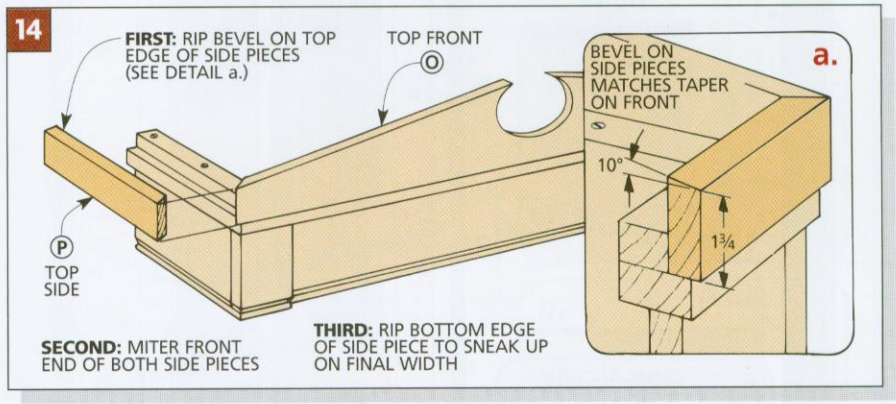
The simplest way to do that is by starting with a board that's wider than needed (in my case, 3"). Then rip a 10° bevel along one edge *(Fig. 14a)*.

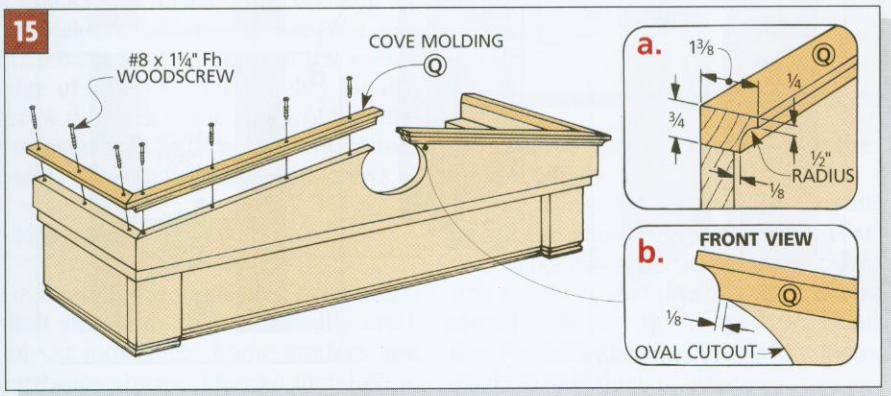
Next, miter the front end and cut the back end to length. Then sneak up on the final width by ripping the edge *opposite* the bevel. Once the top edges are flush, glue them to the cleats.

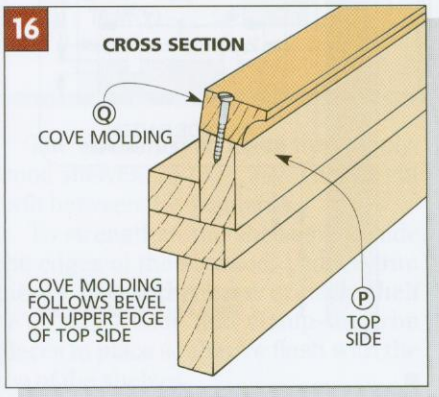
COVE MOLDING. The final piece to add is the cove molding (Q). I started by ripping the molding to its finished width ($1^3/_8$"), and then routing a $^1/_2$" cove *(Fig. 15a)*.

Next, I cut pieces to fit on the sides and front with overhang over the oval *(Fig. 15b)*. Then glue and screw these pieces in place *(Fig. 16)*.









SIDE ASSEMBLIES

Once the top and bottom assemblies were complete I started work on the side assemblies. Their unusual double-wall construction not only adds rigidity but hides the knock-down hardware. This hardware connects the sides with the top and bottom assemblies. The fluted cap on the front adds a touch of elegance and also hides the hardware.

FLUTED CAP. I began to work on the side assemblies by making the fluted caps (R). They have evenly spaced flutes on the face and half flutes on each edge. To help space the flutes evenly, I used a fluting jig (see page 73).

I used an oversized blank to make each cap *(Fig. 17)*. They were longer than needed so stop blocks could be clamped on the ends. These blocks stop the jig in the same spot to keep the flute lengths equal.

The blanks were also wider than needed ($3\frac{3}{4}$"). That way the two outside flutes could be ripped in half when cutting the blanks to their finished width *(Fig. 17a)*.

Now use the fluting jig, router, and a $\frac{3}{8}$"-dia. core box bit (sometimes called a round nose bit) to rout the five flutes in each cap.

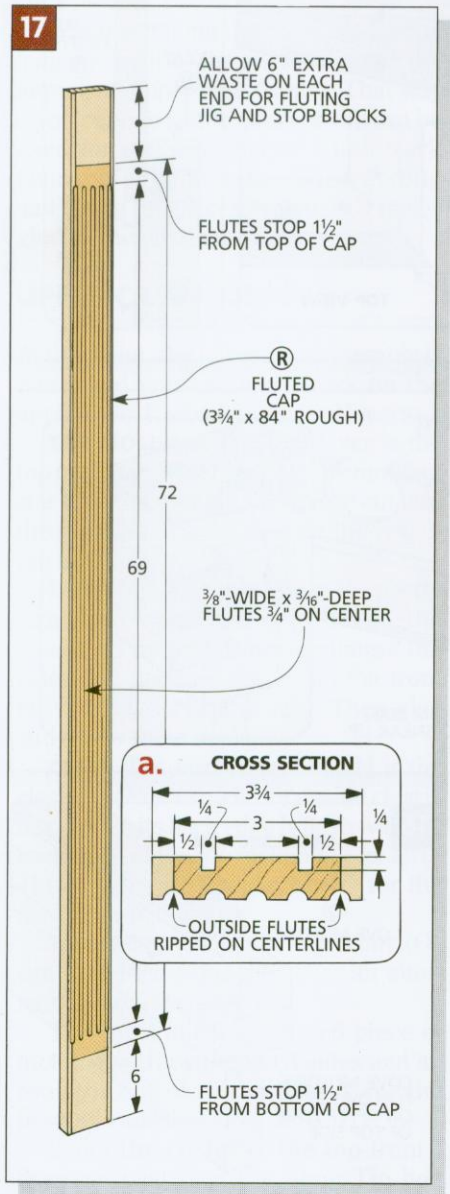
Note: I made a scraper from an old hacksaw blade to clean up some burn marks on the ends of the flutes. Just file the blade to a profile that matches the flutes. Then use it to lightly scrape out any burns.

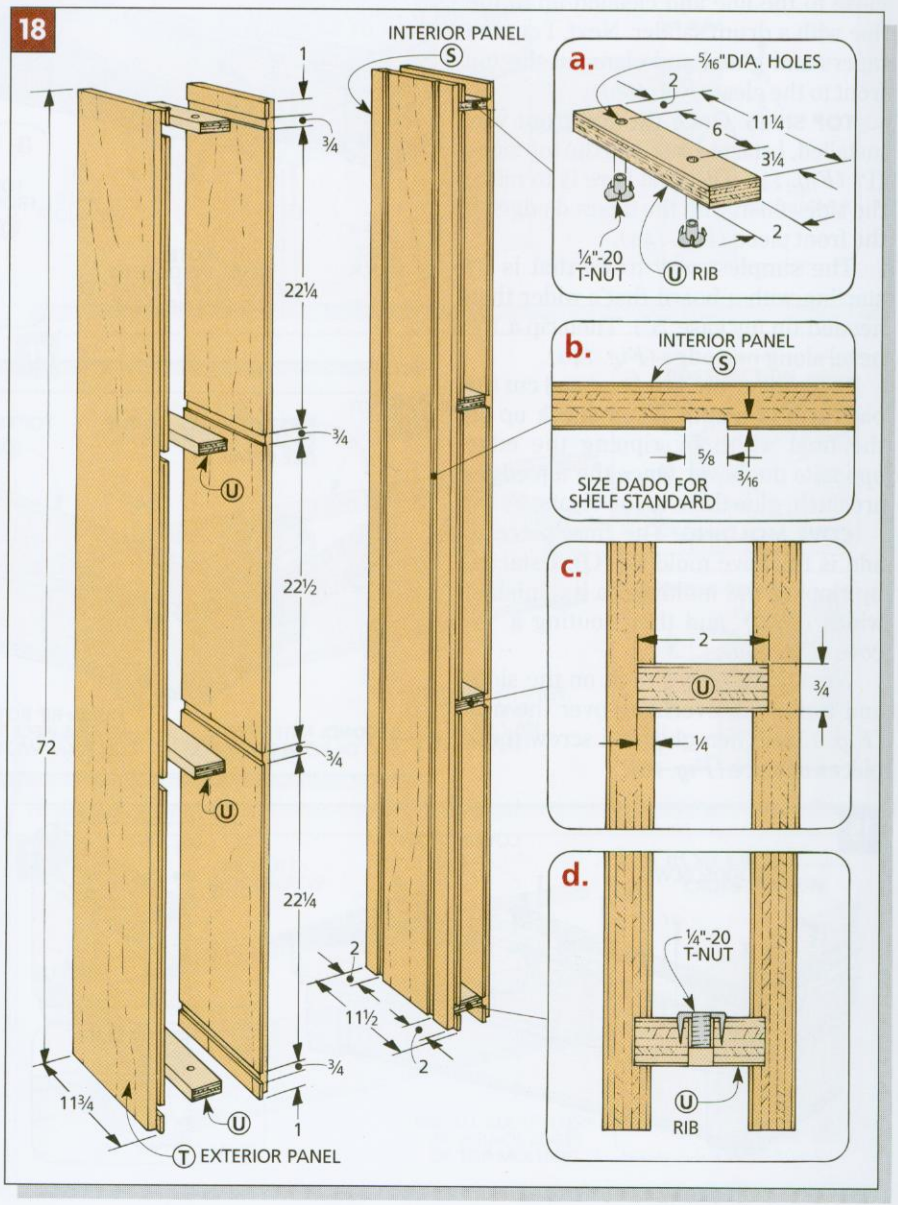
After the flutes are cut, the caps can be cut to finished size *(Fig. 17)*.

Next, I cut two grooves on the back side of each cap *(Fig. 17a)*. These grooves will accept tongues on the front edge of the side panels. When the case is ready to be assembled they help keep the cap aligned with the sides.

SIDES. After cutting the grooves in the cap, I started work on the sides. Both sides have an interior panel (S) and exterior panel (T) made from plywood *(Fig. 18)*. These panels are identical in length, but the interior panel is cut $\frac{1}{4}$" narrower. This allows for the thickness of the plywood back that's installed later.

After the panels were cut to finished length and width, I rabbeted the front edge of each panel to form a tongue. The tongues are cut so they'll fit snugly in the grooves on the back of the caps.





Next, four dadoes are cut on the inside walls of both the interior and exterior panels *(Fig. 18c)*. Plywood ribs fit in these dadoes to help keep the panels aligned.

Then two full-length grooves are cut in the inside face on both interior panels *(Fig. 18b)*. These are for metal shelf standards which are added later.

RIBS. After the grooves are cut, I made four ribs (U) for each side assembly *(Fig. 18a)*. These ribs fit in the dadoes cut in the interior and exterior panels. Two of the ribs are drilled to accept T-nuts. Bolts inserted through the top and bottom assemblies and into the T-nuts are used to draw everything together during final assembly.

SIDE ASSEMBLY. After the T-nuts are installed in the ribs, the side units can be assembled. First glue and install the ribs in the dadoes *(Fig. 18)*. As you install them, remember to put the ribs with the T-nuts at the top and bottom locations.

Then glue and clamp the fluted caps on the front of both side assemblies.

ALIGNMENT BLOCKS. To help put the bookcase back together if it's taken apart, alignment blocks (V) are added to the upper and lower case assemblies. They automatically align the sides and the cases.

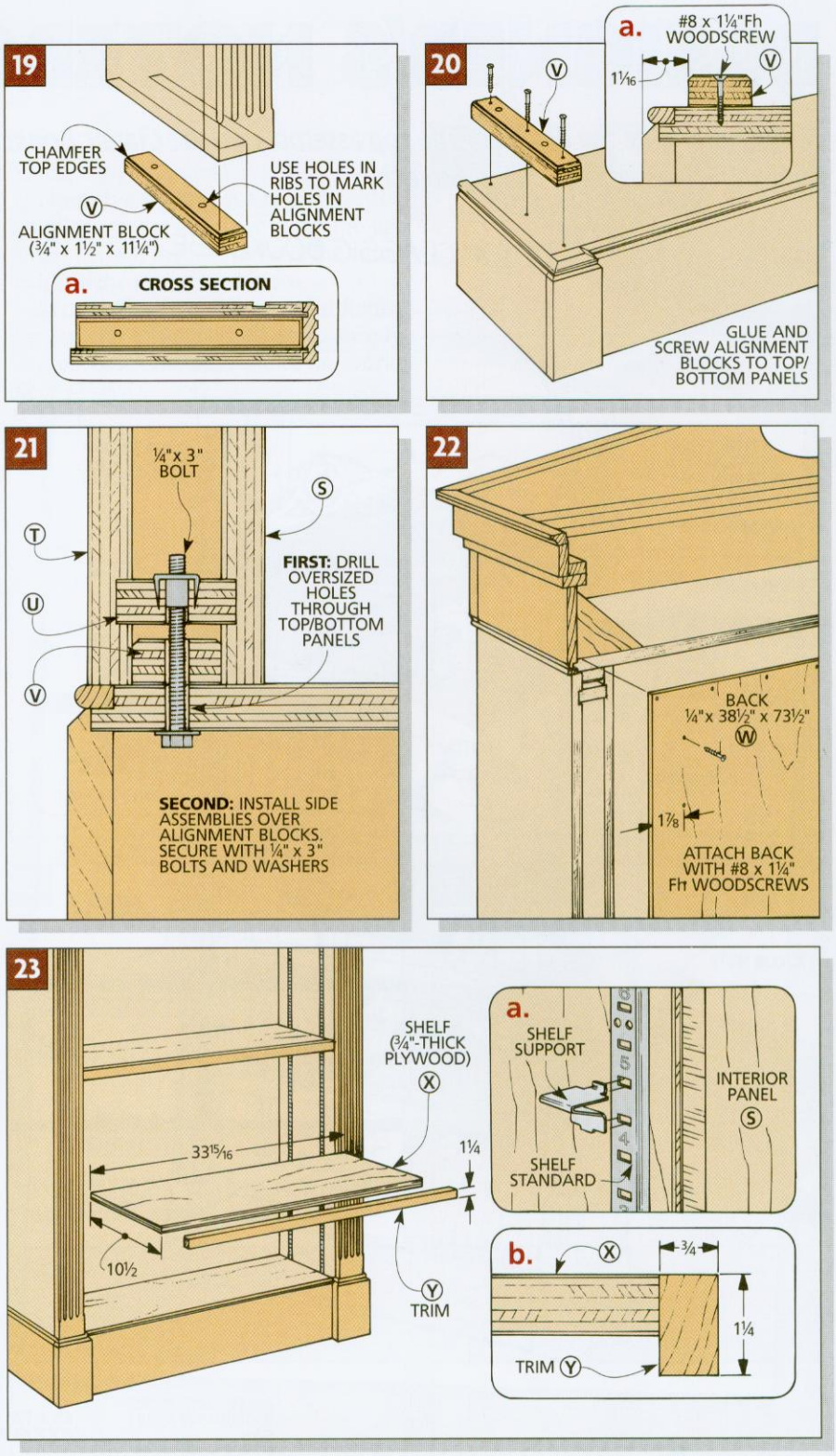
First, the blocks are cut to fit into the top and bottom openings in the sides *(Fig. 19)*. Chamfer the edges so it's easy for the sides to slip over the blocks.

Next, glue and screw the blocks to the top and bottom panels *(Fig. 20)*.

Then drill oversize holes through the blocks and top and bottom panels. The larger holes make it easier to get the bolts aligned with the T-nuts.

After the holes were drilled, I attached the sides to the upper and lower case with 3"-long bolts and washers *(Fig. 21)*.

BACK. Now measure the opening for the back (W) and cut it to size *(Fig. 22)*. (The back butts up against the *inside* edge of both exterior panels.) Finally, screw the back to the edges of the interior panels (S) and the top and bottom panels (E) with flathead woodscrews.



SHELVES

To support the shelves, I used metal shelf standards that are readily available at most local home centers and hardware stores. They're installed in the grooves that you cut earlier in the interior panels.

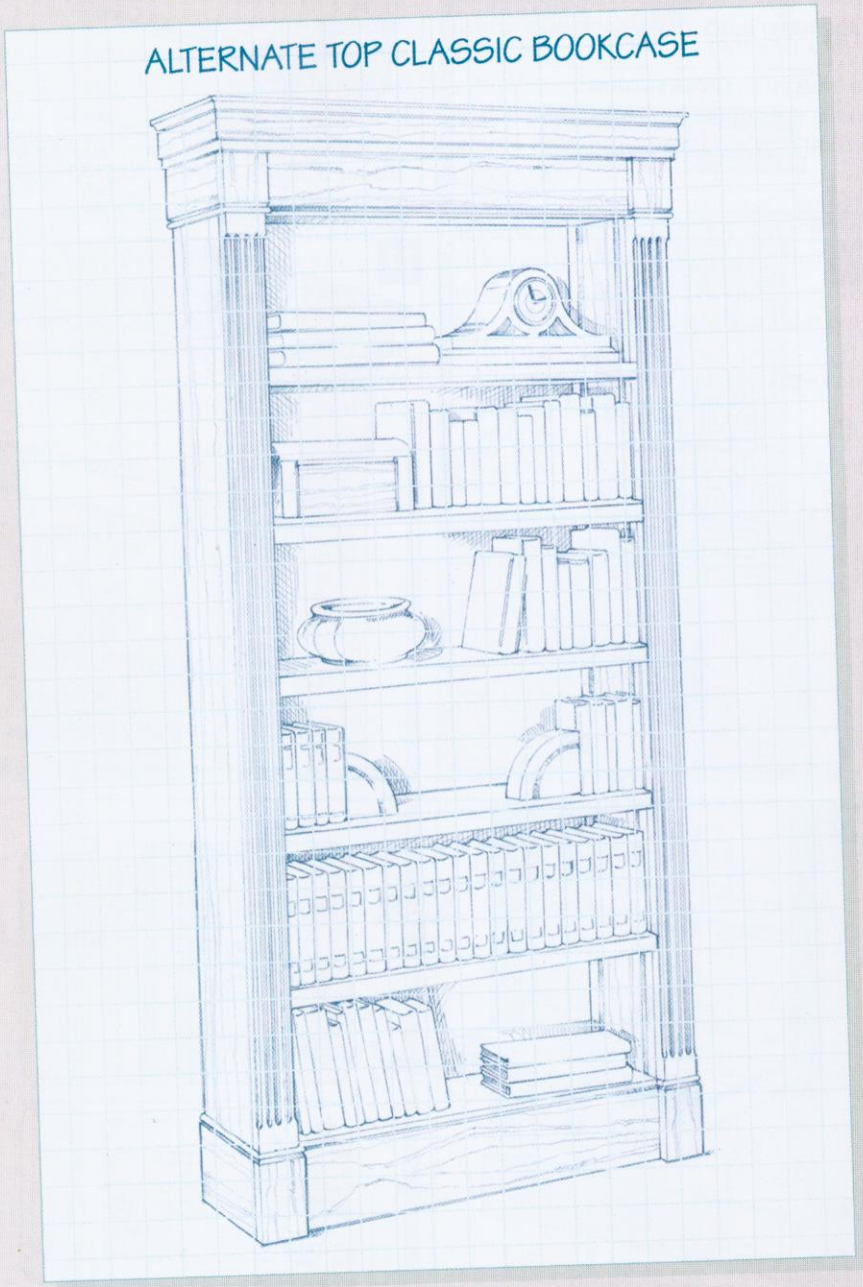
One thing to keep in mind as you install the standards is to check that they're positioned in the same direction (the numbers stamped on the brackets are all right side up) *(Fig. 23a)*. Then use the nails that came with the standards to hold them in place.

The last step is to make the five plywood shelves (X) *(Fig. 23)*. They're cut to fit between the standards.

To strengthen the shelves and hide the edges of the plywood, I added trim pieces (Y) to the front of each shelf *(Fig. 23b)*. Glue and clamp the trim pieces in place so they're flush with the top of the shelves. ■

DESIGNER'S NOTEBOOK

Simply changing the design of the top assembly on the Classic Bookcase will dramatically change the whole appearance of the project.



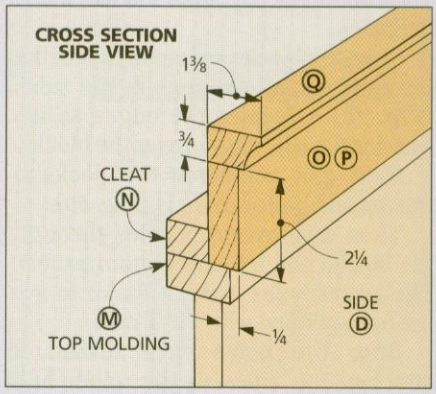
CONSTRUCTION NOTES:

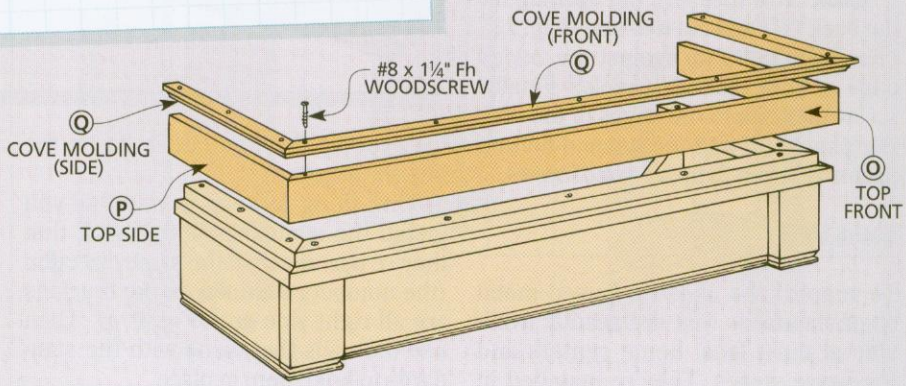
- To make the Classic Bookcase with a simpler top design, start by cutting the top front (O) and top side pieces (P) to a uniform width of 2¼".
- Miter these pieces (O, P) to length to allow for a ¼" overhang over the top molding (see Cross Section below and *Fig. 13a* on page 69).
- Glue and clamp the top front (O) and side pieces (P) to the cleats (N).
- The cove molding (Q) is routed, mitered, and then glued and screwed in place as on the original design (see Cross Section below and page 69).

CHANGES TO MATERIALS

ALTERNATE TOP BOOKCASE:

O	Top Front (1)	¾ x 2¼ - 44 rough
P	Top Sides (2)	¾ x 2¼ - 14 rough
Q	Cove Molding (1)	¾ x 1⅜ - 78 rough





SHOP JIG . . . . . Fluting Jig

When I first saw the shop drawings for the Classic Bookcase, I was pleased. Nice design, basic joinery, and useful, too. Then I saw the flutes (vertical grooves running up and down the caps). These would be interesting.

My first question was how to make them. Right away I knew it would be with a core box bit in the router. But what's the best way to rout the flutes an equal distance apart? What was needed was some sort of indexing jig.

The jig in the photo is the result. It has just two main parts. A piece of hardboard that replaces the base plate on the router *(Fig. 1)*. And a set of spacer strips attached to the hardboard.

SPACER STRIPS. The spacer strips are the key to the jig. The width of each spacer is critical — it should equal the desired distance between the centers of the flutes, in this case 3/4" *(Fig. 1b)*.

The two outside strips act as fences for guiding the jig on the workpiece *(Fig. 1a)*.

BASE PLATE. The base plate should be cut long enough to accommodate the strips on either side of the bit plus the width of the workpiece *(Fig. 2)*.

Then cut two slots parallel to the long edge of the plate. These are for securing the strips *(Fig. 1)*.

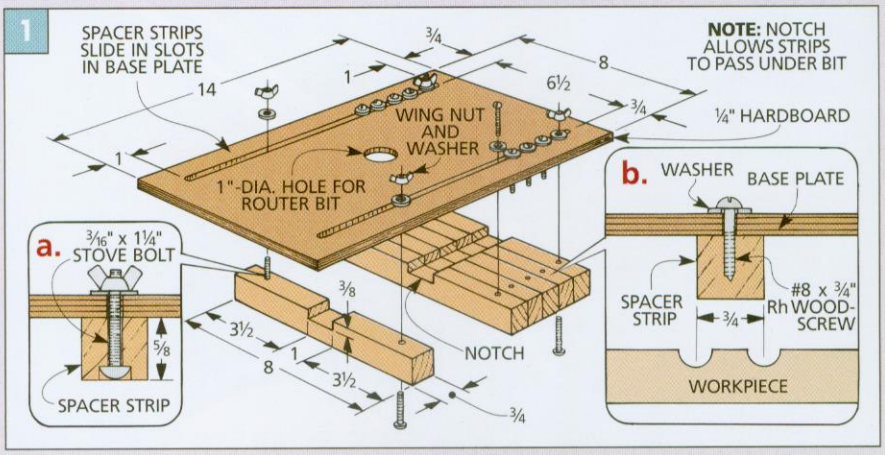
SET-UP. To set up the jig, start by positioning the spacer strips in relation to the bit (first drawing in *Fig. 2*).

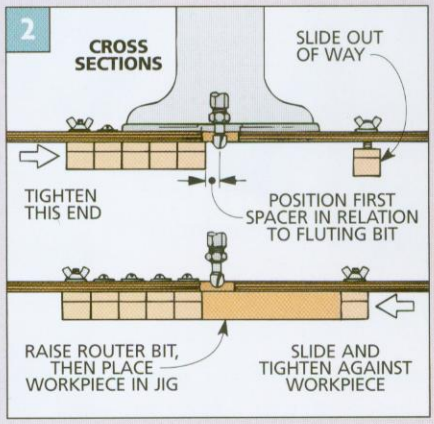
Then the clamping strip needs to be positioned so it rides along the other edge of the workpiece (second drawing in *Fig. 2*).

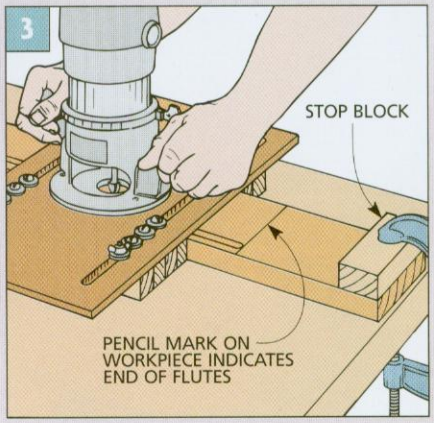
Now the router bit can be adjusted to the desired depth of the flutes, and the flutes routed in a logical sequence (see "Using the Jig" below).

Note: It's a good idea to start with a test piece to get a feel for using the jig. And it helps if the test piece is the same width as the actual workpiece.

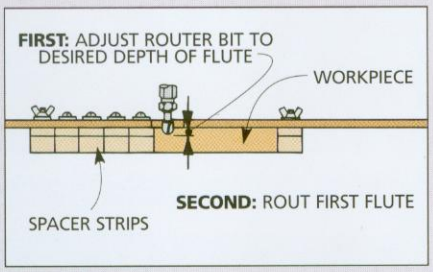
STOPPED FLUTES. For stopped flutes, like on the Classic Bookcase, simply clamp a block on each end of the workpiece *(Fig. 3)*.



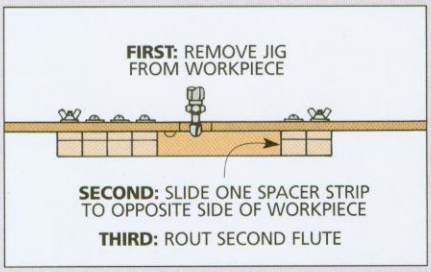




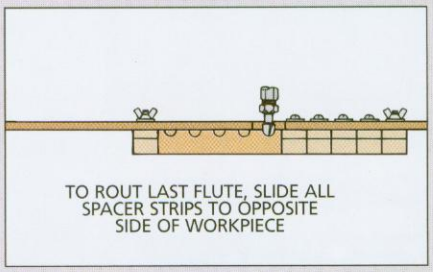
USING THE JIG



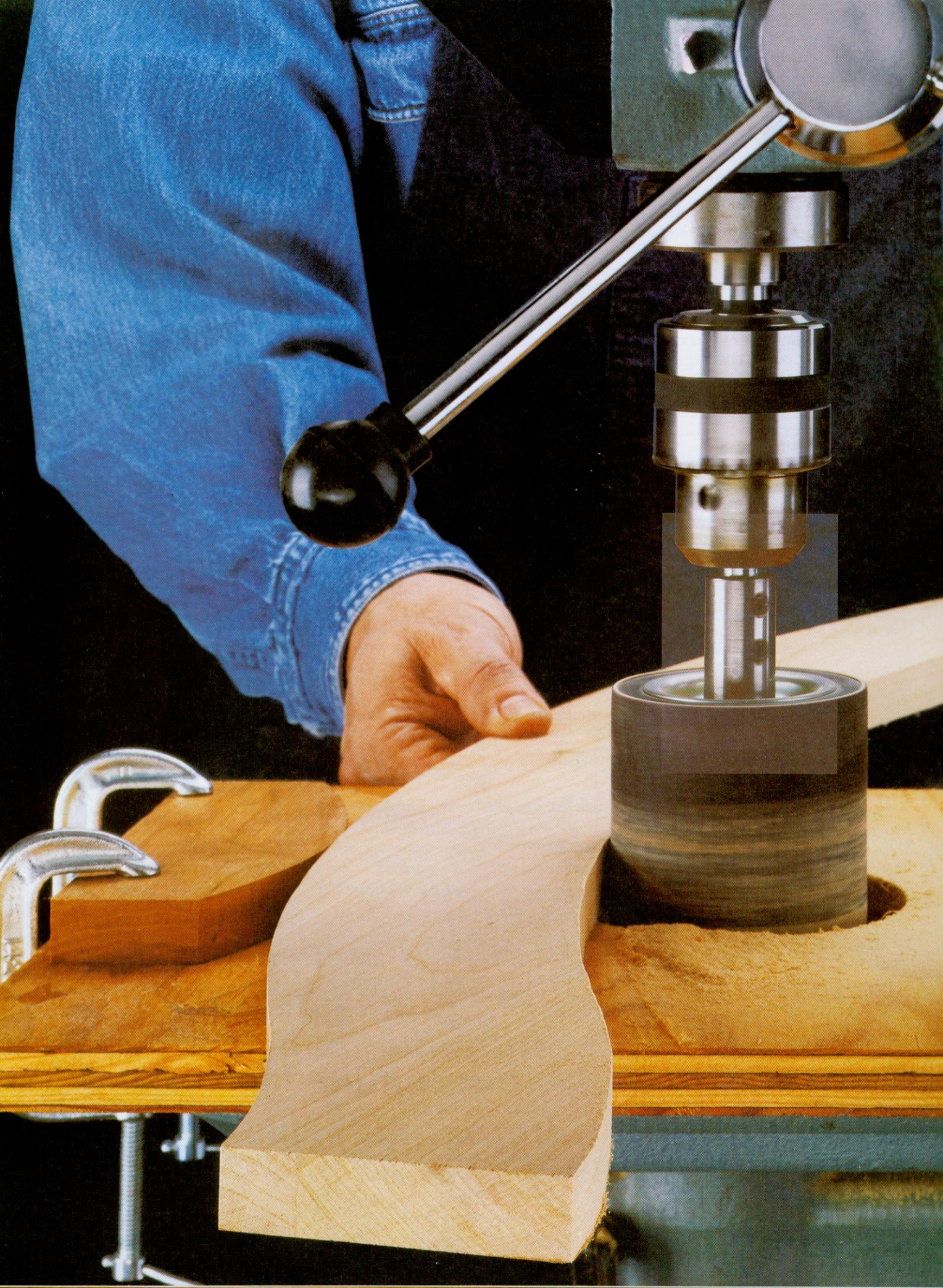
1 *Position the outside strip so there will be a shoulder left along the edge of the workpiece. Then rout the first flute with a 3/8" core box bit.*

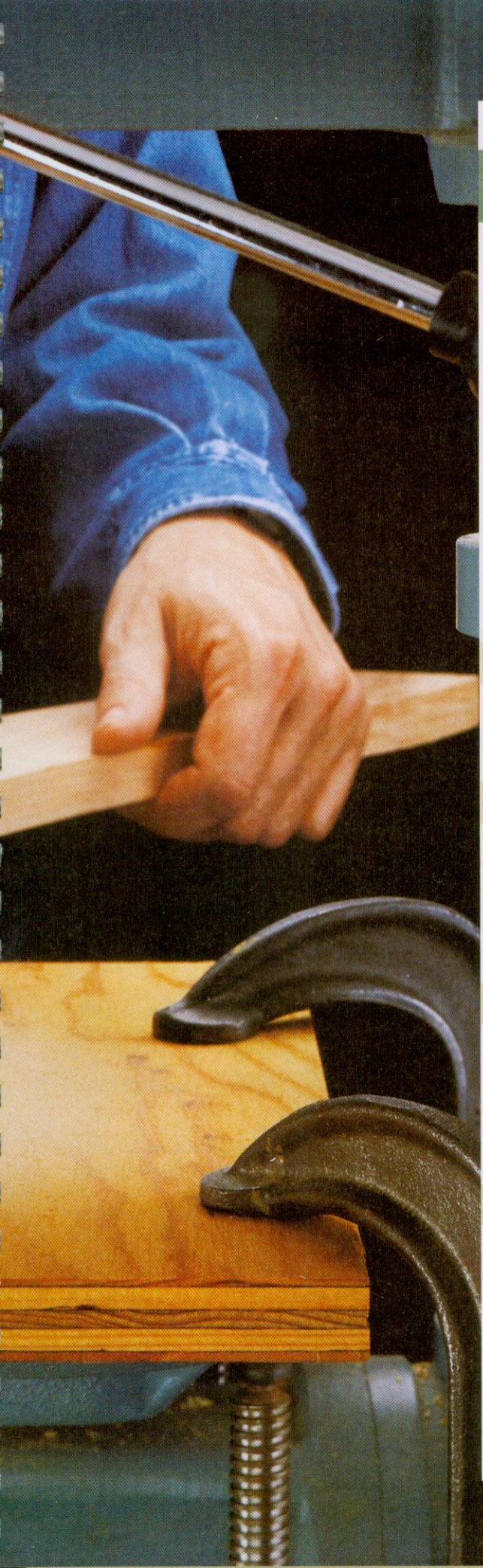


2 *Remove the jig and loosen the next spacer strip. Then move it to the opposite side of the workpiece, retighten, and rout the next flute.*



3 *Continue moving the spacer strips and routing until all the flutes are complete. Then cut the workpiece to finished width and length.*





CABINETS

The motto "a place for everything, and everything in its place" has a special appeal to most homeowners, and that place is often a well designed cabinet.

The four cabinetry projects begin with a wall-mounted collector's cabinet that is surprisingly easy to build, whichever design option you choose. Then there's a traditional American corner cupboard that will grace any dining room. Our stylish modular cabinet system lends itself to a variety of practical uses. Finally, the cherry armoire can be designed as a classic wardrobe or as a state-of-the-art entertainment center. Either way, the finished product will showcase your woodworking skills.

Collector's Cabinet

The beauty of this cabinet is in the removable divider units. You can easily position them to fit your current needs — and rearrange them in the future as your collection changes or grows.

Almost everyone I know has a collection of something — small toys, figurines, or items that simply bring back fond memories. This cabinet is a perfect place to hold and protect them.

It's made of three components: the case, the dividers, and the doors.

CASE. There's nothing complicated about building the case — it's simply a shallow box with mitered corners. To help align these corners and make them stronger, I cut kerfs in the ends and joined them together with hardwood splines.

DIVIDERS. The dividers, the second part of the cabinet, are the most challenging. The problem is collections change over time, and require different divider locations.

To solve the problem, the cabinet dividers are not glued in place, but instead are held by a "friction fit" in shallow dadoes. This allows you to configure the interior any way you like. By eliminating the vertical dividers, the collector's cabinet can even become a display case, see the inset photo and the Designer's Notebook on page 79.

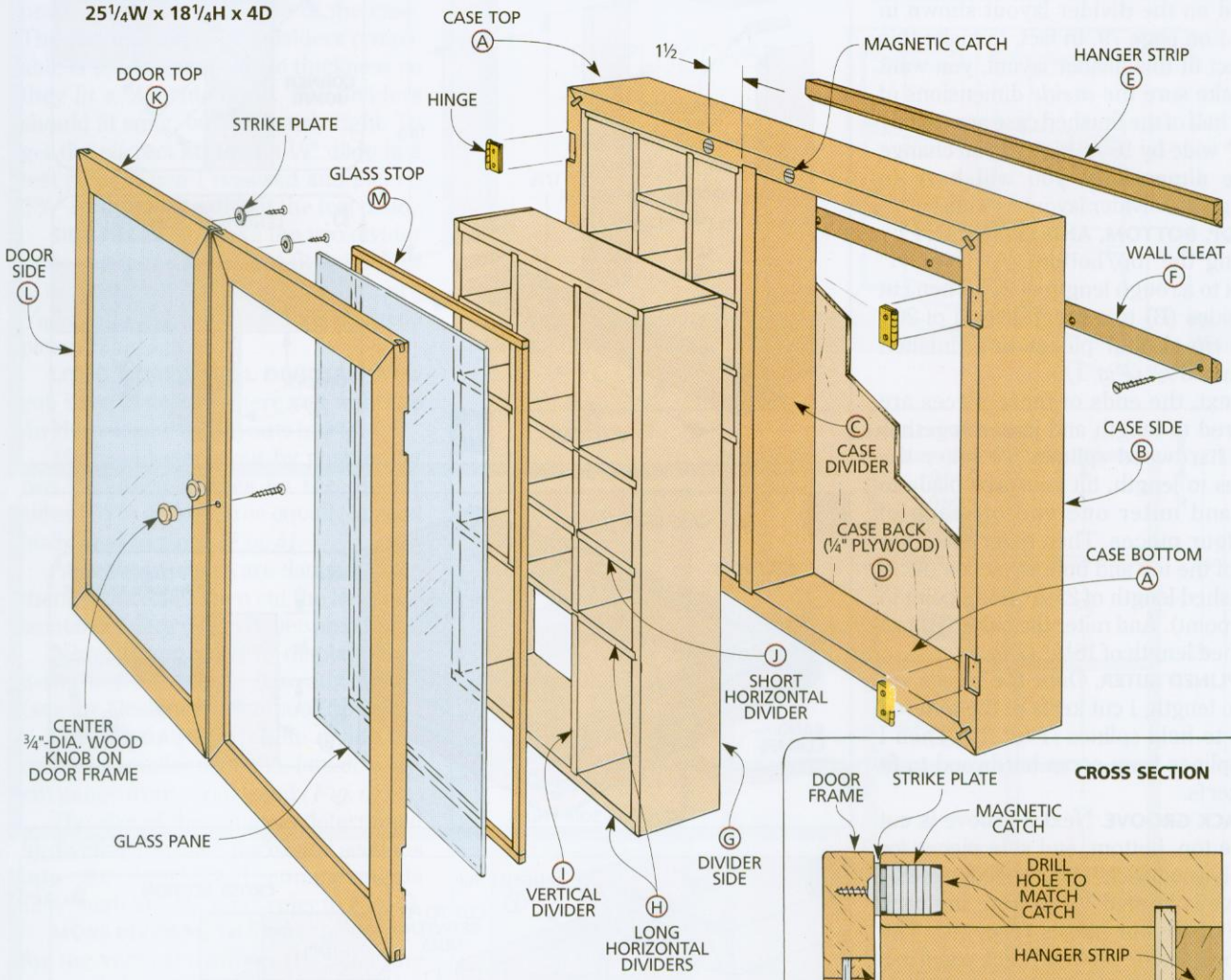
DOORS. The third part of this cabinet is the doors. Here again I used splines to align and strengthen the mitered corners. However, the kerfing technique is slightly different. It's featured in a technique section on page 81.

MATERIALS. To keep the items in the cabinet from getting lost in the shadows, I wanted a light background. So I built the case and all of the dividers out of hard maple. Then I used $1/4$" maple plywood for the back panel. (Another good choice for the back panel would be birch.)

FINISH. To finish the cabinet and dividers I wiped on two coats of a tung oil and urethane combination finish.

EXPLODED VIEW

OVERALL DIMENSIONS:
25¼W x 18¼H x 4D



MATERIALS LIST

WOOD

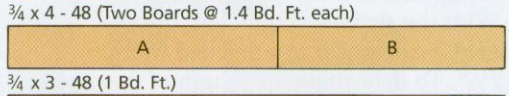
A	Case Top/Btm. (2)	¾ x 3½ - 25¼
B	Case Sides (2)	¾ x 3½ - 18¼
C	Case Divider (1)	¾ x 2¾ - 17⅛
D	Case Back (1)	¼ ply - 17⅛ x 24⅛
E	Hanger Strip (1)	½ x 1¼ - 23¾
F	Wall Cleat (1)	½ x 1¼ - 23¾
G	Divider Sides (4)	¼ x 2¾ - 16¾
H	Lg. Horiz. Divid. (8)	¼ x 2¾ - 11⅛
I	Vertical. Dividers	¼ x 2¾ - 5⅜
J	Shrt. Horiz. Divid.	¼ x 2¾ - 3⅝
K	Door Top/Btm. (4)	½ x 1¼ - 12⅝
L	Door Sides (4)	½ x 1¼ - 18¼
M	Glass Stops (8)	3/16 x 5/16 - 16¼ rough

HARDWARE SUPPLIES

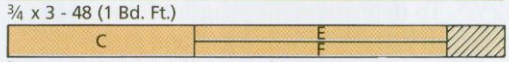
(4) 1 1/16"-wide x 1¼"-long butt hinges
(2) ¾"-dia. wooden knobs
(2) Magnetic catches with strike plates
(2) 1/8"-thick glass, cut to fit

CUTTING DIAGRAM

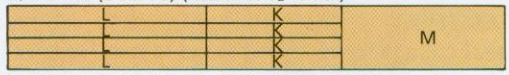
¾ x 4 - 48 (Two Boards @ 1.4 Bd. Ft. each)



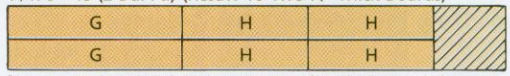
¾ x 3 - 48 (1 Bd. Ft.)



¾ x 6 - 48 (2 Bd. Ft.) (Resaw To ½"-Thick)



¾ x 6 - 48 (2 Bd. Ft.) (Resaw To Two ¼"-Thick Boards)



¾ x 3 - 48 (1 Bd. Ft.) (Resaw To Two ¼"-Thick Boards)

NOTE: ALSO NEED 2' x 4' SHEET OF ¼" HARDWOOD PLYWOOD.

CASE

The dimensions of this cabinet are based on the divider layout shown in *Fig. 4* on page 79. In fact, to make this project fit this divider layout, you want to make sure the *inside* dimensions of each half of the finished case are exactly 11½" wide by 16¾" high. If you change these dimensions, you will have to change the divider layout as well.

TOP, BOTTOM, AND SIDES. Start by cutting the top/bottom (A) from ¾" stock to a rough length of 27". Then cut the sides (B) to a rough length of 20". Now rip all four pieces to a finished width of 3½" *(Fig. 1)*.

Next, the ends of these pieces are mitered to length and joined together with hardwood splines. To miter the pieces to length, tilt your saw blade to 45° and miter one end off each of the four pieces. Then miter the other end of the top and bottom pieces (A) to a finished length of 25¼" (long point to long point). And miter the sides (B) to a finished length of 18¼" *(Fig. 1)*.

SPLINED MITER. Once the pieces are cut to length, I cut kerfs in the mitered ends to hold splines *(Fig. 1a)*. Then I cut splines from scrap hardwood to fit the kerfs.

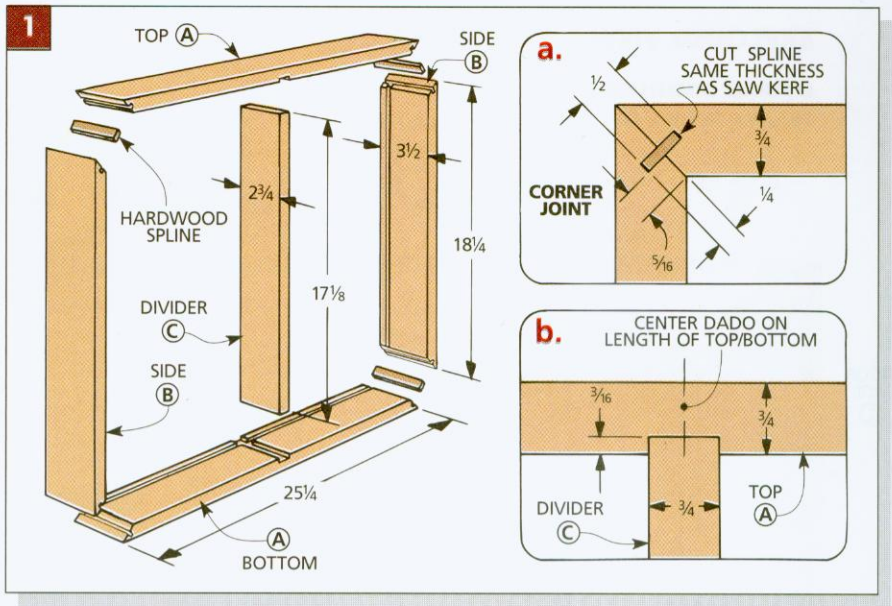
BACK GROOVE. Next a groove is cut in the top, bottom, and side pieces for the plywood back. The front edge of this groove is located ¾" in from the back edge of all four pieces *(Fig. 2a)*. The reason I set the plywood back panel in a full ½" was to conceal the wall-cleat system that holds the cabinet on the wall (refer to *Fig. 3*).

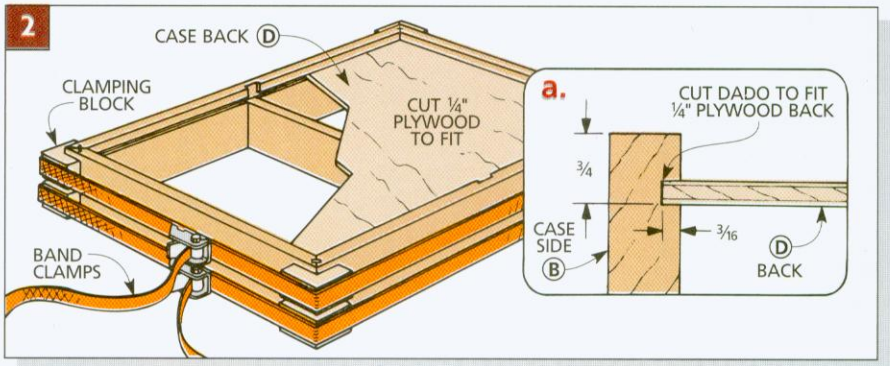
DIVIDER. The next step is to cut dadoes to hold the ¾"-thick case divider (C) *(Fig. 1b)*. These dadoes are centered on the length of the top/bottom pieces (A) and are cut to the same width as the thickness of the divider (¾").

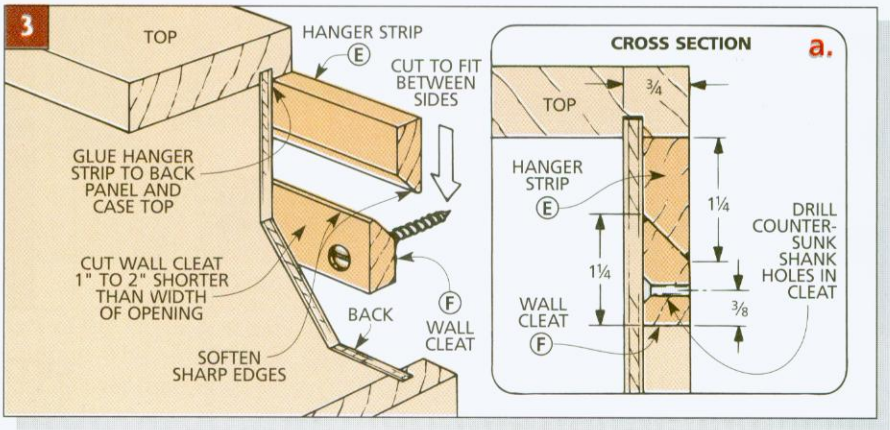
With the dadoes completed, the divider (C) can be cut to a finished width of 2¾". To determine the length of the divider, dry-assemble the case and cut the divider to fit between the dadoes.

ASSEMBLY. Before gluing up the case, I cut a piece of ¼" plywood to use as the case back (D). Then you can glue and clamp the case with band clamps *(Fig. 2)*.

Note: To provide even clamping pressure and protect the corners of the case, I made small clamping blocks from pieces of 2x2 stock.







HANGING SYSTEM

It's difficult to hang a cabinet like this so it's level and secure. To make things easier, I used an invisible hanging system similar to the system shown on page 17.

The system consists of two interlocking strips that are concealed behind the cabinet *(Fig. 3)*. The hanger strip (E) is glued to the back of the cabinet and the wall cleat (F) is screwed to the wall studs.

To make the ½"-thick strips, tilt the saw blade to 45°. Then bevel-rip two 24"-long pieces, 1¼" wide *(Fig. 3a)*. Trim one strip (E) to fit between the sides in the back of the cabinet and glue it in place.

To allow for some side-to-side adjustment, I cut the remaining strip (F) 1" or 2" shorter than the one glued to the cabinet. This cleat will be screwed to the wall studs and the cabinet set over it so the pieces interlock *(Fig. 3a)*.

DIVIDER UNITS

The next things to make are the divider units — one for each side of the case. The key to making the dividers removable is to cut the pieces to thickness so they fit a 1/4"-wide dado. The dividers should fit snug, but not overly tight. To get the correct fit, I cut a 1/4" dado in a test piece. Then I resawed and planed 2 3/4"-wide stock until it fit the test dado.

SIDE PIECES. To make the two divider units, cut four sides (G) to fit the height of the case openings *(Fig. 5)*. Then cut a 1/16"-deep rabbet on the ends of these pieces *(Fig. 5a)*.

LONG HORIZONTAL DIVIDERS. Now you have to decide where you want the dividers. I used the layouts in *Fig. 4*.

My layout starts out by positioning two 1/16"-deep dadoes on the divider sides (G) to create three equally-spaced horizontal sections *(Fig. 5)*.

After these pieces are dadoed, place them in the case. Then cut the long horizontal dividers (H) to fit between them.

Note: If you want to display large items, don't divide the case any farther (see the Designer's Notebook above).

LAYOUT GAUGE. To help divide the case into smaller sections, I made a layout gauge from scrap wood *(Fig. 6)*.

The size of the gauge is determined by dividing the main horizontal sections into six equal-sized compartments (2 1/2" high by 3 1/2" long; refer to *Fig. 4*).

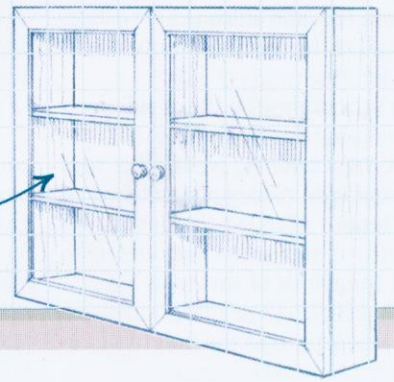
MORE DIVIDERS. To locate the dadoes for the vertical dividers (I), place the gauge tight against one of the divider sides *(Fig. 6)*. Mark the locations and cut 1/16"-deep dadoes at the marks. Then cut the vertical dividers to fit.

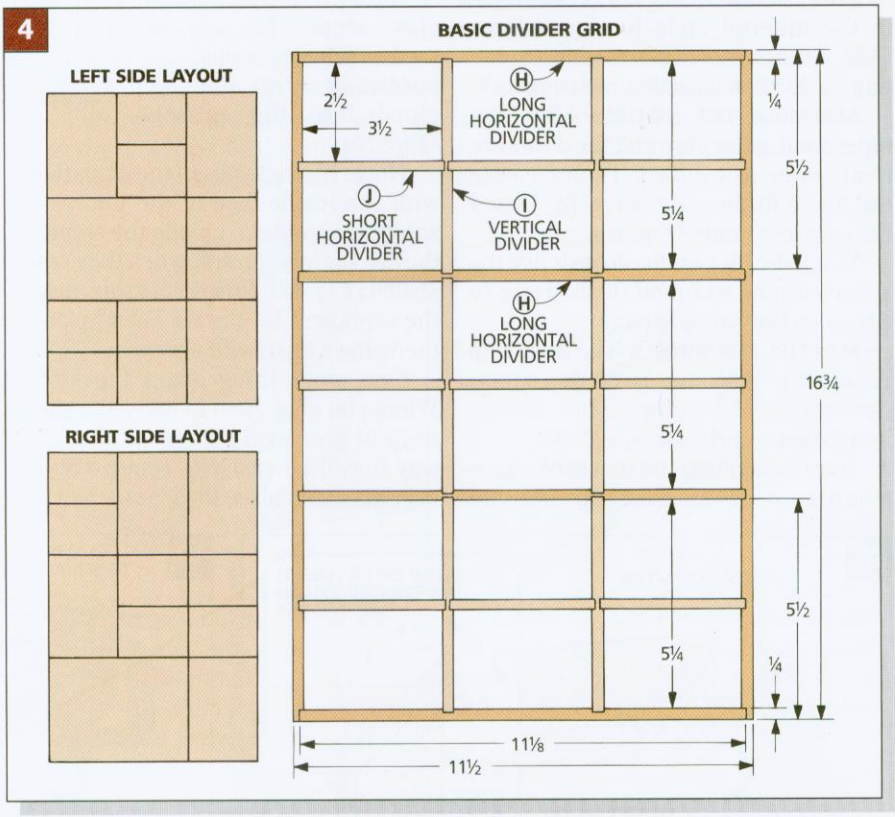
Next, short horizontal dividers (J) can be installed. Again I used the gauge to determine their locations *(Fig. 7)*.

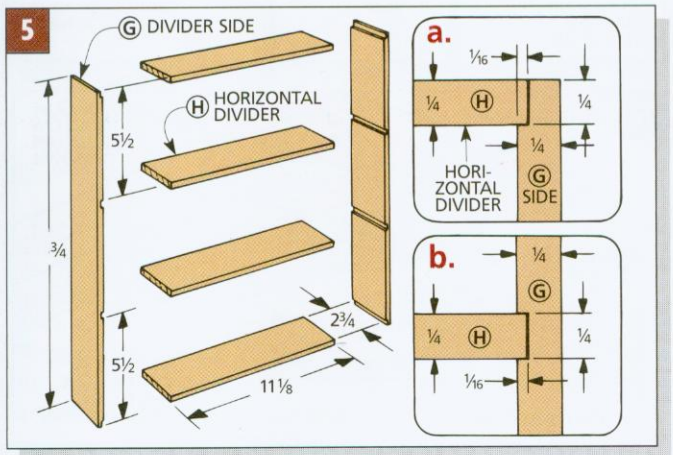
DESIGNER'S NOTEBOOK

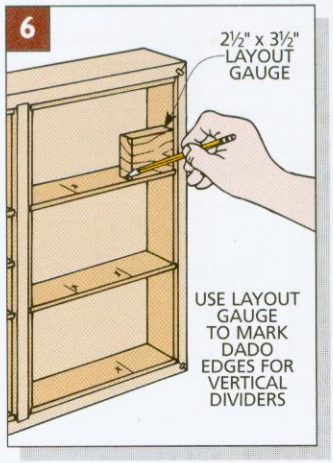
DISPLAY CASE

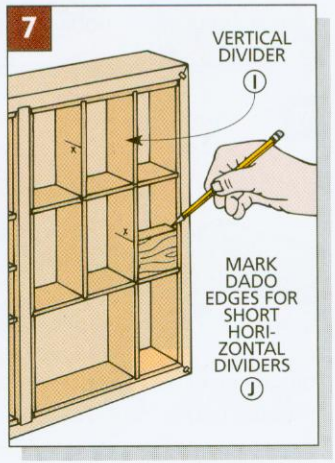
ELIMINATE THE SHORT DIVIDERS AND THERE'S ROOM FOR SHOWING OFF LARGE ITEMS











DOORS

To make the doors, start by resawing stock to ½" thick for the 1¼"-wide top/bottom (K), and sides (L) *(Fig. 8a)*. Then cut all of the pieces for both doors to rough length.

Now cut a rabbet on the inside face of the pieces for the glass *(Fig. 8b)*.

MITER TO LENGTH. Next, the top, bottom, and side pieces are mitered to finished length *(Fig. 8)*. To determine the length of the tops/bottoms (K), measure the width of the case (25¼") and divide in half (12⅝"). The sides (L) are the same length as the height of the case (18¼") *(Fig. 8)*.

KERF THE ENDS. Now kerfs can be cut in the mitered ends for the splines *(Fig. 9)*. For more information on cutting the kerfs and splines, see page 81.

ASSEMBLE THE DOORS. After the miters and splines are cut, the doors are ready to be assembled. To make sure the doors fit the case correctly, I used the case as a guide *(Fig. 10)*.

When the glue on the doors is dry, the splines can be trimmed flush (refer to *Step 6* on the opposite page).

MORTISE FOR HINGES. The next step is to attach the doors. To do this, I mortised four 1¼"-long brass butt hinges into the case and doors *(Fig. 11)*.

Start by scribing the mortises with a sharp knife, 2" in from the top and bottom of the case. Then transfer the mortise locations to the inside of the doors. Now rout or chisel out the mortises to the depth of the hinge leaf, and screw the hinges in place *(Fig. 11a)*.

INSTALL THE GLASS. To complete the doors you just have to install the glass and glue in the glass stops. To determine the size of the glass, measure the rabbeted opening of each door and subtract 1/16" to allow for easy clearance.

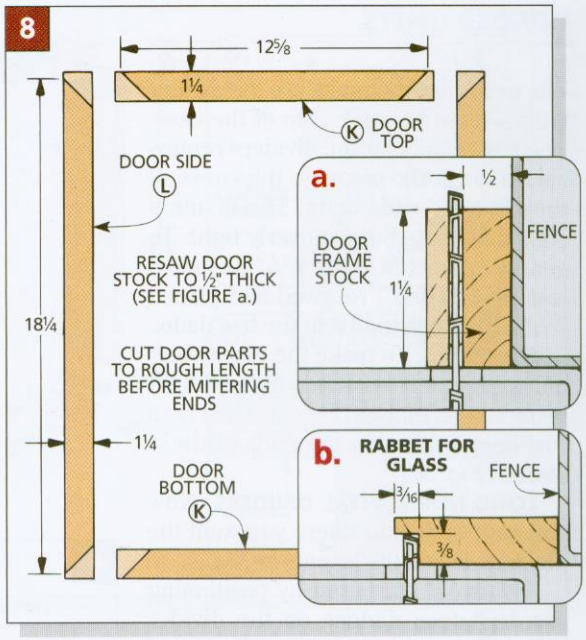
Once the glass is cut, the glass stops (M) can be made. These stops are hardwood strips that are glued into the rabbets *(Fig. 12)*.

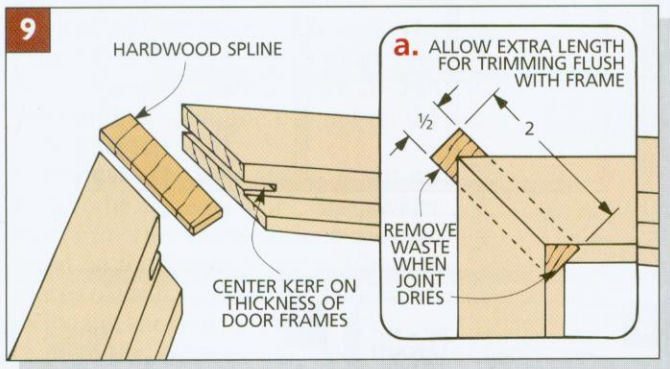
Note: It's tricky to get the stops flush with the inside face of the doors. To solve this problem, I made the stops so they're slightly "proud" when they're installed *(Fig. 12)*. (In my case this means the stops are 5/16" thick.) Then I planed them down flush with a plane.

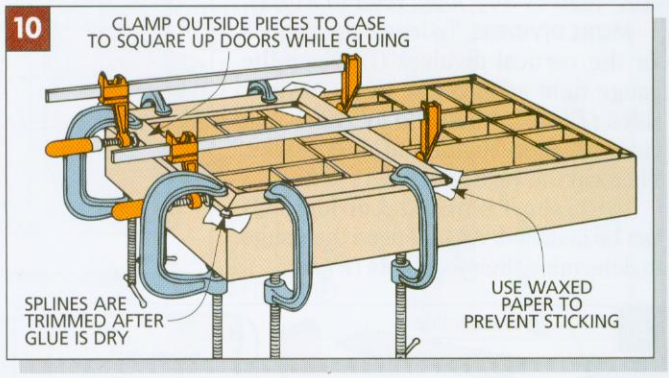
One more thing about the stops. When you glue them in just put a small drop of glue every 2" *(Fig. 12)*. This way they'll be easier to remove if you ever have to replace the glass.

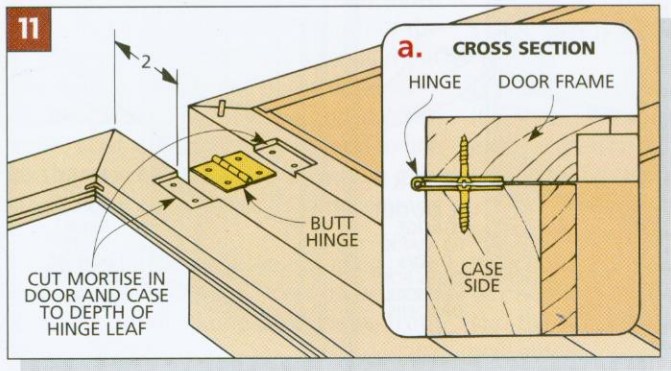
MOUNT THE KNOBS. To finish off the cabinet, I added a couple of wooden knobs to open the doors (refer to the Exploded View on page 77).

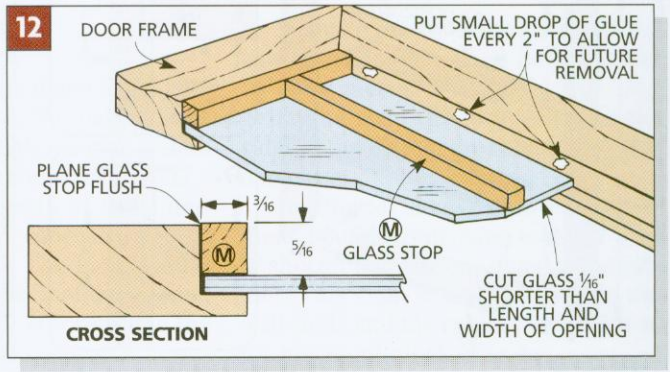
INSTALL THE CATCHES. The last step is to install magnetic catches to each door (refer to the Cross Section and Exploded View on page 77). Locate holes for the catches on the top edge of the case 1½" on either side of the case divider. Then glue the magnetic catches in place. Finally, screw the strike plates to the inside of the doors. ■









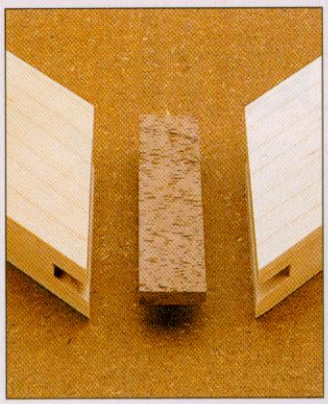


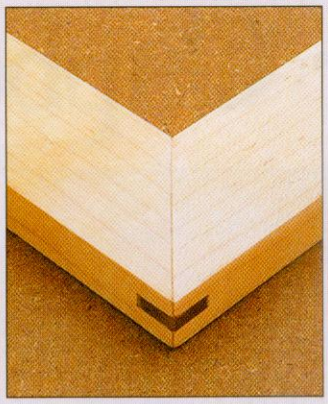
JOINERY . . . . . Face Miter with Spline

When making the doors for the Collector's Cabinet, I used a spline in the mitered corners to align and strengthen the joint. To do this, kerfs are cut in the mitered ends of all of the door pieces.

These kerfs are cut by running the mitered ends over the table saw blade. The problem is that it's difficult to hold the workpiece securely at an angle while making this cut. To solve the problem, I made a simple plywood jig to support the pieces while cutting the kerfs in the ends *(Step 3 below)*.

Once the kerfs are cut, thin hardwood splines can be made to fit the kerfs. The easiest way to do this is to cut the splines off the edge of a piece of stock. But I don't think that's the best way. The grain direction of the spline would end up the same direction as the joint. For greater strength it's better if the grain direction of the spline runs *perpendicular* to the joint line.

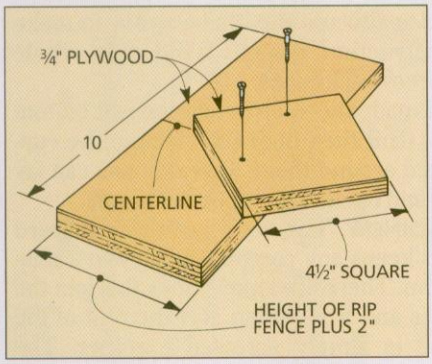




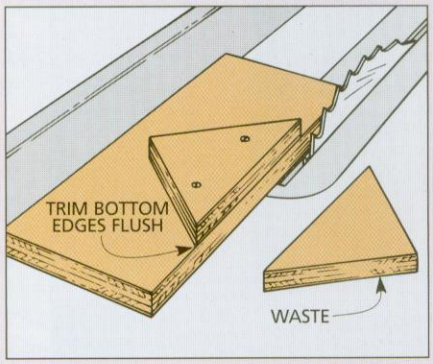
To cut splines with the grain running perpendicular to the joint line I used a two-step technique *(Step 5)*. By cutting the spline off the end of a piece of hardwood stock you'll actually end up with a spline that's wider than it is long. That's exactly the piece you want.

One other thing. For the Collector's Cabinet, I cut the splines out of hard maple to match the doors. Then the spline almost disappears once the doors are glued up.

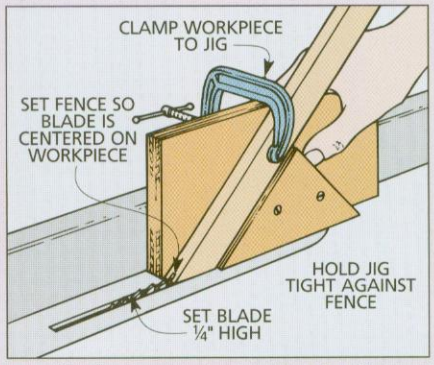
But sometimes I want to use the spline as a decorative accent. For those situations, I will use a contrasting wood, such as the walnut spline in the photos shown above.



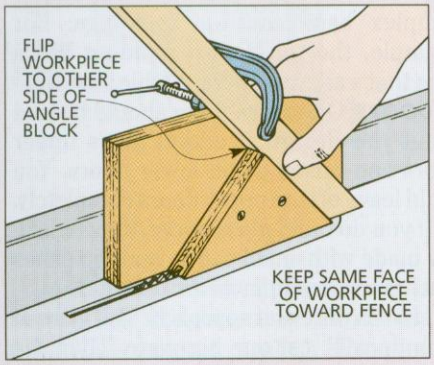
1 *Cut a piece of ¾" plywood for the jig 10" long and to the height of your table saw's rip fence plus 2". Next, center a square piece diagonally on the jig and screw it down.*



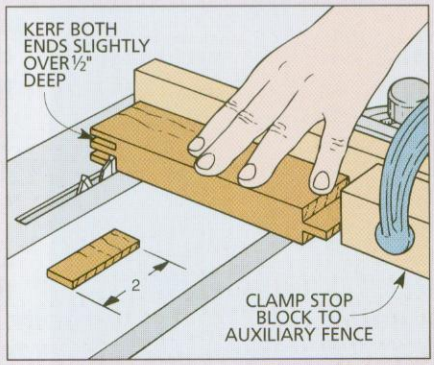
2 *Raise the saw blade and set the rip fence so the angled piece will be trimmed flush with the bottom edge of the jig. Then push the whole jig through the saw and let the waste fall away.*



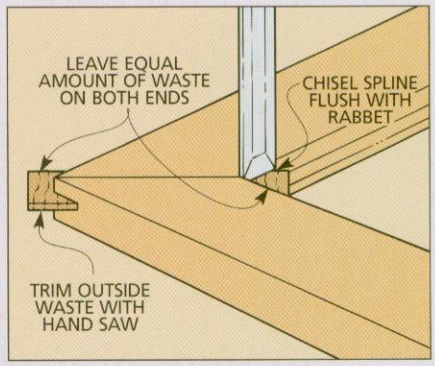
3 *Clamp the workpiece to the jig and set the blade to cut a ¼"-deep kerf. Holding the jig tight against the fence, adjust the fence so the blade is centered on the workpiece. Then cut a kerf.*



4 *To kerf the other end, flip the piece over and clamp it to the other side of the angled support block. Keep the same face of all the workpieces against the jig so the kerfs will all align.*



5 *To cut the splines, raise the blade over ½" high, stand the workpiece on end, and kerf both ends. Then use a miter gauge and stop block to cut splines that fit the kerfs.*



6 *Glue the splines in place so equal amounts stick out either side. Trim off the outside end with a hand saw and sand flush. Use a chisel to trim the inside flush with the rabbet.*

Corner Cupboard

A unique design allows this classic cupboard to be built without a lot of complex joinery or angled measurements. But with glass, raised-panel doors and shop-made moldings, the finished product will enhance any home.

Corner cabinets usually involve a lot of angled cuts and complex joinery. Typically, you would try to figure out all the angles first, then build the case, and finally add the shelves. But to make construction easier, I did this whole process backwards.

I made the shelves and top and bottom first, and then built the sides of the cupboard around them. This way you can lay out and cut the angles on flat pieces.

JOINERY. The design of this cupboard also keeps any complex joinery to a minimum. There are long splines that join the sides and front stiles. But the rest of the case is simply screwed together. The screws are all hidden by moldings.

MOLDINGS. That brings up another thing I like about this project. You can combine a number of simple moldings (that are cut on the router and table saw) and come up with what look like rather complex base and top moldings. For example, the top crown molding has a cove that's an easy cut on a table saw.

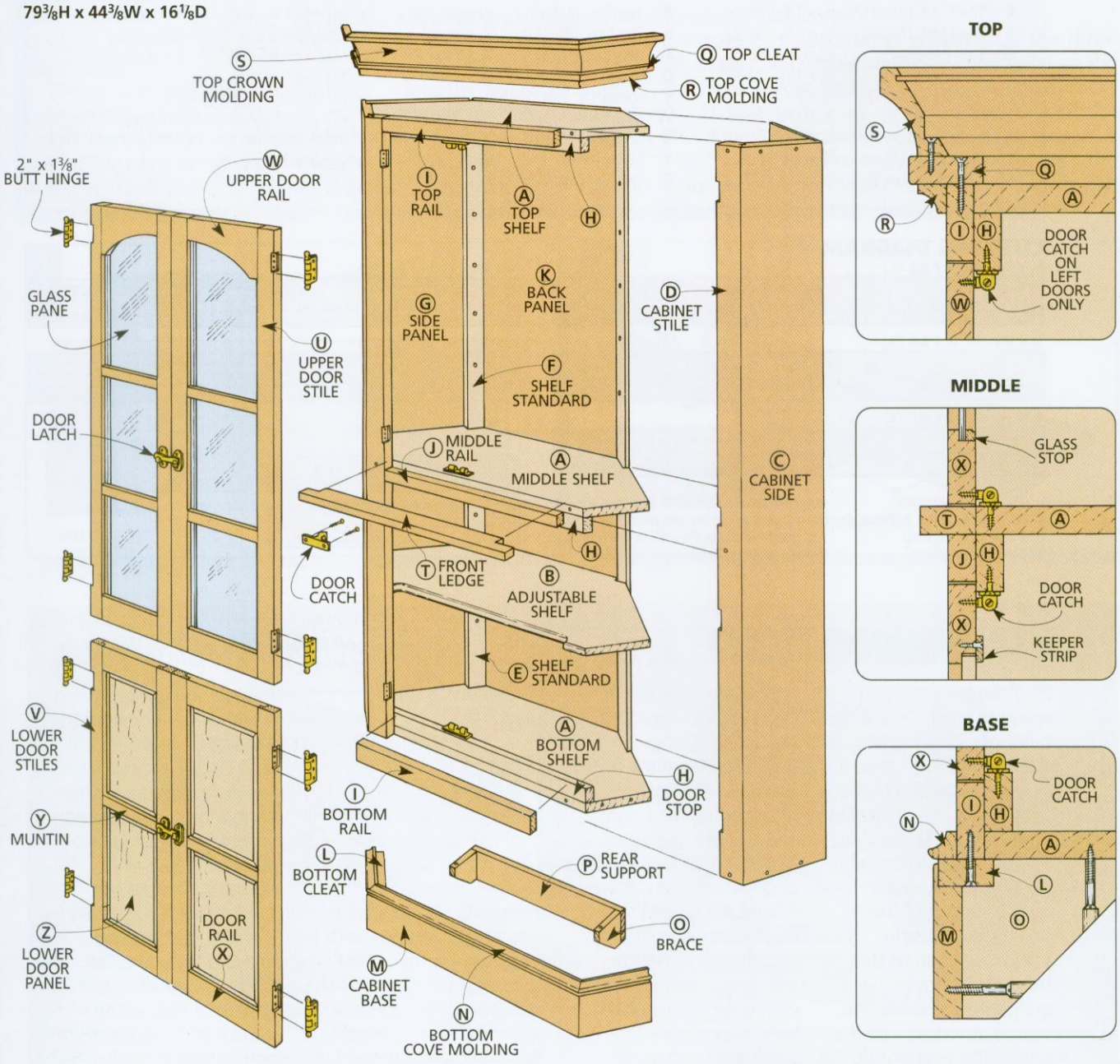
DOORS. One more thing should be said about the design. I added glass upper doors and raised panel lower doors. You could leave off the upper doors completely.

If you do build glass doors, they're usually made with small panes, and top panes that have to be cut in an arc.

I took a different approach. The glass in each door is just one big pane. Then the horizontal muntins (dividers) lay on top of the glass, but they're still tied into the door stiles with an offset mortise and tenon joint. This way the only arc you have to cut is on the top rails of the door, not the glass.

EXPLODED VIEW

OVERALL DIMENSIONS:
79⅜H x 44⅜W x 16⅛D



MATERIALS. I built this corner cupboard using straight-grained Ponderosa pine (C and Better grade). The pine gives the project a classic country look. For the back panel, I wanted to use ¼" plywood. Since pine plywood isn't commonly available at lumberyards, I used birch plywood.

If you were to build the cupboard with a hardwood such as cherry or oak, it would take on a traditional, formal look. Then plywood that matches the rest of the cabinet should be used.

FINISH. To finish the cupboard, I started with a coat of stain controller (see the Finishing Tip box on page 84). Then I stained the cupboard with a coat of early American oil stain. Finally, I brushed on two coats of satin varnish and rubbed it with "000" steel wool.

An alternative approach would be to paint the cupboard so it matches the color of the wall behind it. Then the cupboard will look like it's "built-in."

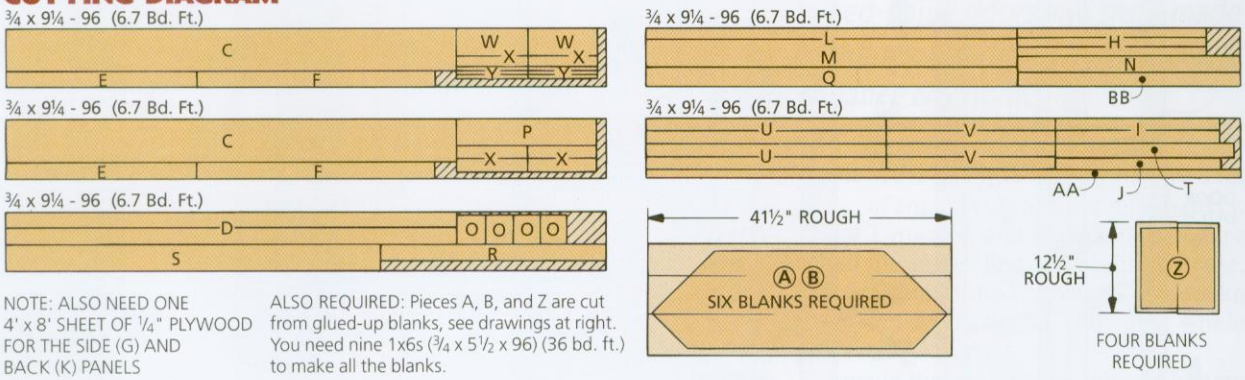
MATERIALS LIST

A	Top/Mid./Btm. (3)	3/4 x 13 3/8 - 40 1/2
B	Adjust. Shelves (3)	3/4 x 13 3/8 - 40 1/2
C	Cabinet Sides (2)	3/4 x 7 1/4 - 72
D	Cabinet Stiles (2)	3/4 x 2 1/2 - 72
E	Shelf Std. (Btm) (2)	3/4 x 1 3/4 - 30 1/4
F	Shelf Std. (Top) (2)	3/4 x 1 3/4 - 39 1/2
G	Side Panels (2)	1/4 ply - 12 x 72
H	Door Stops (3)	3/4 x 1 1/2 - 32 5/8
I	Top/Btm. Rails (2)	3/4 x 2 - 26 3/4
J	Middle Rail (1)	3/4 x 1 1/4 - 26 3/4
K	Back Panel (1)	1/4 ply - 23 1/2 x 72
L	Btm. Cleat (1)	3/4 x 1 1/2 - 60
M	Cabinet Base (1)	3/4 x 4 1/8 - 60
N	Btm. Cove Mld. (1)	3/4 x 3/4 - 60
O	Braces (4)	3/4 x 4 1/4 - 4 1/4
P	Rear Support (1)	3/4 x 4 1/4 - 23 1/4
Q	Top Cleat (1)	3/4 x 2 - 60
R	Top Cove Mld. (1)	3/4 x 3/4 - 60
S	Top Crn. Mld. (1)	3/4 x 3 - 60
T	Front Ledge (1)	3/4 x 1 1/2 - 29
U	Upper Dr. Stiles (4)	3/4 x 2 - 38 1/4
V	Lower Dr. Stiles (4)	3/4 x 2 - 27 3/4
W	Upr. Rails (Top) (2)	3/4 x 4 1/2 - 11 3/8
X	Dr. Rails (6)	3/4 x 2 - 11 3/8
Y	Muntins (6)	3/8 x 3/4 - 11 3/8
Z	Lwr. Dr. Panels (4)	3/4 x 9 7/8 - 11 7/8
AA	Keeper Strips	1/4 x 3/4 - 16 ft.
BB	Glass Stops	1/4 x 3/8 - 16 ft.

HARDWARE SUPPLIES

(86) No. 6 x 3/4" Fh woodscrews
(10) No. 8 x 1" Fh woodscrews
(46) No. 8 x 1 1/2" Fh woodscrews
(32) 5/8" brads
(2) 1/8" glass (cut to fit)
(8) 2" x 1 3/8" brass butt hinges
(4) Adjustable brass door catches
(2) Brass door latches
(12) Pin-type shelf supports

CUTTING DIAGRAM



NOTE: ALSO NEED ONE 4' x 8' SHEET OF 1/4" PLYWOOD FOR THE SIDE (G) AND BACK (K) PANELS

ALSO REQUIRED: Pieces A, B, and Z are cut from glued-up blanks, see drawings at right. You need nine 1x6s (3/4 x 5 1/2 x 96) (36 bd. ft.) to make all the blanks.

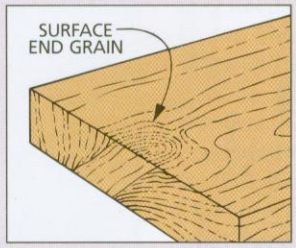
FINISHING TIP ..... Preventing Blotchy Stain

Pine can be a stubborn wood to stain. On a single piece of pine the pores can alternate from large and open to small and dense. In addition, the grain often swirls around so that you find end grain where you don't normally expect it — on the surface of the board (see drawing).

What happens is that these variations in the grain affect the way the stain is absorbed into the wood. The pigments in the stain settle in the pores, and the deeper the pore, the more stain it holds. So some areas, such as the end grain areas on the surface, hold more pigment than others. This can result in a series of light and dark blotches (see left side of the board in the photo).

Here are some of the steps you can take to help control blotching:

- Be selective in the boards you use. Look at the edge of the board for a tight and straight grain pattern. Avoid boards with swirling or unusual grain patterns.
- Sand the project thoroughly, working through progressively smoother grits of sandpaper. Areas with large scratches left behind by coarse-grit sandpaper trap more pigment and stain darker. If you want to end up with a lighter color, use a finer grit (180) sandpaper as this will seal up the pores.
- Once you're through sanding the entire surface, go back and sand any end grain a little more with the next higher grit. This will fill in the pores of the end grain with fine dust. Then when the stain is applied, it won't penetrate these areas as deeply.
- Brush on a stain controller (sometimes called a "conditioner") before applying the stain. The controller partially seals up the large pores so they won't hold as much pigment. The result is a more even stain (see the right side of the photo).
- Begin applying the stain right away — before the stain controller has dried completely.
- Stir the stain frequently to keep the pigments in suspension and ensure consistent color.



Applying an oil stain to this piece of pine creates a series of light and dark blotches (left). But using a stain controller first helps even out the color (right).

TOP, BOTTOM, AND SHELVES

I started work on the corner cupboard by making the top, middle shelf, and bottom (all labeled A), and the three adjustable shelves (B). All six pieces are made by edge-gluing $^3/_4$"-thick stock to make blanks $13^3/_8$" wide by $40^1/_2$" long.

Note: For more on edge-gluing panels, see pages 92 and 93.

LAY OUT ANGLES. Once the blanks are made, you can lay out the angles that give these pieces (and eventually the cabinet) their shape *(Fig. 1)*.

Note: Lay out and cut one blank. Then, use that blank as a template to mark the others.

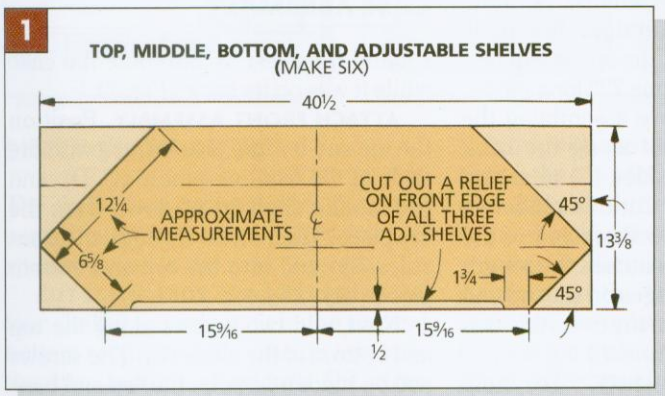
Begin the layout by drawing a centerline on the blank *(Fig. 1)*. Then make reference marks on the front edge $15^9/_{16}$" from each side of the centerline.

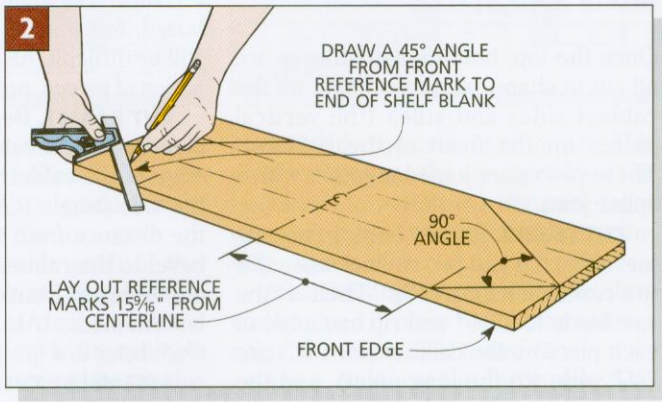
Next, place a combination square along one end to lay out a 45° angle from the reference mark on the front edge to the end of the blank *(Fig. 2)*. In my case, this line measured $6^5/_8$" long *(Fig. 1)*.

Then flip the combination square over so it points toward the back edge and lay out another line at a 90° angle from the first line.

CUT OUT SHAPE. After the lines are layed out on both ends, you can cut out the finished shape. I did this with the miter gauge set at a 45° angle on the table saw.

ADJUSTABLE SHELVES. On the three adjustable shelves, I cut a relief on the front edges *(Fig. 1)*. (This makes room for keeper strips on the back of the lower doors, refer to Fig. 36, page 91.) Then I routed a plate groove along the back edges of two of these shelves (B), as shown in the Shop Tip box below.





SHOP TIP . . . . . Routing a Plate Groove

After making the adjustable shelves for the corner cupboard, I decided to rout what's called a "plate groove" along the back edges of two of the shelves. This groove holds plates upright to display them.

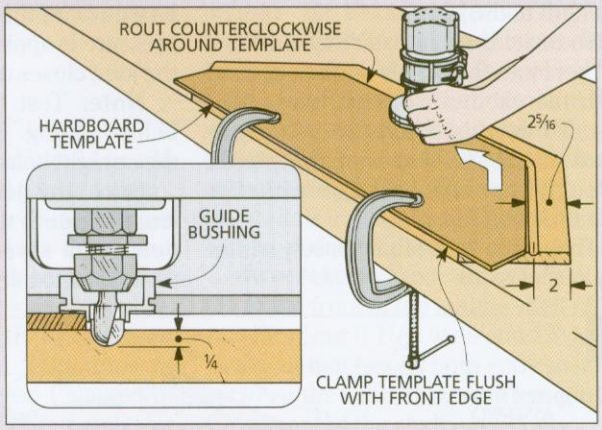
I found that a ½" core box bit routs the best groove. When the groove is centered 2" from the back edge, it holds plates at a nice angle.

The challenge was to figure out a way to rout a groove that turns the corners and runs along all three back edges. I did this by mounting a guide bushing to the base of my router and followed a ¼" hardboard template that's clamped to the top of the shelf (see drawing).

Router guide bushings are designed to follow a template. They fit around the bit and screw to the bottom of the router base (see detail in drawing). You can buy bushings for your specific router from many mail order catalogs, or you can buy a universal base with bushings.

The trick when using this technique is figuring out the exact size of the template. Since I wanted the groove to be centered 2" from the back edge of the shelf, the template had to be cut at least 2" short of the back of the shelf.

But you also have to take into consideration the diameter of the guide bushing. In this case I used a bushing with a ⅝" outside diameter ($^5/_{16}$" radius).

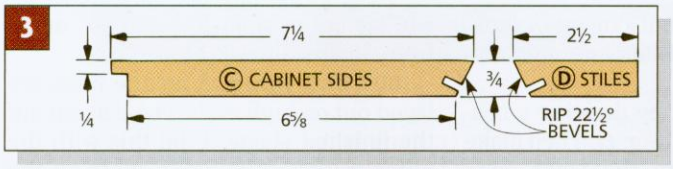


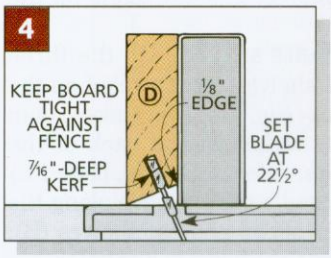
This meant I had to cut the template a total of $2^5/_{16}$" short of the back edges of the shelf.

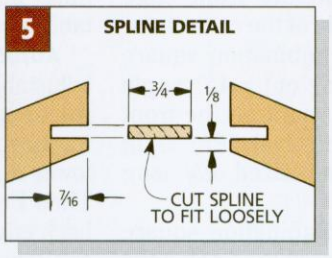
After making the template, I clamped it flush to the front of the shelf and $2^5/_{16}$" from the back.

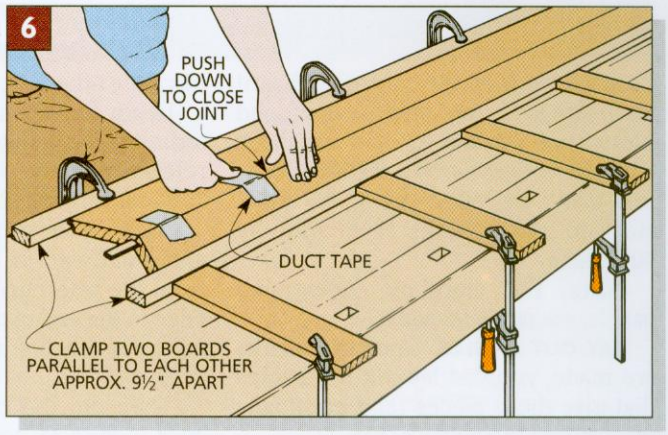
Next, mount the guide bushing and bit in the router and lower the bit so it makes a ¼"-deep cut.

Once everything is set up, rout in a counterclockwise direction around the template. To rout a smooth, "burn-free" groove, press the bushing up tight against the template. Make one continuous pass and don't slow down while routing.









SIDES AND STILES

Once the top, bottom, and shelves are all cut to shape, work can begin on the cabinet sides and stiles (the vertical pieces on the front of the cabinet). These pieces are joined together with a spline joint.

CUT TO SIZE. Start by cutting two cabinet sides (C) and two cabinet stiles (D) to a common length of 72". Then set the saw blade to 22½° and rip one edge of each piece so the cabinet sides (C) are 7¼" wide (to the long point), and the stiles (D) are 2½" wide *(Fig. 3)*.

MAKE SPLINE JOINT. The purpose of the spline between the sides (C) and the stiles (D) is to help align the pieces when gluing. (It doesn't add significant strength to the joint.)

To make the joint, start by cutting a ⅛" kerf into the bevels on the edges of both the cabinet sides (C) and stiles (D). To do this, keep the saw blade tilted at 22½°. Then run the pieces through the saw on edge with the bevels down *(Fig. 4)*.

Then cut a spline to fit loosely within the kerf *(Fig. 5)*.

Note: The spline could be ⅛" hardboard, but if it fits too tight, assembly will be difficult. Also, the spline can be a series of pieces, not one 72"-long piece.

CUT RABBET. Before assembling the pieces, I cut a rabbet along the back edge of the cabinet sides (C) to accept the side panels (G). Cut this rabbet so the distance from the short end of the bevel to the rabbet matches the length of the angled front edges on the top and bottom pieces (A). (In my case, this was 6⅝"; refer to *Figs. 1 and 3*.)

ASSEMBLE THE JOINT. To help assemble the joint, I clamped a couple of straight boards to my bench parallel to each other and about 9½" apart *(Fig. 6)*. Then I wedged a cabinet side (C) and stile (D) together between the straight boards (with the spline in place). When pressure is applied on top of the pieces the joint closes up.

Note: Test clamp this setup dry before gluing. The distance between the straight boards may need adjusting.

Once the joint is tight down its length, glue it up and hold the pieces down with several strips of duct tape while the glue dries *(Fig. 6)*.

CASE ASSEMBLY

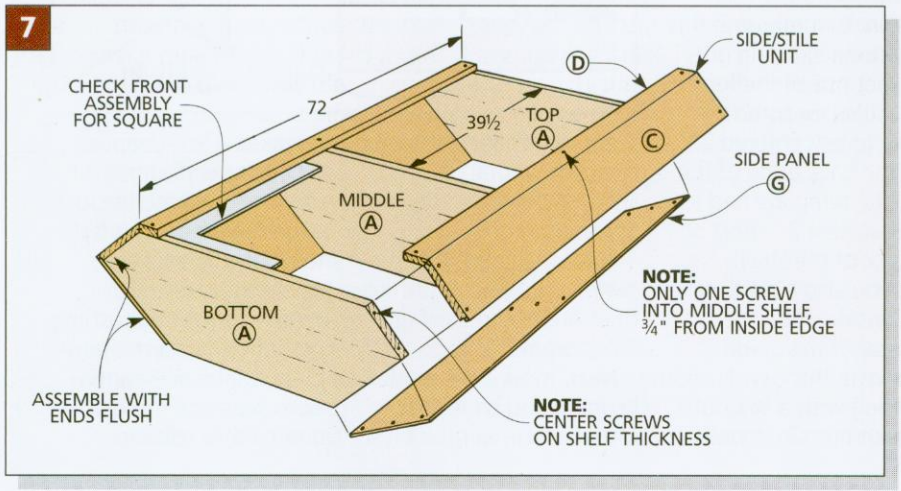
I found it easiest to assemble the case while it was on its back *(Fig. 7)*.

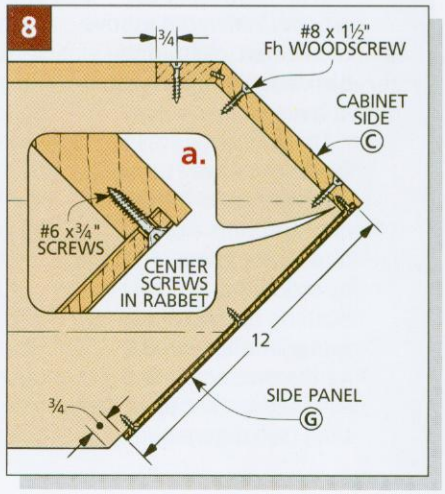
ATTACH FRONT ASSEMBLY. Position the top and bottom pieces flush with the ends of the front assembly (C, D), and the middle shelf 39½" down from the top piece. Then screw through the front stiles (D) and into the top and bottom pieces (A) *(Fig. 7)*.

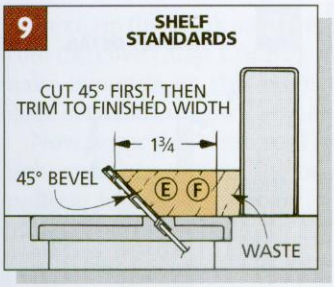
Next, add two screws along the top and bottom of the sides (C). The screws will be hidden later by the top and base moldings. But that's not the case with the middle shelf. There I just used one screw through the front stile and into the middle shelf (¾" in from the inside edge of the stile) *(Fig. 8)*. It will be covered later by a front ledge.

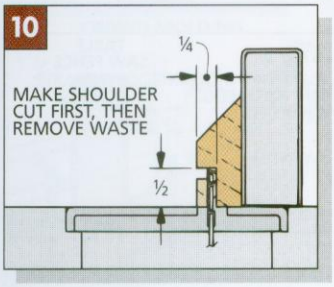
ADD SIDE PANELS. Once the front pieces are screwed down, turn the case over and measure for the ¼" plywood side panels (G). Cut the width of the side panels ¾" less than the distance from the inside of the rabbet to the back corner *(Fig. 8)*.

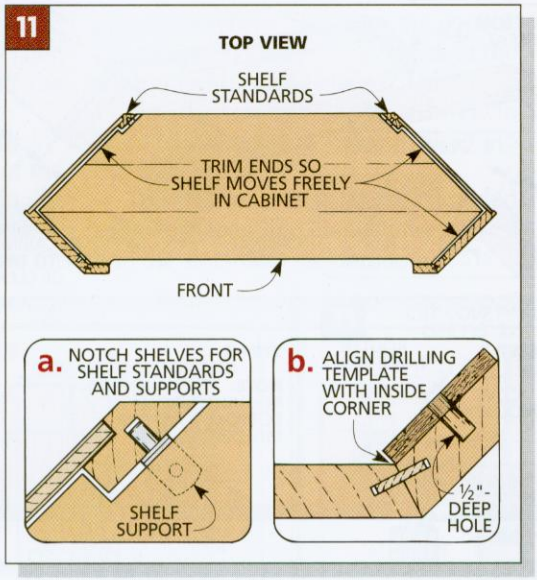
After the side panels are cut to size, they can be screwed down *(Fig. 8a)*.

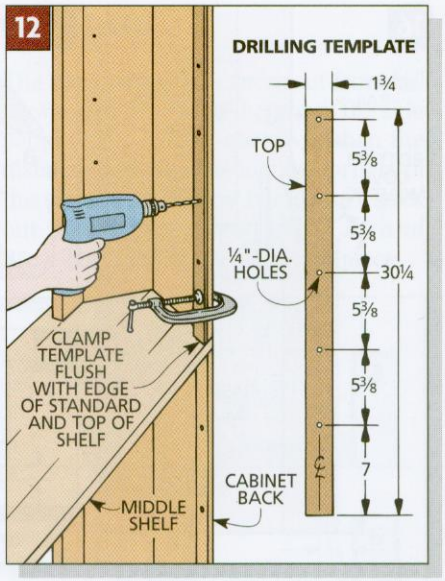












SHELF STANDARDS

The shelves are supported by shelf supports that fit into holes drilled in shelf standards and in the case *(Fig. 12)*.

CUT STANDARDS. Start by cutting the four shelf standards to fit in the top and bottom sections of the case. In my case, the two bottom standards (E) were 30¼" long and the two top standards (F) were 39½" long.

Next, cut a 45° bevel off one edge of all four standards (to fit against the back of the cabinet) and then trim them to a common width of 1¾" *(Fig. 9)*. Now cut a rabbet opposite the bevel to fit around the side panel *(Fig. 10)*.

ATTACH STANDARDS. After the rabbets are cut, glue the standards to the inside of the cabinet *(Fig. 11a)*.

DRILLING TEMPLATE. I found the easiest way to keep all the pin support holes aligned was by making a drilling template *(Fig. 12)*. To make the template, cut a piece of ¼" plywood to the same width and length as the bottom shelf standard (E). Then drill ¼" holes centered on the width and positioned as shown in Fig. 12.

Now, with the template clamped so it sits on the top of the shelf, drill through each hole until there's a ½"-deep hole in the shelf standard *(Fig. 12)*.

After drilling holes in each of the standards at the back of the cabinet, I used the template to drill matching holes at the front (inside) of the cabinet. Align the edge of the template on the joint *(Fig. 11b)*.

NOTCH SHELVES. Once all of the holes are drilled, notch the three adjustable shelves (B) to fit around the standards. Then trim the ends slightly so the shelves will fit around the supports *(Fig. 11a)*.

STOPS AND RAILS

The next step on the cabinet is to add the door stops, rails, and a front ledge.

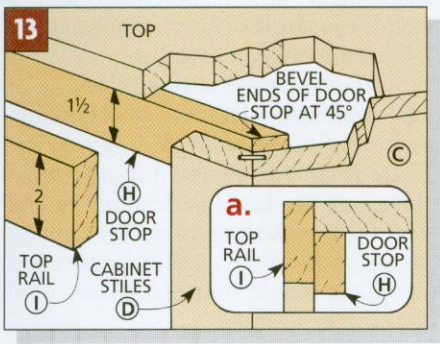
STOPS. There are three door stops (H) — one at the top of the upper section and two in the lower section. Start by ripping the stops 1½" wide. Determining the length of the door stops is a little tricky. The stops fit behind the stiles (D), and I wanted to bevel both ends at 45° to match the angle inside the cabinet *(Fig. 13)*. The distance between the short points of the bevel has to match the distance from one spline joint (on the inside) to the other spline joint.

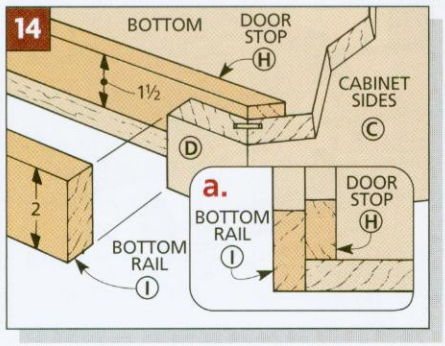
After the stops are cut to length, they can be glued in place behind the cabinet stiles (D) *(Figs. 13, 14, and 15)*.

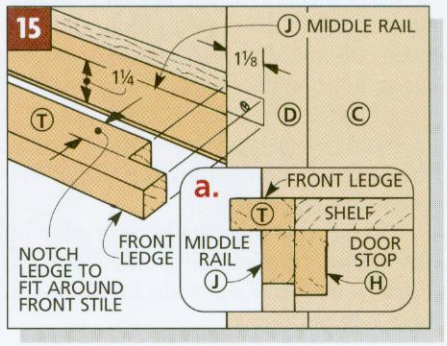
RAILS. Next, cut the three rails. The top and bottom rails (I) are cut to a width of 2". But the middle rail (J) is cut 1¼" wide since there's a ¾" front ledge added above it *(Fig. 15a)*.

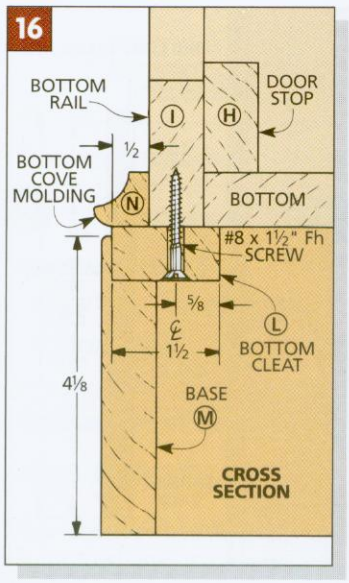
To determine the length of the rails, measure the distance between the cabinet stiles (D). (In my case this measurement was 26¾".) After they're cut to length, glue the rails to the front of the stops. The top and bottom rails (I) are mounted flush with the top and bottom of the cabinet *(Figs. 13a and 14a)*. But the middle rail (J) is aligned with the *bottom* of the middle shelf *(Fig. 15a)*.

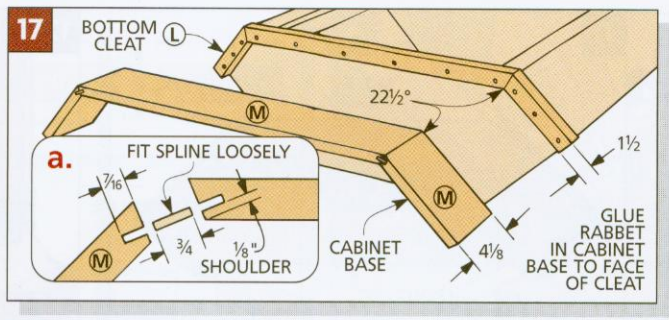
FRONT LEDGE. Next, add a front ledge (T) to the front of the middle shelf *(Fig. 15)*. First, cut it 1½" wide and 29" long. Next, cut notches on both ends so it fits between the cabinet stiles. Then glue it to the front of the shelf.

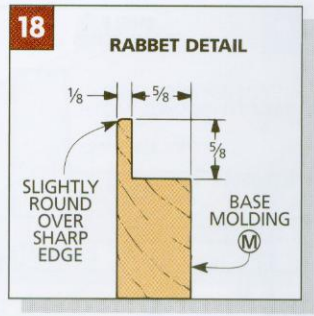


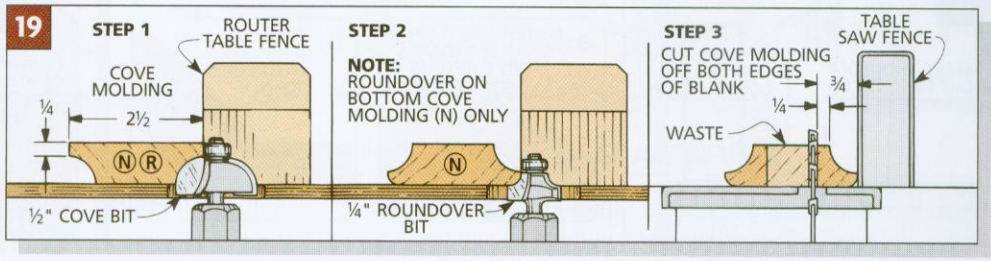












BASE

The base of the corner cupboard is built using a number of pieces *(Fig. 16)*. I started by screwing cleats (L) to the bottom of the cabinet to provide a mounting surface for the base.

CLEAT. Begin by cutting the cleats (L) to a width of 1½" and rough length. Then miter both ends of the *middle* cleat at 22½° so the ends align with the joints of the stiles and sides *(Fig. 17)*, and it sticks out ½" from the front of the cabinet *(Fig. 16)*.

After the middle cleat is cut to length, miter the front end of each side cleat and then cut the back end to length (at 90°).

BASE. After the cleats were screwed down, I added the base pieces (M) to the front. These three pieces have a rabbet cut on the top edge to fit around the cleats *(Fig. 18)*. After cutting the rabbet, miter the pieces so the miters align with the miters on the cleats.

To join the base pieces, I used a spline joint like the sides and stiles *(Fig. 17a)*. Then I glued the base pieces to the cleats.

COVE MOLDING. The last step on the base is to add the cove molding (N). To make the molding, first rout ½" coves along both edges of a 2½"-wide by 36"-long blank *(Step 1 in Fig. 19)*.

Note: While you're set up, you may want to rout enough molding (R) for the cabinet top as well.

Then round over the bottom edge of the *bottom* cove molding only *(Step 2)*. Finally, trim the ¾"-wide molding off both edges *(Step 3)*.

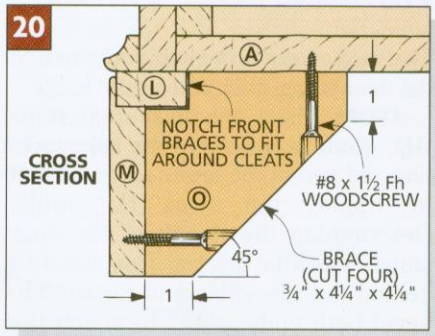
Now miter the molding to fit around the cabinet and glue it in place on top of the cleats *(Fig. 16)*.

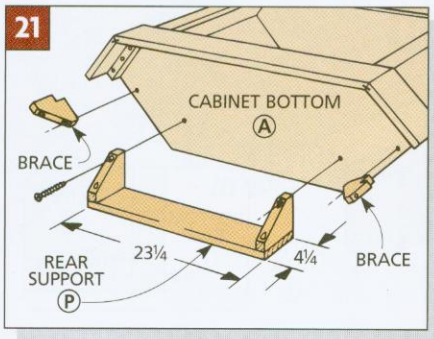
SUPPORT BRACES

To add strength to the base of the cabinet, I screwed triangular braces (O) behind the base pieces. Two of the braces fit behind the front base piece and the other two support a rear support *(Fig. 21)*.

TRIANGULAR BRACES. Start by cutting four braces 4¼" square. Then trim one corner off each brace at 45° leaving 1" shoulders along two edges *(Fig. 20)*.

To fit around the bottom cleats (L), cut notches out of the two front braces *(Fig. 20)*. Then screw two of the braces to the back of the base piece (M) and to the bottom of the cabinet (A).





REAR SUPPORT. The back of the cabinet is held up with a rear support (P) *(Fig. 21)*. Cut it to the same width as the braces (4¼") and to the same length as the back edge of the cabinet bottom (23¼" in my case). Then screw the back braces onto the inside face of the rear support. Now screw this assembly to the bottom of the cabinet.

TOP MOLDING

The top molding is made from a combination of pieces fastened together.

TOP CLEAT. Begin by making and screwing down three top cleats (Q) just like the bottom cleats *(Fig. 24)*. The top cleats are a little different though. They're 2" wide and mounted so they stick out 1" in front of the cabinet.

COVE MOLDING. Next, cut the cove molding (R) you made earlier and glue it underneath the cleats *(Fig. 24)*.

CROWN MOLDING. To make the crown molding, I started by cutting two blanks 3½" wide. Then cut one to a rough length of 36" for the front and one 24" for the two sides.

To cut the wide cove on the face of the molding, clamp a straightedge fence to the saw at a 30° angle to the blade *(Fig. 22)*. Position the fence so the top of the blade is centered on the width of the blank. Now cut the cove by making very light passes, increasing the blade height between passes until the cove is ¼" deep.

Next, rip the blank so *one* edge is 5/8" from the cove *(Step 1 in Fig. 23)*. Then make two cuts on this edge with the blade set at 30° *(Steps 2 and 3)*.

Now lower the blade so it's only 1/4" high, and cut a slot on the back of the molding for a spline *(Step 4)*. Finally, cut off the other edge at 30° *(Step 5)*.

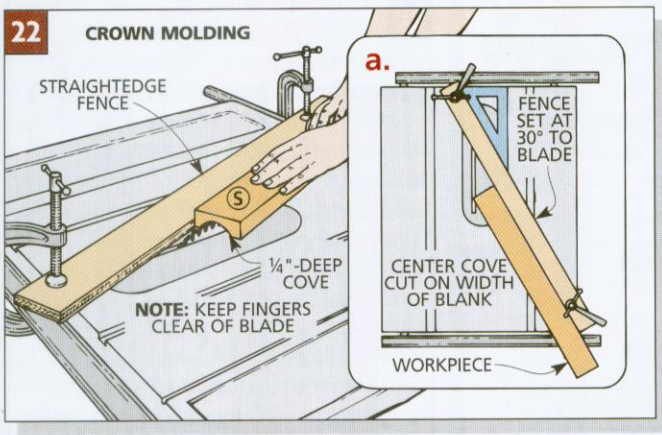
The last step is to cut a pocket for mounting screws. To make the pocket, cut an angled groove in the back of the molding with a dado blade *(Step 6)*.

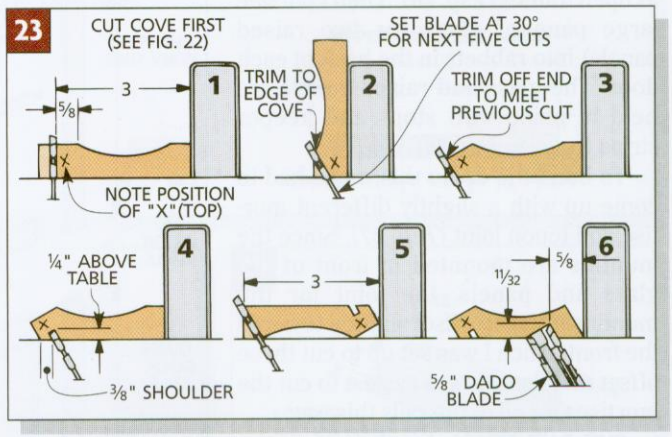
Now the crown molding can be cut to fit on top of the cleat (see the Shop Tip box below).

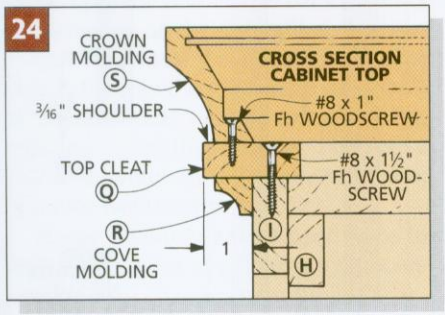
To hold the joints together, I added splines shaped like elongated triangles into the slot in the molding *(Fig. 25)*.

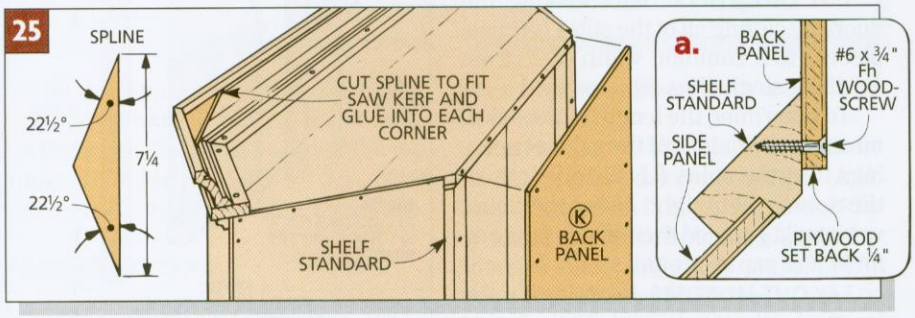
BACK PANEL

The back panel (K) can be cut from 1/4" plywood. It's the same height as the side panel (72"), but 1/2" narrower than the distance between the outside corners of the standards (so the back won't stick out beyond the sides) *(Figs. 25 and 25a)*. Then screw the panel into place.









SHOP TIP . . . . . Mitering Crown Molding

Fitting crown molding around the top of a project usually means cutting a compound angle. One way to do this on a table saw is to angle the miter gauge and tilt the blade. The angles are usually determined by referring to a chart.

But if the molding can be tilted to the angle it will be when attached to the project, the blade can stay at 90°, and only the miter gauge needs to be angled.

To do this, I screwed an auxiliary fence to the miter gauge. The auxiliary fence has to be high enough to support the molding when it's standing up as it will appear on the cupboard (see detail in drawing).

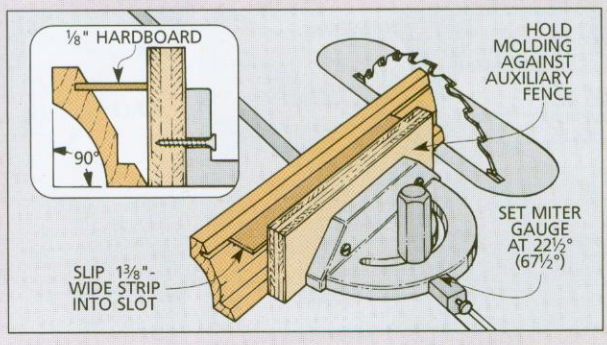
The back of the molding has a 1/8" kerf cut in it. This kerf is used to accept a spline when the top is assembled, but it can be used for another purpose.

If you slip a narrow strip of 1/8" hardboard in the kerf, and then hold the hardboard against the auxiliary fence, it helps support the molding in the correct position while it's being cut.

Now, to miter the crown molding, rotate the miter gauge to 22 1/2° (this reads 67 1/2° on some miter gauges). Then bring the molding tight against the auxiliary fence, so the base of the crown molding is flat on the table, and make the cut.

To cut the other end of the front piece, just move the miter gauge to the opposite slot on the table saw and turn it to the opposite 22 1/2° setting.

The side pieces only need a miter on one end.



DOOR STILES

After the case of the cupboard was complete, I built the doors. I made glass upper doors and paneled lower doors. (You could leave off the upper doors.)

DESIGN CONSIDERATIONS. The basic construction of both the upper and lower doors is the same. They're built as open frames *(Fig. 26)*. Then I put one large pane of glass (or two raised panels) into rabbets in the back of each door. The glass and raised panels are held in place with stops and keeper strips (refer to *Fig. 36*).

To build the doors this way, I had to come up with a slightly different mortise and tenon joint *(Fig. 27)*. Since the muntins are mounted in front of the glass and panels, the joint for the muntins must be offset slightly towards the front. Once I was set up to cut these offset mortises, it was easiest to cut the mortises for all of the rails this way.

CUT OUT STILES. Start making the doors by cutting all of the stiles (vertical pieces) to a common width of 2" from $^3/_4$"-thick stock *(Fig. 28)*.

To determine the length of the stiles, measure the height of the cabinet openings. Cut the stiles (U, V) to length so the doors will fit tight. (After the doors were built, I planed them down for a uniform $^1/_{16}$" gap all around.)

LAY OUT MORTISES. Next, lay out the location of the mortises along the inside edge of the stiles *(Fig. 28)*. The mortises for the rails are $1^1/_4$" long. Those for the muntins are $^1/_2$" long.

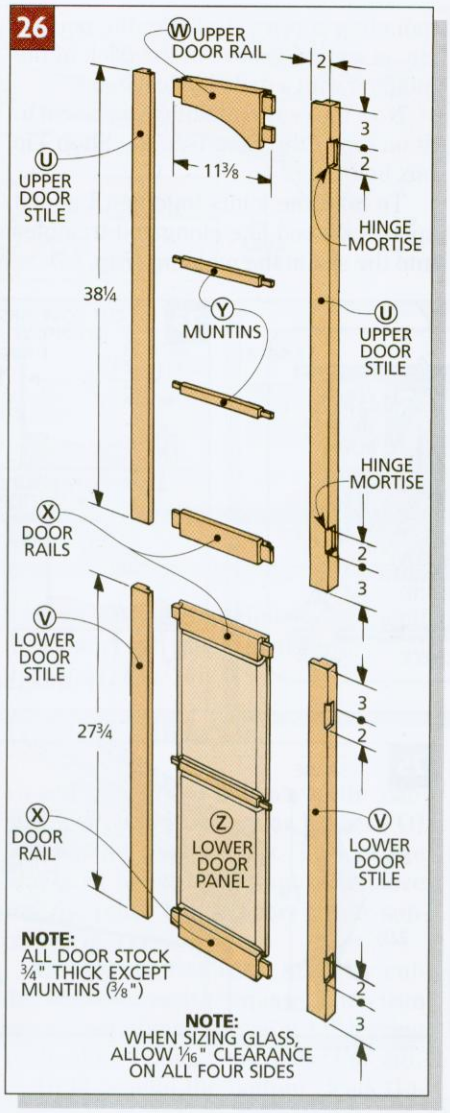
CUT MORTISES. I drilled out the mortises on a drill press with a fence *(Fig. 29)*. (If you don't have a fence, clamp a straight board to your drill press table.)

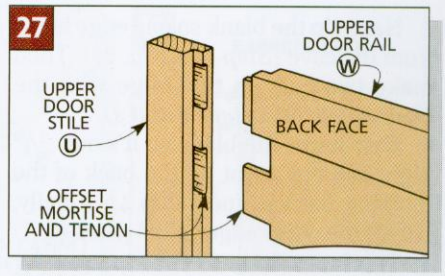
To cut the mortises, first insert a $^3/_{16}$" brad point bit in the drill press and set the speed to about 2000-2500 RPM. Then tighten the fence down so it's $^3/_{16}$" from the inside edge of the bit. To get the mortise to be offset toward the front of the stile, keep the *front face* of the stile against the fence. This will leave room for the $^3/_8$" rabbet on the inside face of the stile (refer to *Fig. 31a*).

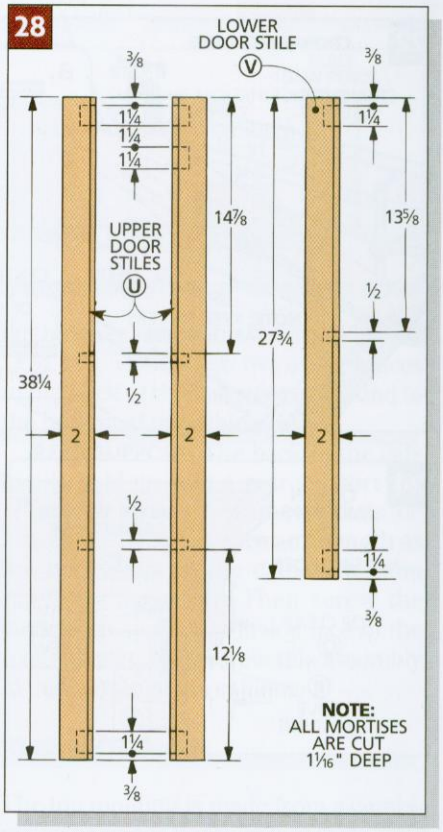
To make a mortise, start by drilling holes at each end. Then drill a series of holes next to each other *(Fig. 29)*. (Don't overlap the holes or the bit can wander into the previous hole.)

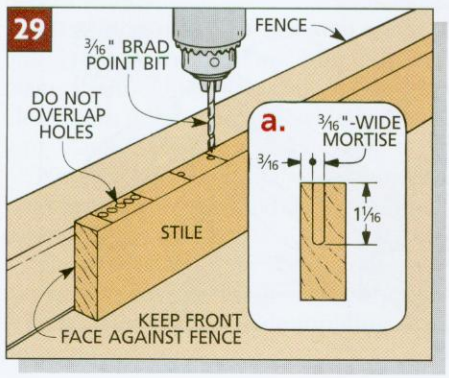
After the initial holes were drilled, I went back and drilled out the areas between the holes. Finally, I used a "milling" action to clean out the remaining ridges *(Fig. 30)*. Rapidly raise and lower the bit while slowly moving the workpiece from side to side.

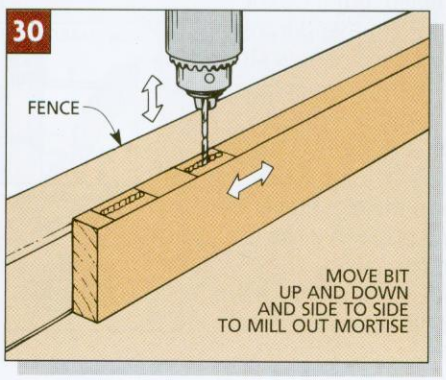
ROUT RABBET. After the mortises are cleaned out, rout a rabbet along the back edge of each stile *(Fig. 31)*.

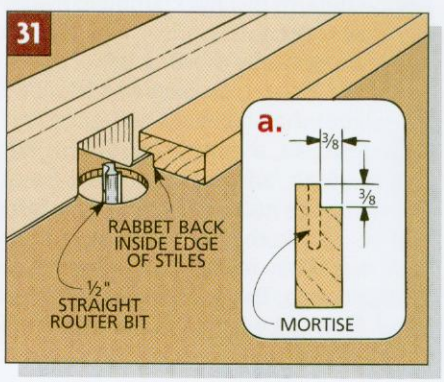












DOOR RAILS

Next, I made the rails and muntins. To determine their length, measure the distance between the *cabinet* stiles (D) and divide by two (for two doors). Then subtract 4" (for the two door stiles), and add 2" (for the 1" tenons on each end.)

Now, cut the two top upper door rails (W) 4½" wide, the other six rails (X) 2" wide, and the six muntins (Y) ¾" wide.

The muntins are mounted so they're in front of the glass and raised panels. So they have to be resawn to ⅜" thick.

CUT THE TENONS. Next, to avoid confusion when cutting tenons, I marked the front and back face of all the pieces.

On the rails (but not the muntins), cut a ⅜"-deep rabbet at the ends on the *back* face *(Fig. 33)*. Then, cut a rabbet on the *front* face to create a tenon that fits the mortise. Also cut this same rabbet on the front face of the muntins.

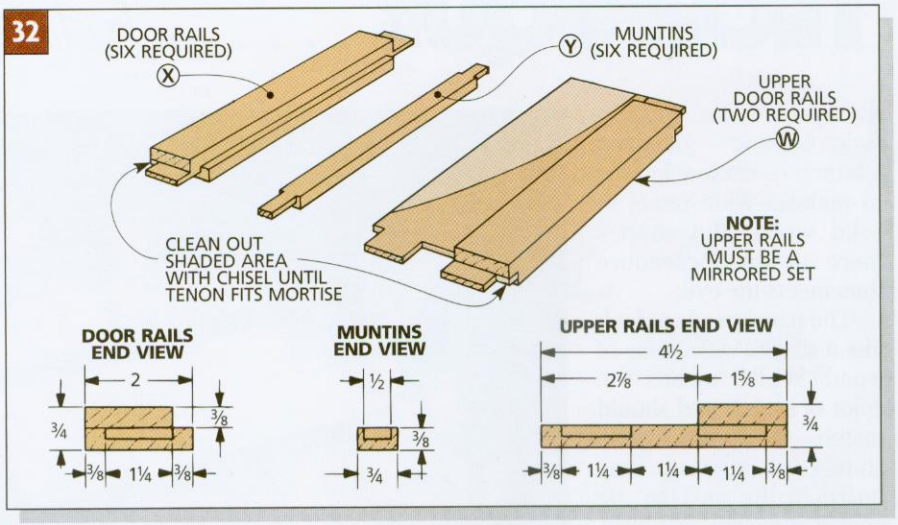
Note: The rabbet on the front face is wider than the one on the back so it fits in the rabbet on the door stiles.

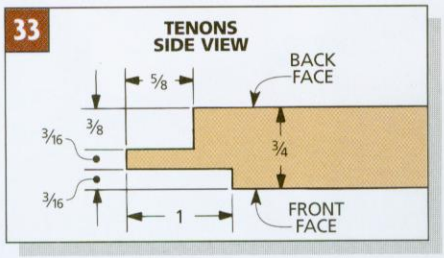
CUT TO WIDTH. To permit the tenons to fit in the mortises, trim the shoulders by cutting ⅜" from the corner of the rails and ⅛" on the muntins. Then cut a 1¼"-wide notch in the upper rail tenon to create two tenons *(Fig. 32)*.

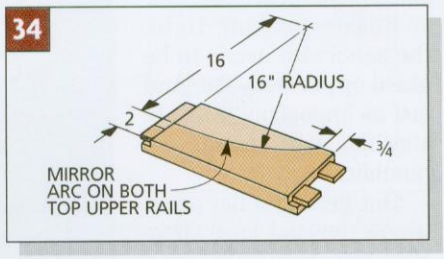
Note: Two tenons are used here to limit the amount of expansion and contraction with changes in humidity.

Next, there's a little area under the outside corner of each rail that has to be cleaned out with a chisel *(Fig. 32)*.

CUT RABBET. After all of the tenons fit the mortises, cut a rabbet on the back inside edges of all the rails (but not the muntins) to accept the glass or panels. This rabbet is ⅜" wide on the six rails (X) *(Fig. 32)*. However, the rabbet on the two top upper rails (W) is 2⅞" wide.







CUT TOP RAIL ARC. Next, lay out and cut an arc on the bottom edge of the top upper door rails (W) *(Fig. 34)*. Now assemble the doors, checking for square.

PANELS, STOPS

To make the raised panels (Z) that fit in the lower doors, start by edge-gluing four panels. Then cut the panels to fit in the rabbets on the doors. (Don't fit them too tight. They may expand with changes in humidity.)

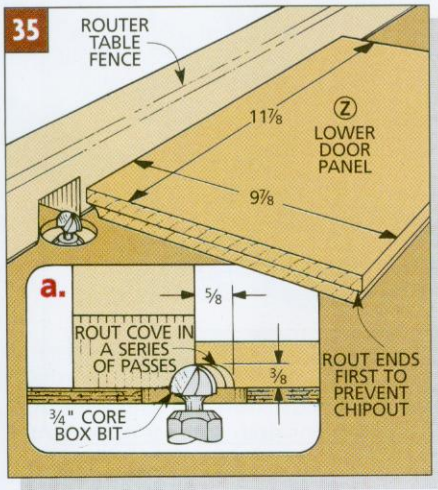
COVE. Now, rout a cove around the front edge of each panel *(Fig. 35)*. To do this, make a series of passes (move the fence between passes) with a core box bit *(Fig. 35a)*.

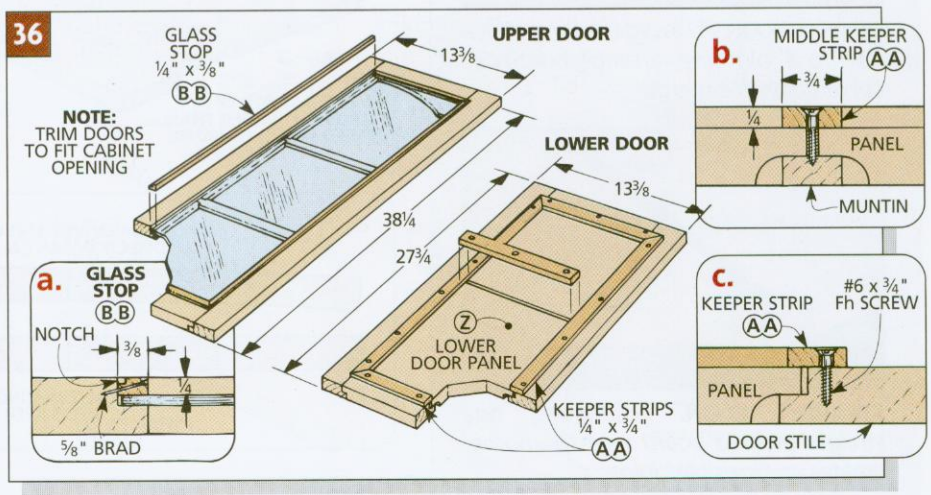
KEEPER STRIPS. To hold the panels in place, I screwed keeper strips (AA) behind each panel *(Figs. 36b and 36c)*.

GLASS STOPS. To hold the glass in the doors, I made ¼"-thick stops (BB). Miter the stops, and then tack them to the stiles *(Fig. 36a)*. (The notch along the edge of each stop makes it easier to remove if the glass should break.)

HINGE MORTISES. Before mounting the glass, I cut hinge mortises in the door and cabinet stiles (refer to *Fig. 26*).

HARDWARE. After applying the finish, mount the door catches and latch (see Exploded View on page 83). ■





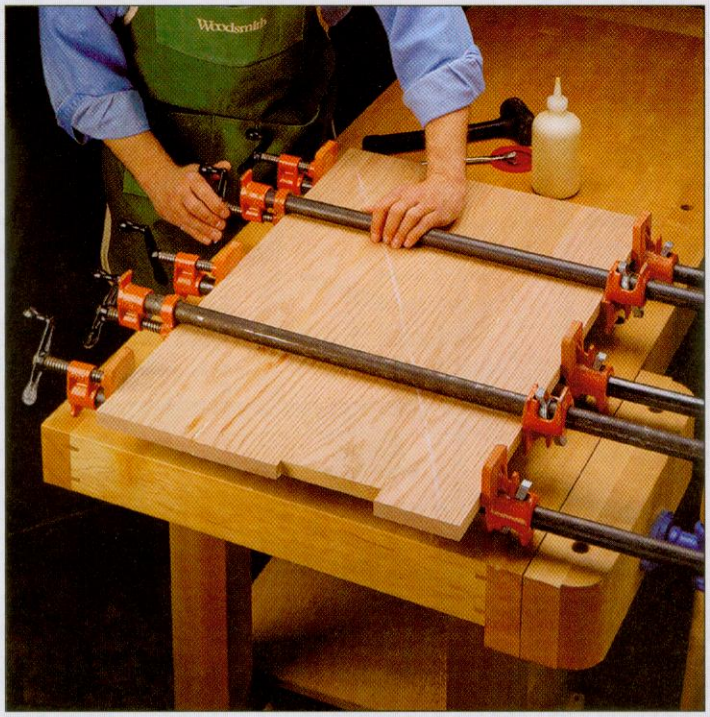
TECHNIQUE . . . . . Edge-Gluing Panels

It seems like such a simple thing — gluing up a bunch of narrow boards to make a wide panel of solid wood. But there's more to this procedure than meets the eye.

The panel needs to look like a single, wide piece of wood. Which means the color of each board should match. And the grain should blend from one board to the next so the joint lines almost disappear.

Besides looking right, the panel also needs to be glued up perfectly flat. And just as important, it has to stay flat with changes in humidity.

But getting a flat panel where the joint lines virtually "disappear" doesn't just happen when it's time to glue up the boards. It starts when you select and lay out the lumber.



SELECTION AND LAYOUT

As you sort through a pile of lumber, take some time to find boards that are close in color. And try to visualize what the overall grain pattern will look like when you cut the boards and lay them edge-to-edge.

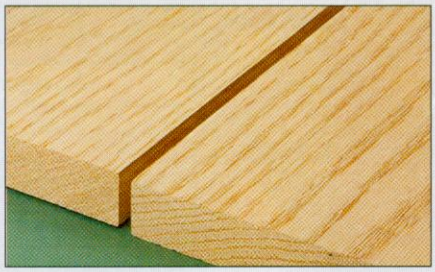
APPEARANCE. To create a uniform-looking panel, the goal is to match the color and grain of one board as closely as possible to the one next to it. So as you turn the boards over and flip them end for end, arrange them so one curve flows into another, or the straight-grained lines on one piece match those on the piece next to it (see photos below left).

MOVEMENT. Also, think about how the panel will move with changes in humidity. This depends on the growth rings on the end of each board.

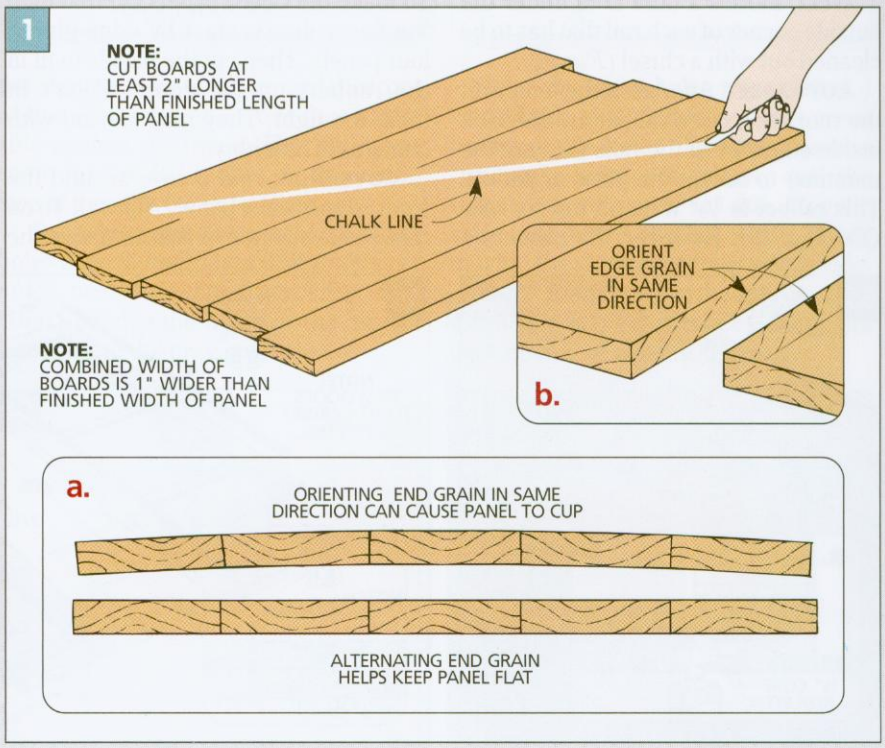
If the rings are all oriented the same way, the entire panel tends to cup in one direction *(Fig. 1a)*. But when you alternate the rings, each board moves in opposite directions. Then the panel is more likely to stay flat.

GRAIN DIRECTION. If you're going to plane the panel once it's glued up, you also need to look at the grain direction of the boards. To prevent chipout, check the grain on the edge of each board *(Fig. 1b)*. Then position the boards so the grain runs the same direction.

CURVED GRAIN. *To avoid drawing attention to a joint line, arrange boards so curved patterns merge.*



STRAIGHT GRAIN. *Positioning one straight-grained board next to another creates an "invisible" joint.*



A COMPROMISE. Although it makes sense to arrange boards for appearance, wood movement, and grain direction, sometimes you have to compromise. No matter how much you shuffle the boards, there's a "stubborn" one that just won't fit.

In the end it all depends on which criterion is most important for the project. For me, it's usually apperance.

EDGE PREPARATION

Now you can turn your attention to the edge joints. To lay the groundwork for a strong joint, the edges are critical.

JOINT EDGES. The goal here is to get the edges of each board smooth, straight, and square. So after marking the panel with chalk to keep track of the position of the boards *(Fig. 1)*, I joint clean, crisp edges on each board with a jointer or table saw with a sharp blade.

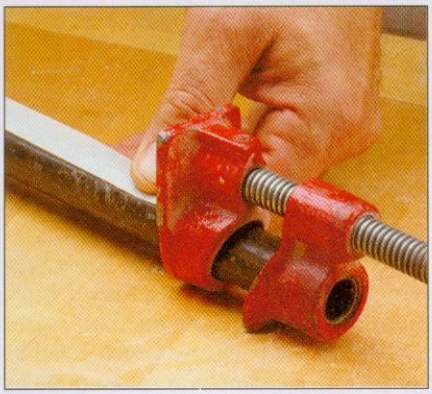
DRY CLAMP. At this point, it's tempting to break out the glue bottle. But I always dry clamp the panel first. If the panel cups (or there's a gap in one of the joints), the edges may need work (see "Troubleshooting" at bottom right).

GLUE-UP

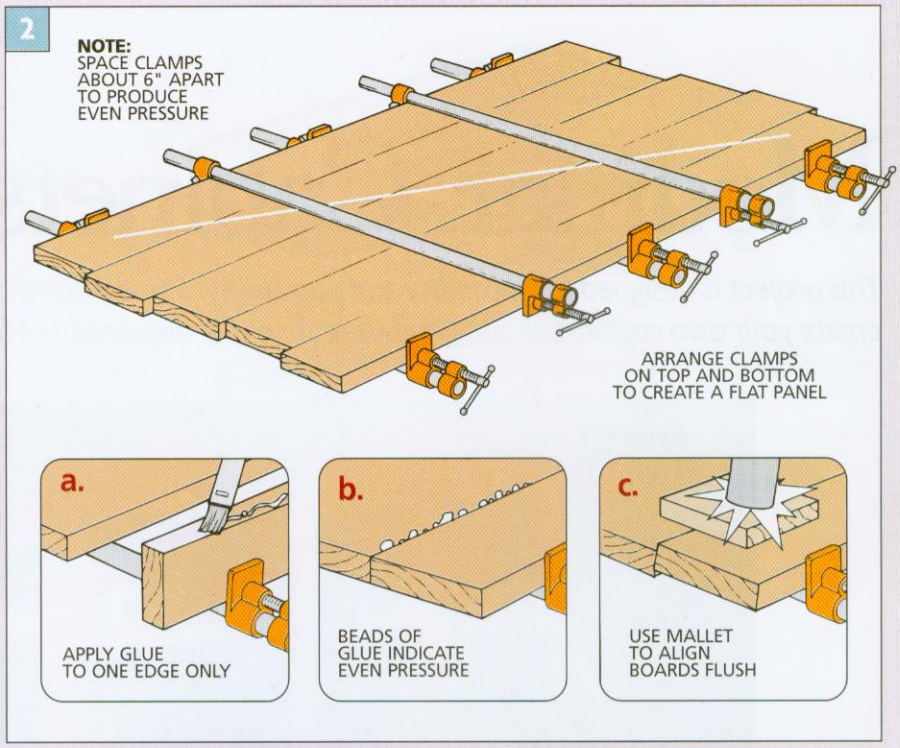
Once you're satisfied with how the boards fit, you're ready start to glue up the panel.

To keep the panel flat and produce even clamping pressure, the idea is to arrange the pipe or bar clamps above and below the panel so they're about 6" apart *(Fig. 2)*.

Note: To prevent black stains from appearing on the wood, I cover iron pipe clamps with wax paper or masking tape; see photo below.



Applying a strip of masking tape to the pipe prevents the iron from reacting with the water in the glue and staining the wood.

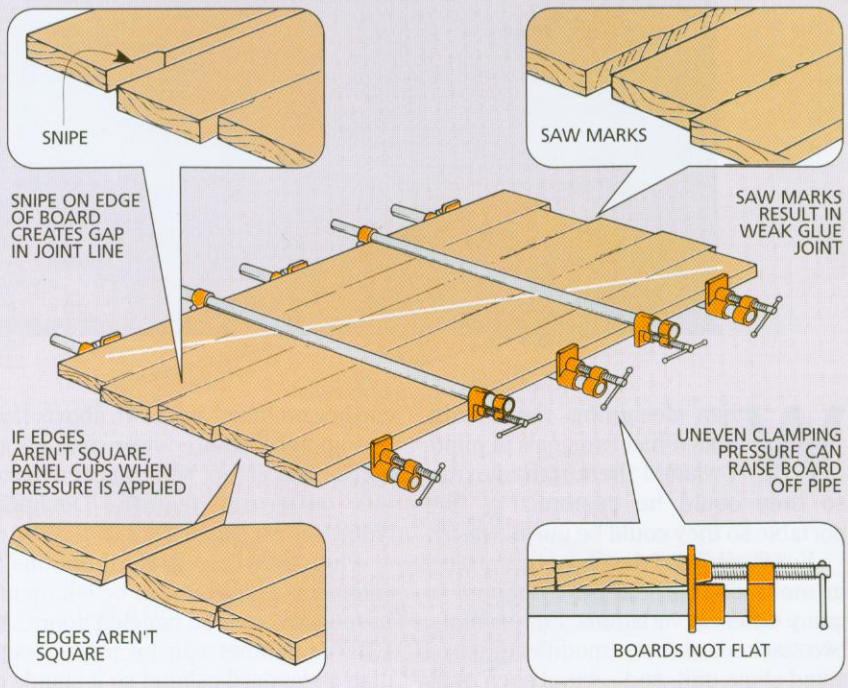


APPLY GLUE. With clamps at hand, you can apply the glue. To speed things along, I squeeze out a generous line of glue on only one edge of each board and brush it to an even film *(Fig. 2a)*.

TIGHTEN CLAMPS. Now it's time to tighten the clamps. Start in the center of the panel and work toward the ends, alternating between the top and bottom clamps. Don't overdo it here. You want to apply just enough pressure so there's an even bead of glue *(Fig. 2b)*.

Finally, if the surface of one board sticks up above the piece next to it, a mallet and a scrap of wood make quick work of getting them flush *(Fig. 2c)*.

TROUBLESHOOTING



Modular Cabinets

This project is designed for flexibility and portability. Standardized units can be mixed and matched to create your own custom cabinets, and they are easily disassembled for transport or storage.

When designing these cabinets, I had two goals in mind. I wanted them to be flexible so they could be customized. And portable so they could be moved easily.

For flexibility, I designed this project in modules that can be combined in many different variations. For example, two stacked cabinets (modules) make a stand-alone unit, and several such units can be combined as shown above. If you line up two or more lower cabinets and add a countertop, you can even make a nice buffet unit (see the Designer's Notebook on pages 102 and 103).

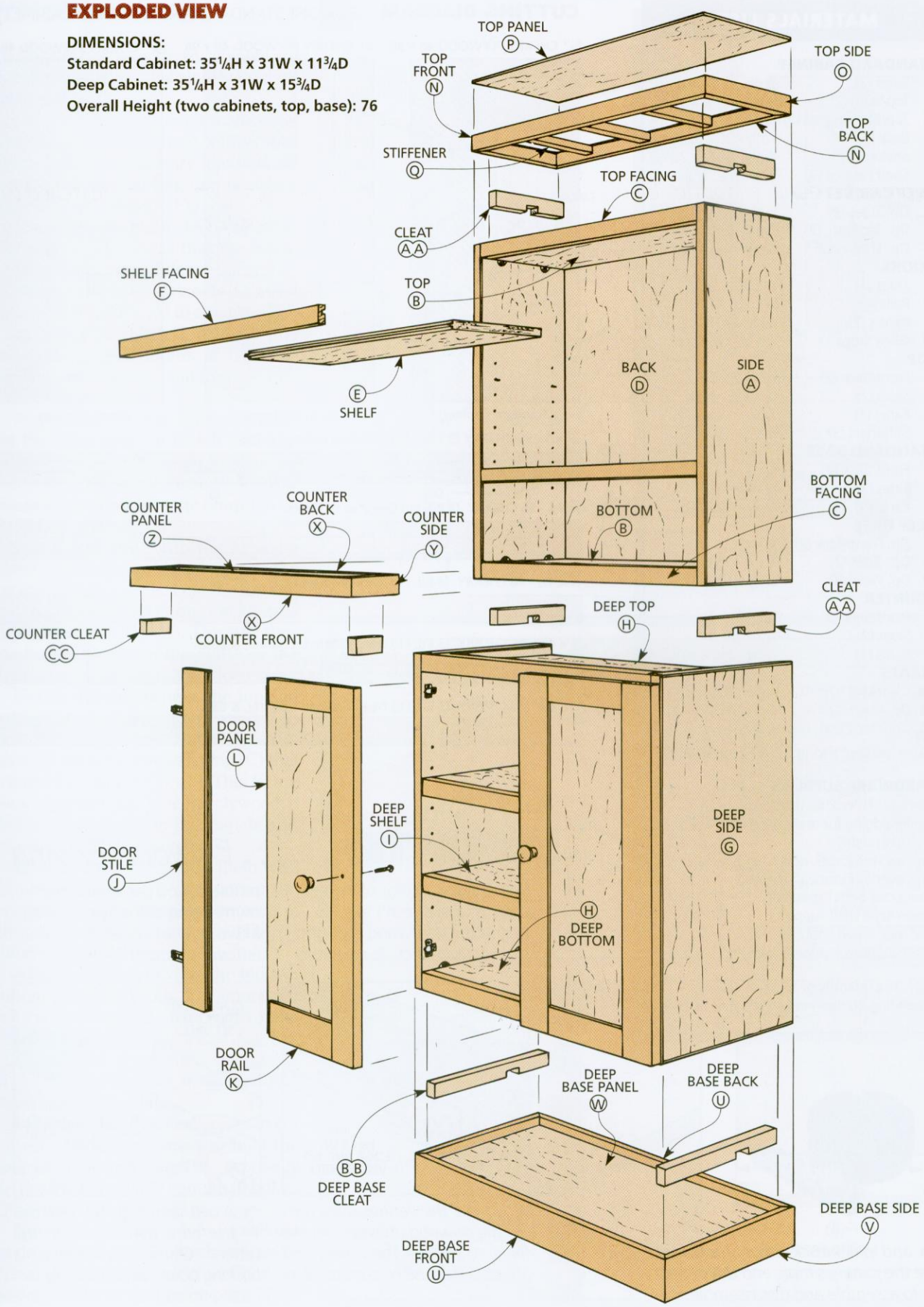
Plus, there are several options for each unit. The front can be left open or have glass or wood paneled doors. And a lower cabinet can be made deeper than a standard cabinet so it stands out a little more from the wall.

As I said, another goal in designing these cabinets was portability. I built them using knock-down hardware. Once all of the parts are constructed in your shop, it's simple to reassemble in any room in the house.

I built my cabinets from solid cherry and cherry plywood. And I finished them with an oil and urethane finish.

EXPLODED VIEW

DIMENSIONS:
Standard Cabinet: 35¼H x 31W x 11¾D
Deep Cabinet: 35¼H x 31W x 15¾D
Overall Height (two cabinets, top, base): 76



MATERIALS LIST

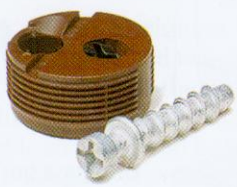
STANDARD CABINET		
A	Sides (2)	¾ ply - 11¾ x 35¼
B	Top/Btm. (2)	¾ ply - 11¼ x 29½
C	Top/Btm Facings (2)	¾ x 1½ - 29½
D	Back (1)	¼ ply - 30 x 32¾
E	Shelves (2)	¾ ply - 10¾ x 29⅜
F	Shelf Facings (2)	¾ x 1½ - 29⅜
DEEP CABINET*		
G	Dp. Sides (2)	¾ ply - 15¾ x 35¼
H	Dp. Top/Btm. (2)	¾ ply - 15¼ x 29½
I	Dp. Shelves (2)	¾ ply - 14¾ x 29⅜
DOORS		
J	Stiles (4)	¾ x 2½ - 33¾
K	Rails (4)	¾ x 2½ - 10⅞
L	Panels (2)	¼ ply - 10¾ x 29⅛
M	Glass Stops	¼ x ⅜ - 16 lineal ft.
TOP		
N	Front/Back (2)	¾ x 1½ - 31
O	Sides (2)	¾ x 1½ - 11¾
P	Panel (1)	¼ ply - 11 x 30¼
Q	Stiffeners (3)	¾ x ¾ - 10¼
STANDARD BASE		
R	Front/Back (2)	¾ x 4 - 31
S	Sides (2)	¾ x 4 - 11¾
T	Panel (1)	¼ ply - 11 x 30¼
DEEP BASE		
U	Dp. Front/Back (2)	¾ x 4 - 31
V	Dp. Sides (2)	¾ x 4 - 15¾
W	Dp. Panel (1)	¼ ply - 15 x 30¼
COUNTER		
X	Front/Back (2)	¾ x 1½ - 31
Y	Sides (2)	¾ x 1½ - 4
Z	Panel (1)	¼ ply - 3¼ x 30¼
CLEATS		
AA	Cleats (4)	¾ ply - 1½ x 10¼
BB	Dp. Cleats (2)	¾ ply - 1½ x 14¼
CC	Counter Cleats (2)	¾ ply - 1½ x 2½

*Also Needed: Facings (C & F) and Back (D)

HARDWARE SUPPLIES

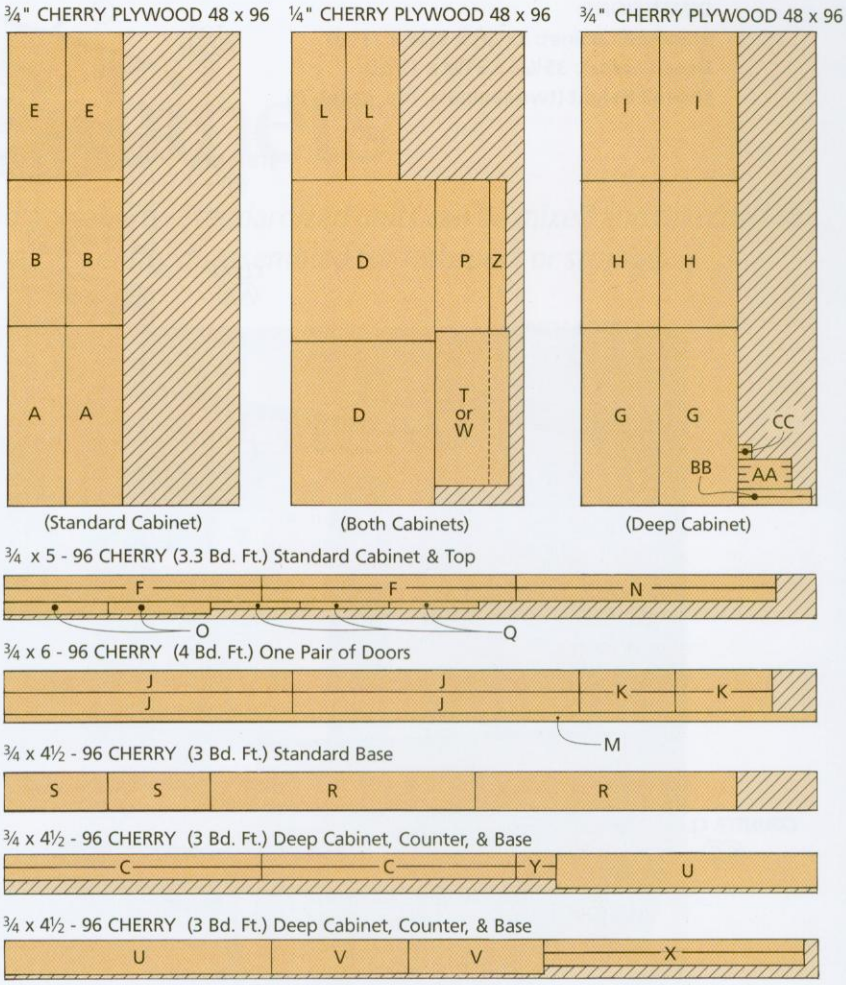
#8 x 1¼" Fh woodscrews
Veneer edging (or make your own, see Shop Tip at right)
Cam and pin knock-down hardware
125° overlay European hinges
Connector bolts (optional)
Spoon-style shelf supports
1⅛"-dia. wood knobs
⅛"-thick glass (optional) with ½" brads

Note: The quantity of supplies will vary depending on the number of cabinets built.



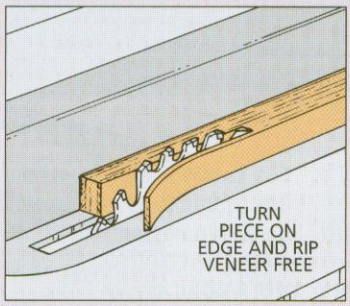
Cam and pin knock-down hardware make the joinery simple and the project easy to assemble and dissassemble.

CUTTING DIAGRAM (FOR ONE STANDARD AND ONE DEEP CABINET)

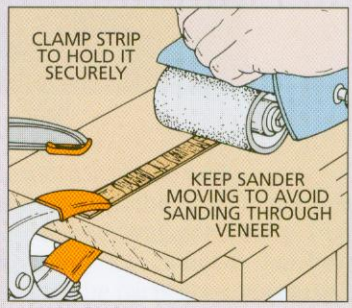


SHOP TIP ..... *Plywood Edging*

The grain and color of veneer edging tape doesn't always match the hardwood plywood used on a project. To solve this problem, you can make your own edging strips by removing a thin layer of veneer from your leftover scraps of plywood.



1 *To cut the veneer free, turn the plywood on edge. Set the fence to remove the veneer and about 1/32" of the core material.*



2 *A belt sander quickly removes the core material from the veneer. Clamp the strip to a backing board while sanding.*

To see just how easy these cabinets are to build, take a look at a single standard cabinet (*Fig. 1*).

Each standard cabinet is made up of a pair of sides, top, bottom, and 1/4" plywood back. The sides are identical. So are the top and bottom; one is simply flipped "upside down" (*Fig. 1b*).

You can also build deep cabinets. The only difference is that the sides, top, and bottom are 4" deeper (*Fig. 1a*).

SIDES. To build the cabinets, I started by cutting the sides (A) to size from 3/4"-thick plywood. Then I covered the exposed plywood edges of the side panels — top, bottom, and front — with veneer edging.

Note: You can buy veneer edging, but the color may not match your plywood. For a perfect match, I made my own veneer edging from some leftover pieces of plywood (see the Shop Tip on the opposite page).

TOP & BOTTOM. With the exposed edges veneered, work can begin on the top and bottom panels. I cut the top and bottom (B) to length, but cut them a little wide at first (11 1/2"). This way they can be cut to match the width of the sides after the facing (C) is added later.

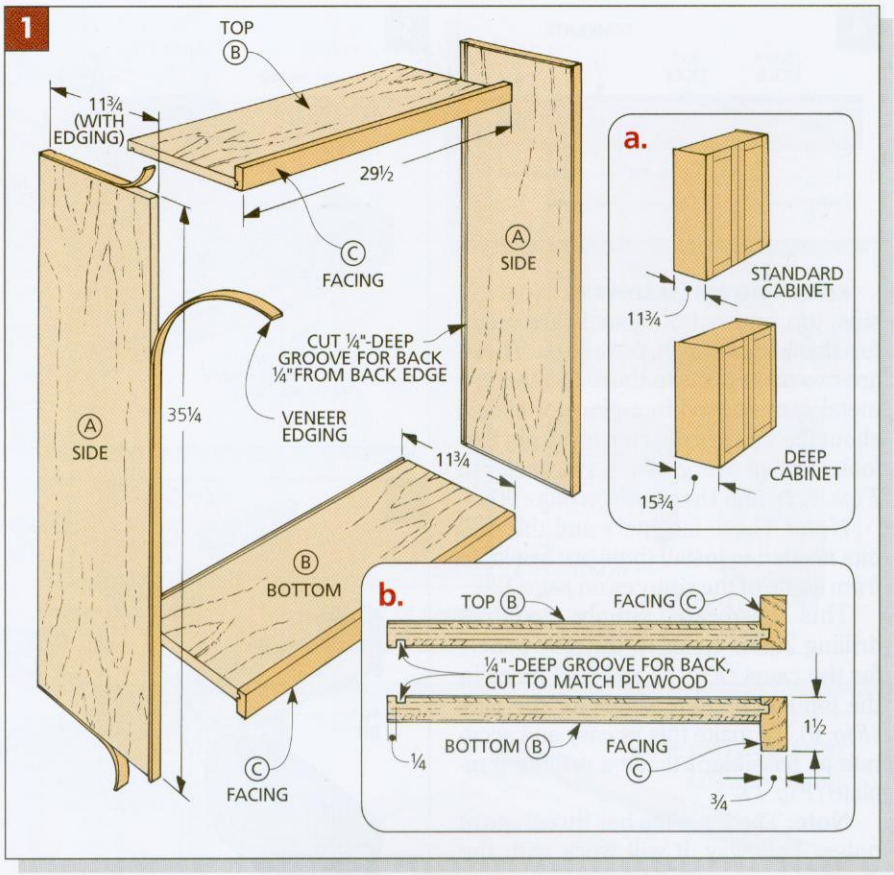
Unlike the side panels, the top and bottom panels have edging applied to their *front* edges only. And this time, I used 3/4"-thick hardwood facing (C) that I ripped 1 1/2" wide (*Fig. 1b*). This facing does more than just hide the plywood; it also adds strength to the panels and prevents them from sagging.

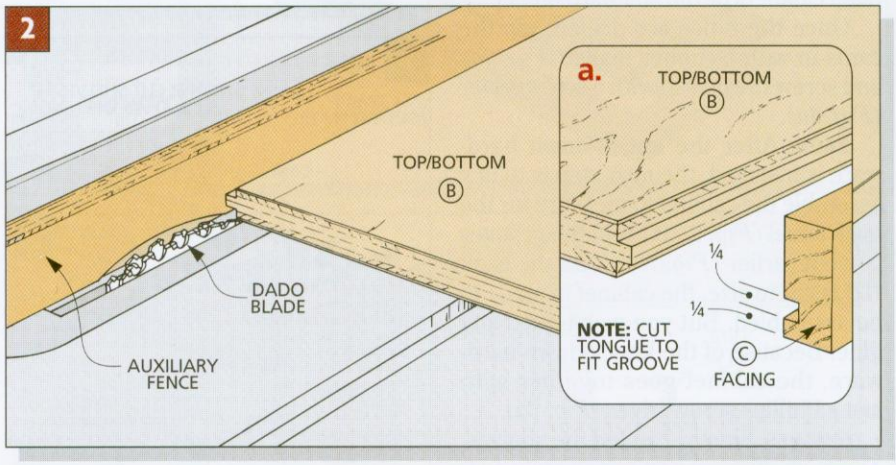
To help align the facing flush with the panels, I cut a 1/4" x 1/4" groove in the facing and a mating tongue on each of the panels (*Figs. 2 and 2a*). Then I glued them together.

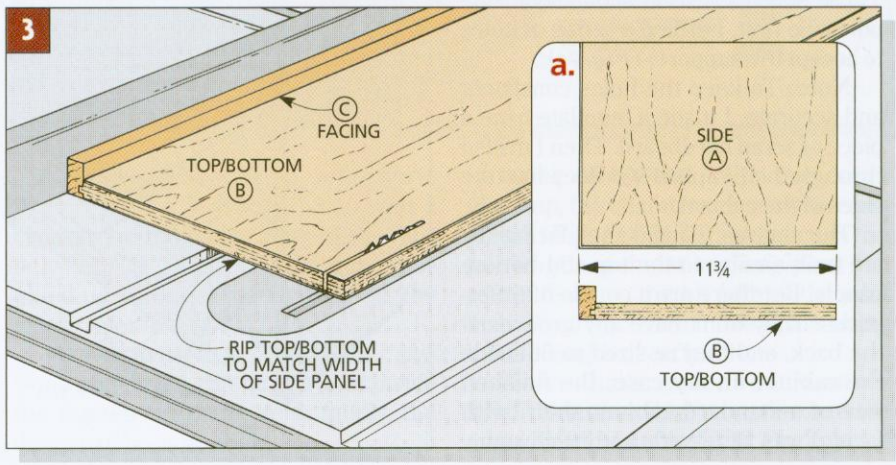
After the glue is dry, rip the top and bottom panels to width. The important thing is that they match the width of the edged side panels (*Figs. 3 and 3a*). The final width of a standard cabinet is 11 3/4". A deep cabinet is to be 15 3/4" wide (*Fig. 1a*).

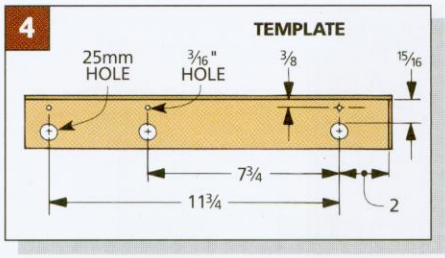
BACK GROOVE. The next step is to cut a groove on *all* the pieces to hold the back (*Figs. 1 and 1b*). This groove is 1/4" deep and just wide enough to hold a 1/4" plywood panel.

Note: If you want to hang a cabinet up on the wall, set the back groove in 3/4" and use a 3/4" cleat-and-hanger system similar to the one on page 17.









KNOCK-DOWN HARDWARE. Now the side, top, and bottom panels are ready for the knock-down fasteners. There are two main parts to these fasteners: a metal cam housed in a piece of plastic about the size of a quarter, and a pin that looks like an overgrown screw (refer to *Figs. 7, 7a* and the photo on page 96).

Note: These fasteners and the drill bits needed to install them are available from some of the sources on page 126.

This hardware simply requires drilling 25mm holes in the side panels for the cams *(Fig. 5)* and 3/16" holes in the top and bottom panels for the pins *(Fig. 6)*. To make this as easy and accurate as possible, I made a drilling template *(Fig. 4)*.

Note: The template has three sets of holes. This way, it will work with the deep cabinets or the standard ones.

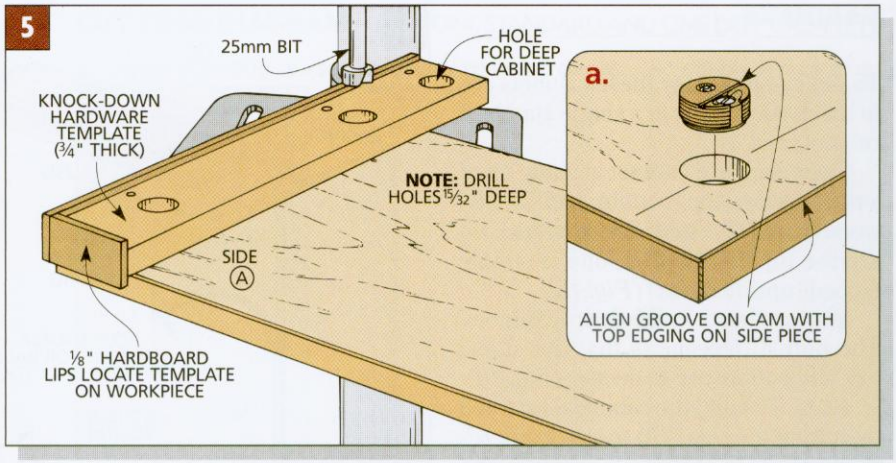
Once the holes are drilled, tap the cams in with a rubber mallet *(Fig. 5a)* and screw the pins in with a screwdriver *(Fig. 6a)*.

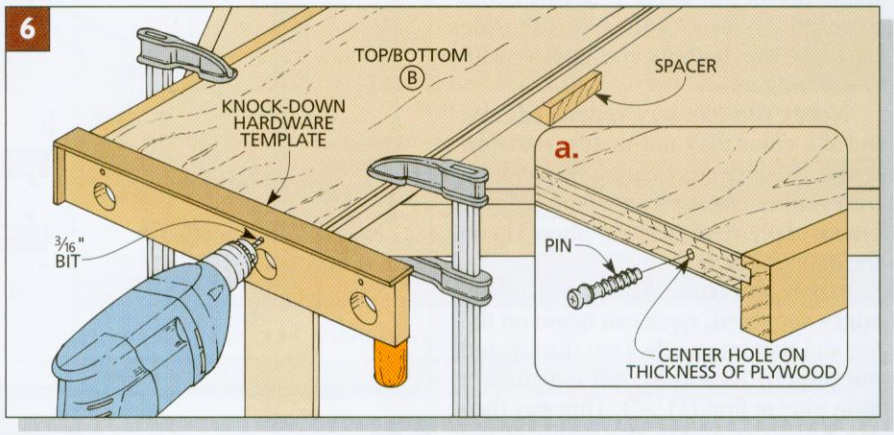
BACK. After the knock-down hardware is installed, the next step is to dry assemble the cabinet to measure for the back panel *(Fig. 7)*. It fits in the grooves you cut earlier *(Fig. 7b)*. After the back (D) is cut to size, the cabinet is ready to be assembled. But you won't need any glue. Because of the knock-down hardware, the cabinet goes together with just a Phillips screwdriver *(Fig. 7a)*.

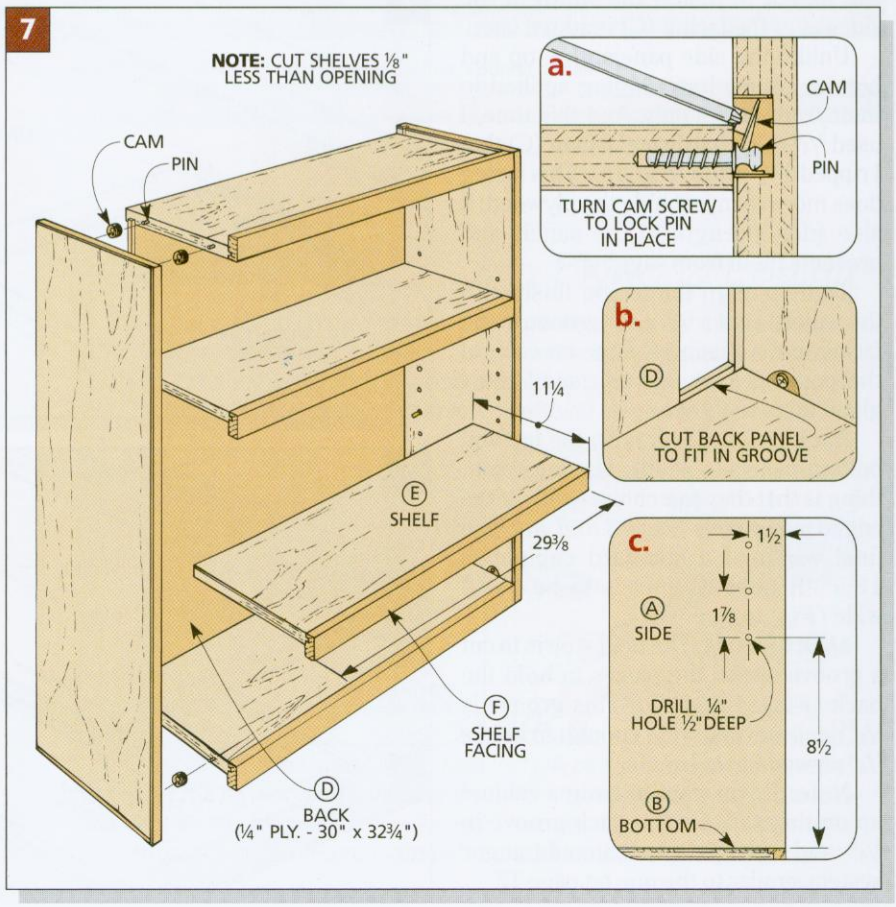
SHELVES. Finally, I added the shelves. These shelves rest on spoon-style supports. So first, I drilled a series of holes to accept the supports *(Fig. 7c)*.

Note: To keep the holes consistent and accurate, I made a template from a piece of scrap hardboard. Then I drilled through the template 1/2" deep into the sides of the cabinet.

The shelves (E) and shelf facing (F) are built similar to the top and bottom panels. But there are a couple of differences. They don't have any grooves at the back, and they're sized to fit inside the cabinet. In my case, the finished size of a standard cabinet shelf (with facing) was 11 1/4" wide and 29 3/8" long.





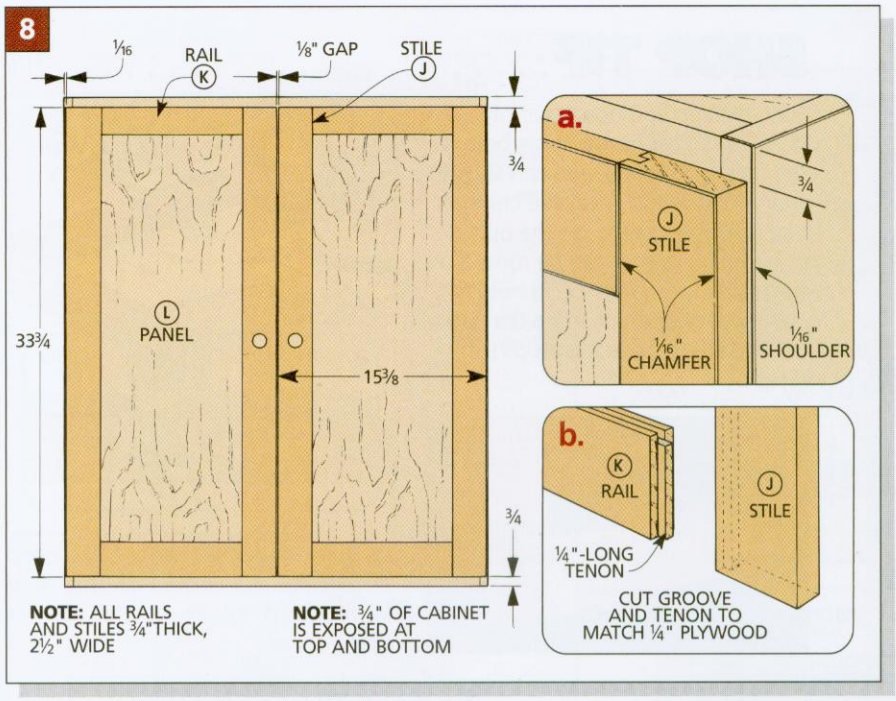


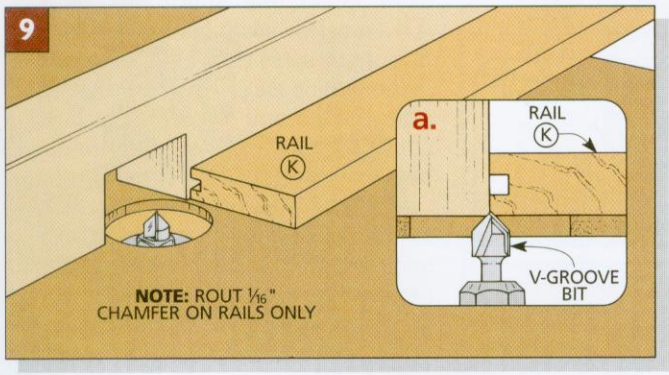
DOORS

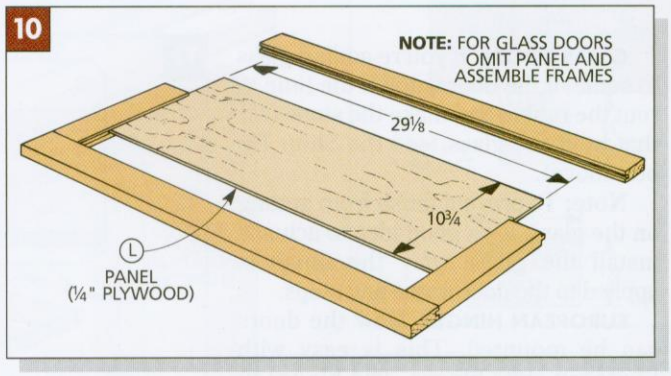
Like the cabinets, I kept the doors simple. Just a hardwood frame around a panel, all held together with stub tenon and groove joints. And you can choose either 1/8"-thick glass or 1/4" plywood for the panels. (For more on the glass panels, see page 100.)

Even hanging the doors is easy. I used European-style hinges that snap on and off. And they're adjustable, so after the doors are installed, you can fine-tune the fit, if needed. (For more information about these hinges, see pages 104 and 105.)

STILES & RAILS. To build the doors, I began by making the stiles (J) and rails (K) from 3/4"-thick stock *(Fig. 8)*. The width of all these pieces is 2 1/2". But the stiles and rails are different lengths. To find the lengths, you need to determine the overall size of the doors.





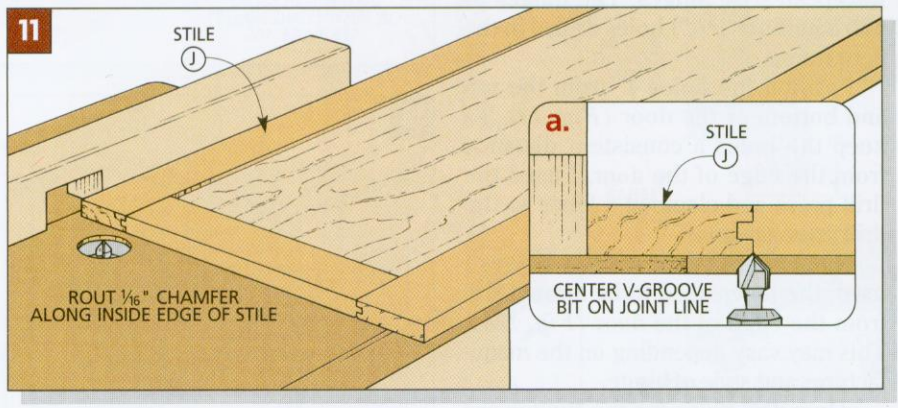


The door stiles are cut 1 1/2" shorter than the height of the cabinets *(Fig. 8)*. (Mine were 33 3/4" long.) They're 1 1/2" shorter because the doors lay over the cabinets, leaving 3/4" exposed at the top and bottom *(Fig. 8a)*.

Arriving at the length of the door rails takes a little more work. What you want to end up with are two doors with 1/16" of the cabinet exposed on both edges and a 1/8" gap between the doors. Plus, you have to allow for the width of the door stiles and the 1/4"-long tenons on both ends of the door rails. (Since the overall width of my cabinet was 31", my door rails needed to be 10 7/8" long.)

STUB TENON & GROOVE. Now to join the stiles and rails, first cut a groove on the inside edge of all the stiles and rails *(Fig. 8b)*. Then cut stub tenons on the rails to fit in the grooves.

CHAMFER. Before assembling the doors, I decided to add a chamfer around the inside edge of the frame.



This was a two–step procedure. First, I used a V-groove bit to rout a chamfer on the inside edge of the rails only *(Fig. 9)*. Later, *after* the frame was glued up, I routed the chamfer on the stiles (refer to *Fig. 11*).

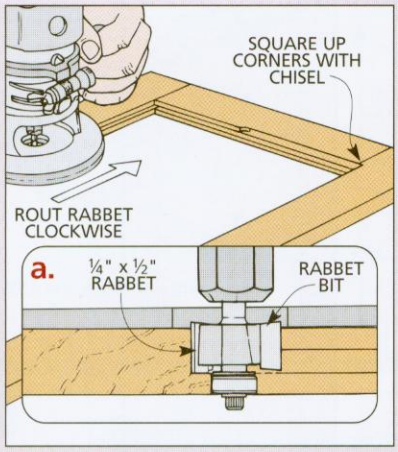
PLYWOOD PANELS. Next, the 1/4" plywood panels (L) can be cut to fit inside the frames *(Fig. 10)*. And, finally, the doors can be assembled.

MORE CHAMFERS. With the doors glued up, the chamfers can now be completed *(Fig. 11)*. This chamfer runs the full length of the stile. Simply set the router fence so the bit follows the joint line *(Fig. 11a)*. Then make a pass along the full length of each stile.

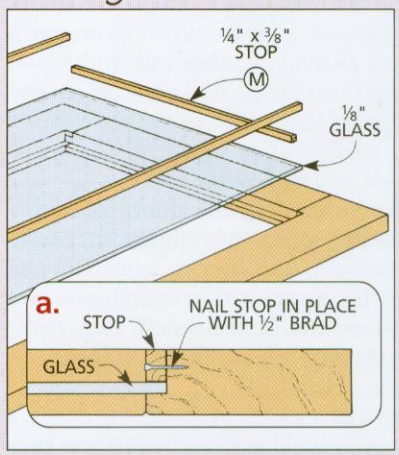
When that's done, rout another small chamfer (1/16") on the outside edge of each door (refer to *Fig. 8a*).

SHOP TIP ..... Installing Glass Panels

Even though you don't want to install the glass in the doors before the finish is applied, you can still get everything ready. After the chamfer has been completed on the outside of a door, a rabbet can be routed on the inside face *(Step 1)*. To hold the ⅛"-thick glass, I cut some thin strips of solid cherry to act as stops (M) *(Step 2)*.



1 *First, rout a ¼" rabbet, ½" deep around the inside of the door frame. Then square up the corners with a chisel.*



2 *Next cut ¼" x ⅜" stops to hold the ⅛"-thick glass panel. Be sure to predrill pilot holes before tacking the stops in place.*

GLASS DOORS. If you're adding glass to some of the doors, now's the time to rout the rabbet and make the stops (M) that hold the glass (see the Shop Tip box above).

Note: To prevent finish from getting on the glass, it's a good idea to actually install the glass *after* the finish is applied to the door frame and stops.

EUROPEAN HINGES. Now the doors can be mounted. This is easy with European-style hinges. The hinges fit into 35mm (or 1⅜") holes drilled in the door frame.

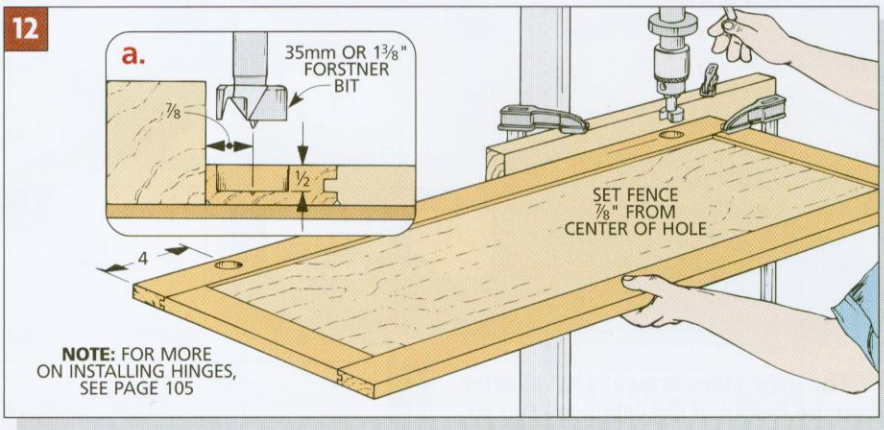
Position the holes 4" from the top and bottom of the door *(Fig. 12)*. To keep the holes a consistent distance from the edge of the door, I used the drill press and clamped a fence to the drill press table.

Note: On the 125° overlay hinges I used, the holes need to be located ⅞" from the edge of the door *(Fig. 12a)*. This may vary depending on the manufacturer and style of hinge.

Once the holes for the hinges are drilled, pilot holes can be drilled *inside* the cabinet for matching mounting plates *(Fig. 13)*. These pilot holes must align directly across from the holes in the door. So to help lay out the pilot holes, I built a layout jig (see page 105).

WOODEN KNOB. With the doors mounted, the last step is to add a knob centered on the width and height of the stiles *(Figs. 13 and 13a)*.

12



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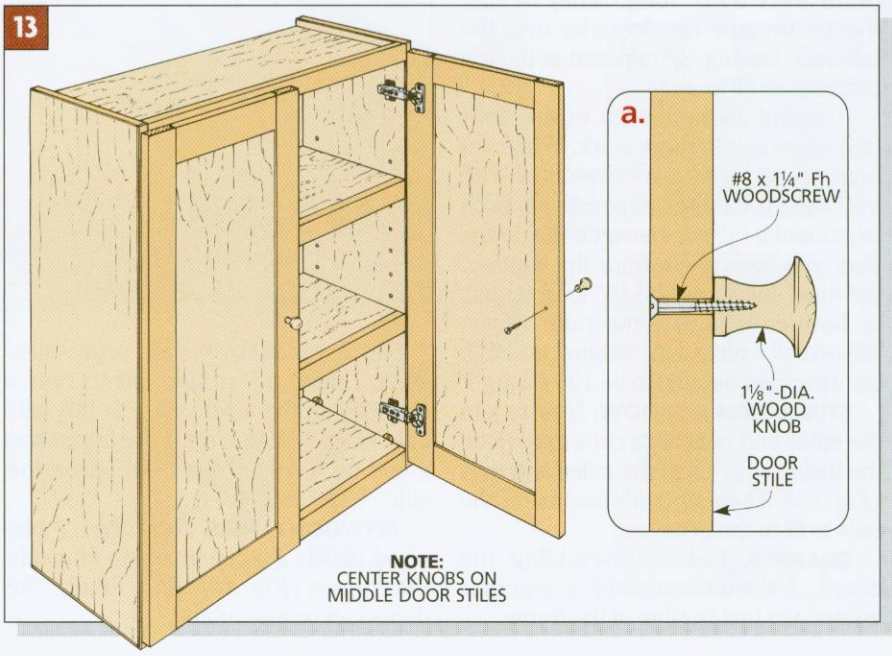


TOP, COUNTER, & BASE

Once all the individual modules were complete, I began to put everything together. This required more parts.

To finish the standard cabinets, I added a framed top panel *(Figs. 14 and 14a)*. There's also a counter to cover the exposed section of the deeper cabinet *(Fig. 14b)*, and a base frame to raise the cabinet off the floor *(Fig. 14c)*.

These parts are all similar. They're hardwood frames strengthened with plywood panels and built to match the width and depth of the cabinets.

TOP. I started with the top. First, the $^3/_4$"-thick pieces (parts N and O) are ripped $1^1/_2$" wide (tall). Then they're mitered to length so the assembled frame will match the top of the cabinet.

To add stability to the frame, all the pieces are rabbeted to hold a $^1/_4$" plywood panel (P) *(Fig. 14a)*.

After the frame and panel were assembled, I glued three stiffeners (Q) underneath. This adds extra support in case anything heavy is set on the top.

And to "hide" the line between the top frame and the cabinet below, I cut a small rabbet ($^1/_8$" x $^1/_8$") around the bottom edge on the front and sides.

COUNTER. If you build a deep lower cabinet, you'll need a counter. The counter is like a narrow top unit without stiffeners *(Fig. 14b)*. Its purpose is to cover the exposed opening on top of the deep cabinet. The top surface of the counter should be flush with the inside of the cabinet above.

BASE. Finally, I added a base underneath each lower cabinet *(Fig. 14c)*. It's a little different from the top unit.

First, the frame of the base is taller. Another difference is the location of the plywood panel. Instead of being flush with the top, the panel is held in a groove that's cut $^3/_4$" down from the top. This provides room for cleats that will align the cabinet and base later. Also, like the counter, there's no need for stiffeners underneath the plywood.

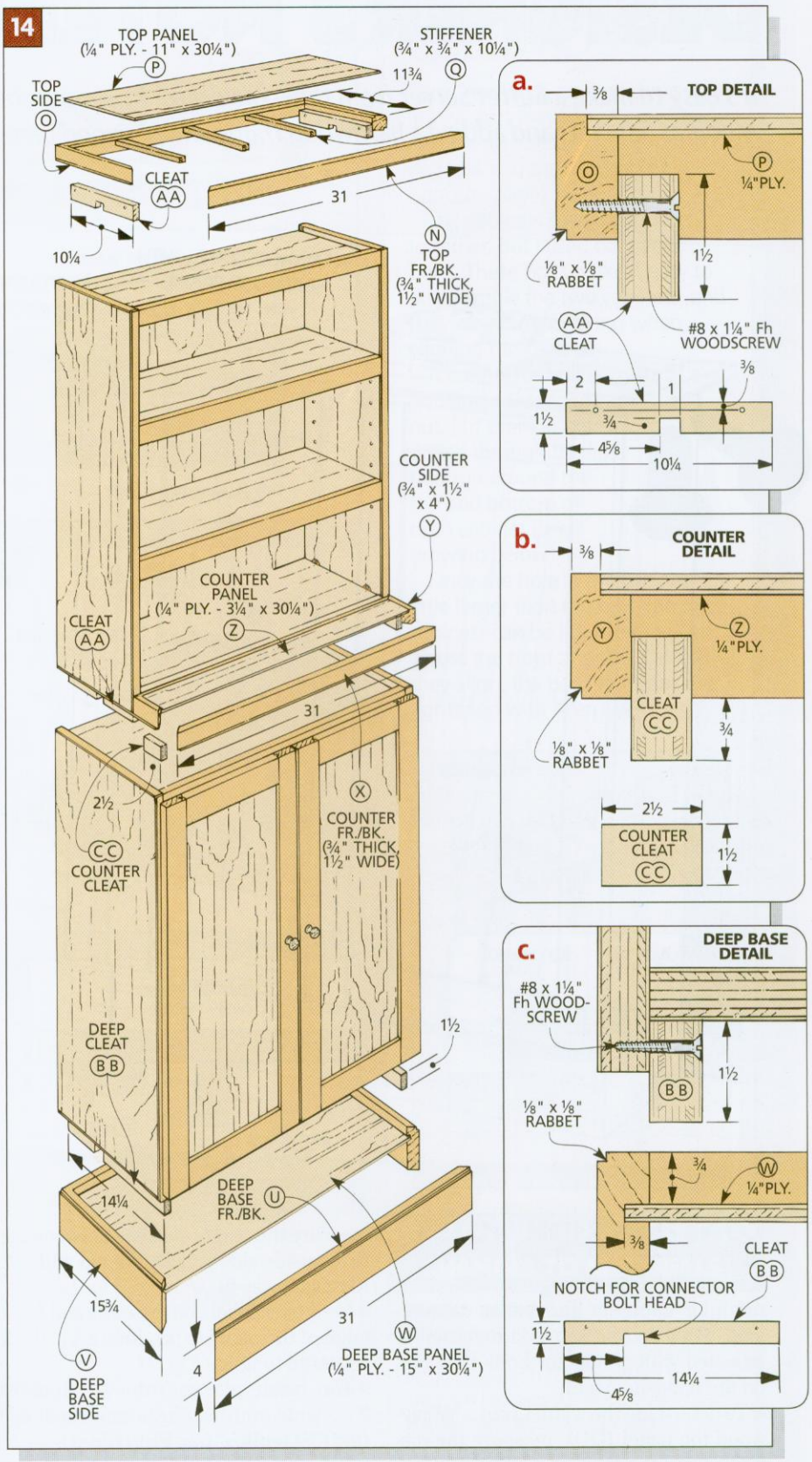
FINAL ASSEMBLY. After the top, counter, and base frames are complete, it's time to put the whole thing together.

To hold two cabinets together side-to-side, I used connector bolts (refer to page 103). (They're not needed if you're only building one set of cabinets.)

To keep a set of stacked cabinets aligned, I added $^1/_2$"-wide plywood cleats (AA, BB) *(Fig. 14)*. A notch is cut in each cleat to fit around the head of a connector bolt.

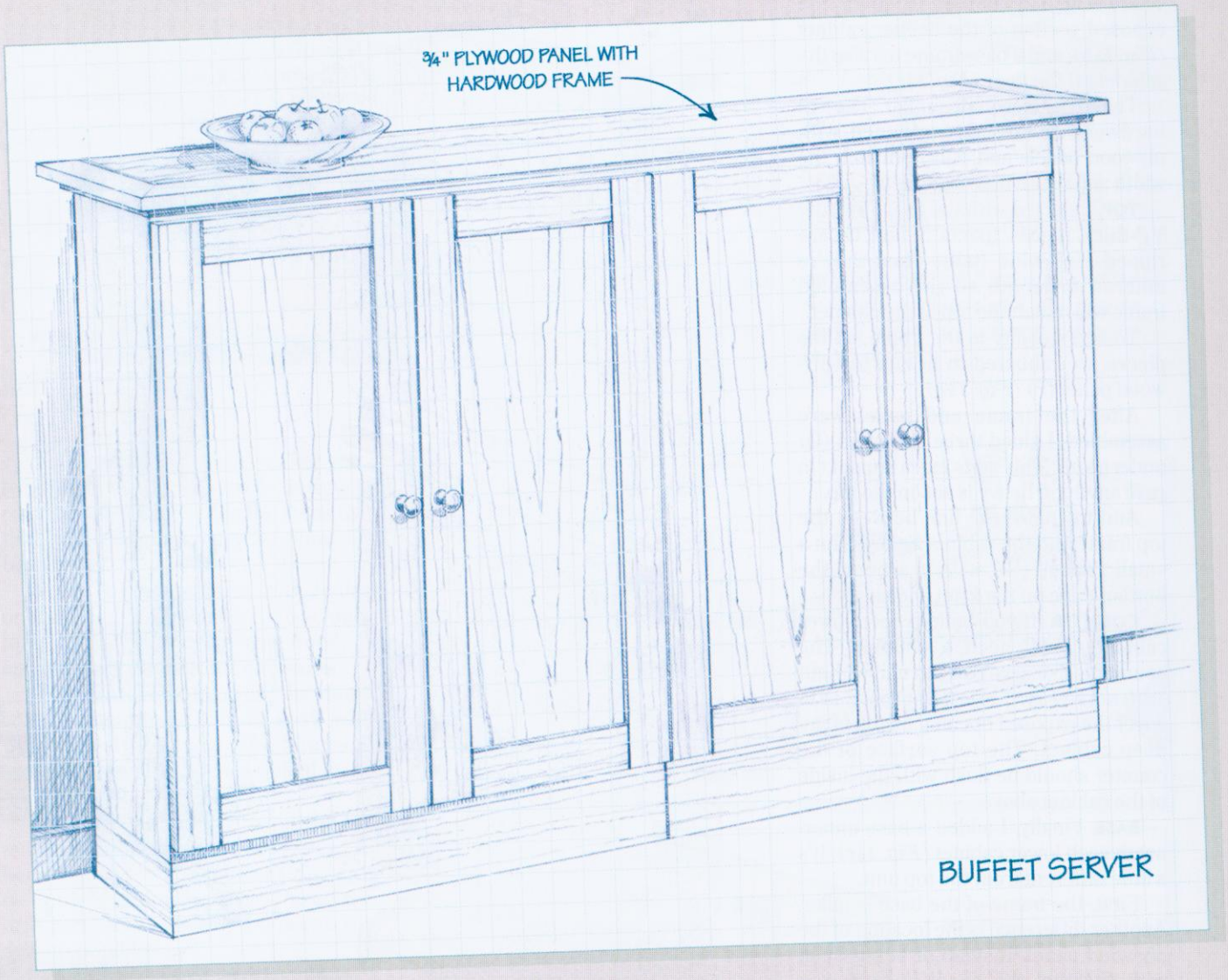
The cleats are screwed beneath the top frame and each of the cabinets *(Figs. 14a and c)*. Then the cleats fit into the cabinet (or base) below.

Also glue two small cleats (CC) underneath the counter *(Fig. 14b)*. ■



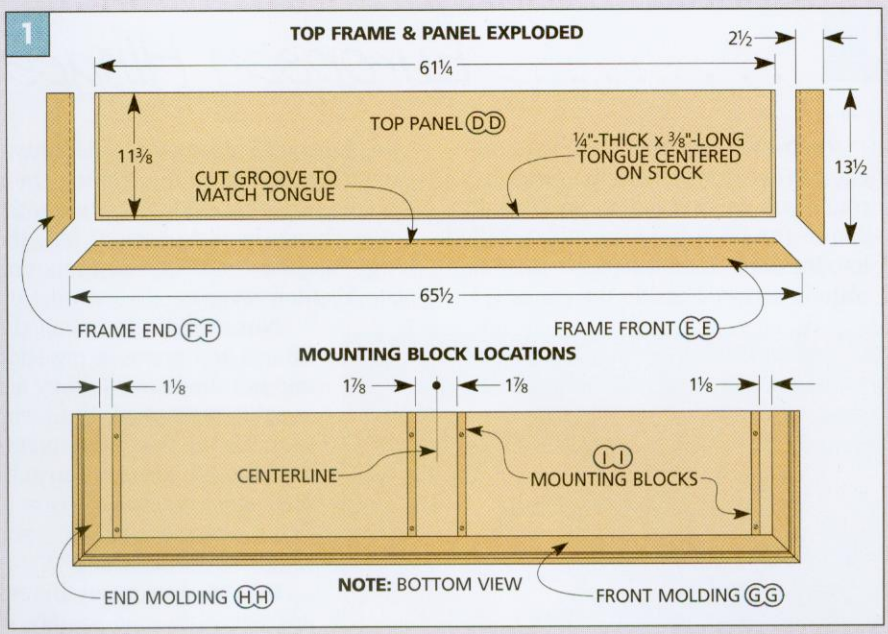
DESIGNER'S NOTEBOOK

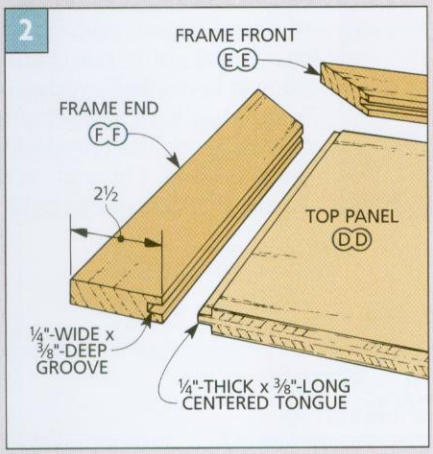
It's easy to make a Buffet Server from the basic design by simply connecting two of the standard lower Modular Cabinets and adding a hardwood frame and plywood panel top.

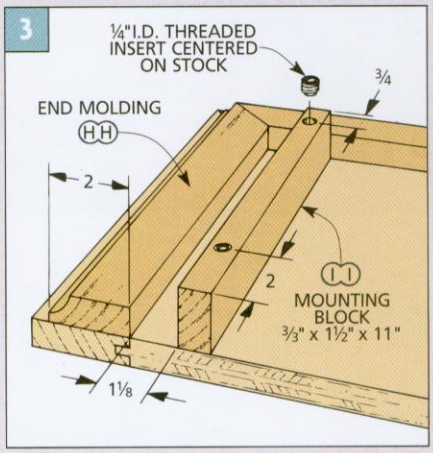


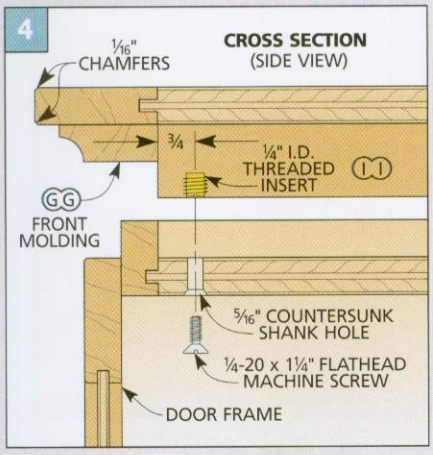
CONSTRUCTION NOTES:

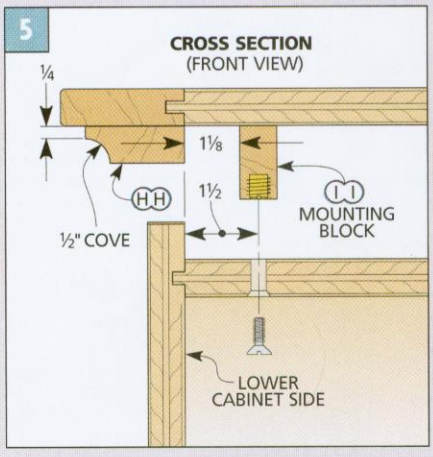
- Start by connecting two standard modular cabinets and bases side-by-side. They can be screwed together or attached with connector bolts (see box on the opposite page).
- To determine the width to cut a ¾" plywood top panel (DD), measure the distance from the back of a cabinet to the *inside* of the top facing (C) and add ⅜". My panel was 11⅜" wide *(Fig. 1)*.
- To determine the length of the panel, measure the *inside* distance between the two outside side panels (A) and add ¾". My panel was 61¼" long *(Fig. 1)*.
- Rout ⅜" rabbets on the ends and front edge of the panel to produce a ¼"-thick centered tongue *(Fig. 2)*.
- Cut frame pieces from ¾" stock to 2½" wide and to rough lengths of 67" (for EE) and 15" (for FF) *(Fig. 1)*.
- Cut a groove on the inside edge of each frame piece to match the tongue on the panel *(Fig. 2)*. Position the groove so the top of the frame and panel are flush.
- Miter the ends of the frame pieces to fit around the ends and front of the plywood panel *(Fig. 1)*.
- Glue together the frame and panel.
- Rout a 1/16" chamfer on the top and bottom edges of the frame *(Fig. 4)*.
- Cut a 2"-wide molding strip from ¾"-thick stock to rough lengths (GG, HH). These strips fit under the frame *(Fig. 3)*.
- Rout a ½" cove on the outside bottom edge of the molding strip (refer to *Fig. 5*).
- Miter the molding strips to final lengths. Then glue each strip in place, aligning it











with the glue line between the panel and the frame *(Fig. 3)*.

- Cut four mounting blocks (II) to size from ¾"-thick stock *(Fig. 3)*.
- Install threaded inserts in the bottom edge of the mounting blocks *(Fig. 3)*.
- Glue the mounting blocks to the underside of the frame and panel, positioned as shown in *Figs. 1 & 3*.
- Drill countersunk holes through the underside of the cabinet tops to align with the threaded inserts *(Figs. 4 & 5)*.
- Position the top on the cabinets and secure with machine screws *(Figs. 4 & 5)*.

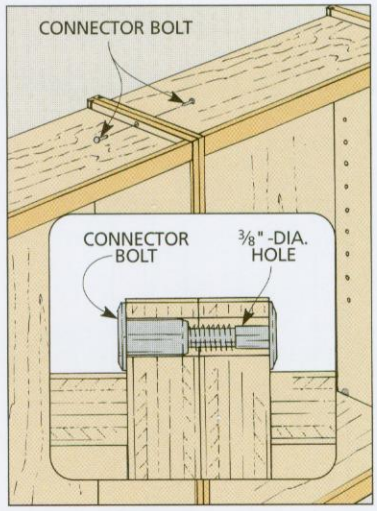
CONNECTING THE CABINETS

Each Modular Cabinet is built separately, but they can also be lined up side-by-side (see the photo on page 94 and the drawing on the opposite page).

The cabinets can be screwed together, but I used connector bolts. These bolts make it easy to disassemble the two cabinets, and they are more forgiving when aligning the cabinets.

A connector bolt consists of a bolt and a threaded cap nut. I fit them in holes drilled through the lips that run around the top and bottom of each cabinet (see drawing below).

Since the hole in the cabinet is a little larger than the bolt, the two cabinets can be adjusted to align across the front and top. Once they align, the bolts and caps are tightened with Allen wrenches.



CHANGES TO MATERIALS

BUFFET SERVER:

DD	Top Panel (1)	¾ ply - 11⅜ x 61¼
EE	Frame Front (1)	¾ x 2½ - 65½
FF	Frame Ends (1)	¾ x 2½ - 13½
GG	Front Molding (1)	¾ x 2 - 64½
HH	End Moldings (2)	¾ x 2 - 13
II	Mounting Blks. (4)	¾ x 1½ - 11

HARDWARE:

(4) Connector bolts with cap nuts
(8) ¼"I.D.(inside dia.) threaded inserts
(8) ¼–20 x 1¼" machine screws

HARDWARE . . . . . European Hinges

What's the most difficult part of mounting doors on a cabinet? I think it's getting the hinges positioned correctly. If you're even a *little* off, the door will fit crooked on the cabinet.

The beauty of European-style hinges like those used on the Modular Cabinets shown on page 94 is that they're easy to mount and adjust. If the doors are even slightly crooked or out of alignment with each other, you can easily adjust the hinges to get everything lined up perfectly.

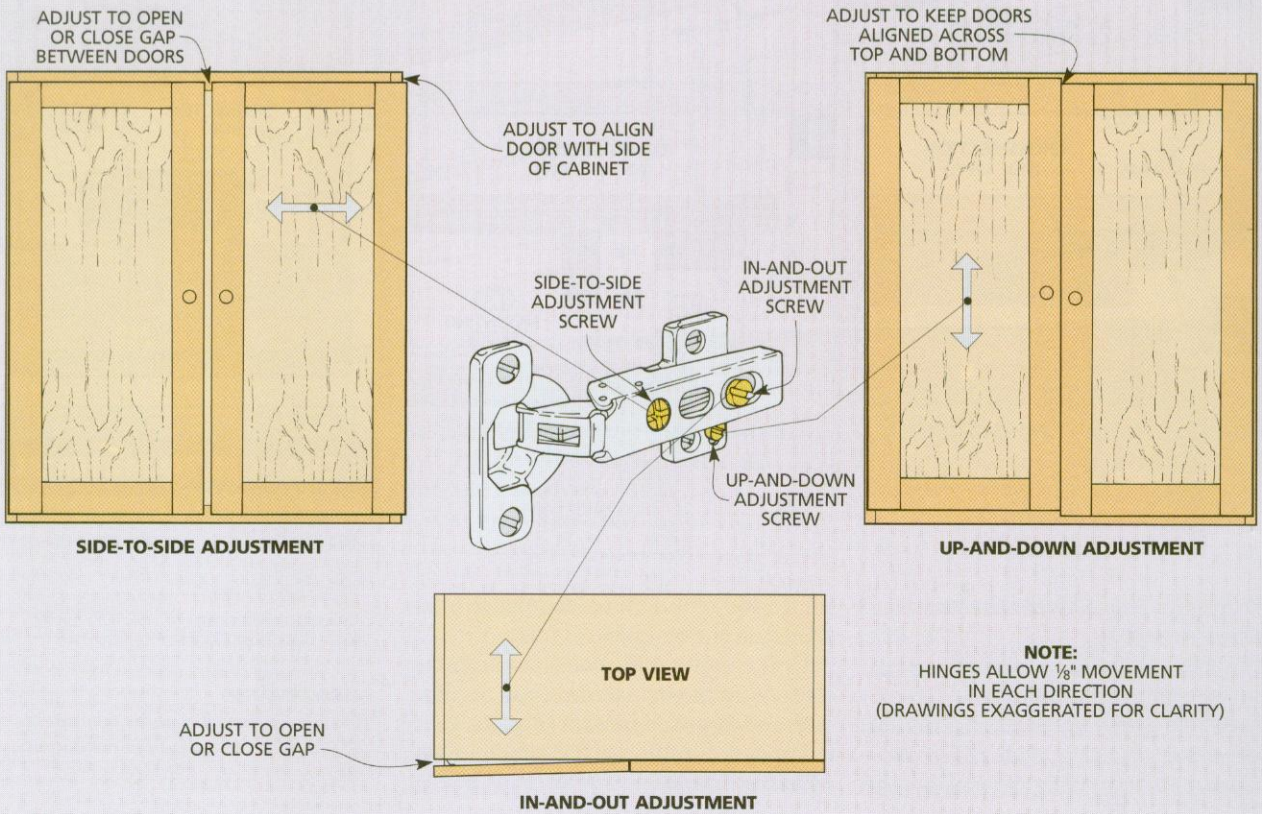
Adjustment is just a matter of loosening an adjustment screw, repositioning the door, and then retightening the screw (see below). The door can be adjusted up to 1/8" in three ways — side-to-side, in-and-out, or up-and-down. (I've noticed that most people will see an up-and-down misalignment first so pay special attention to that.)

TWO-PART HINGES. These hinges come in two parts. The actual hinge has a round cup on the bottom that fits into a 35mm (or 1 3/8") hole (mortise) drilled into the door. Then a separate mounting plate is screwed inside the cabinet. On some European hinges you slide the two parts together and then tighten them with the turn of a locking screw. On the hinge shown in the photo at left, the hinge snaps on and off the mounting plate. You don't even need a screwdriver.

Note: I like to install the hinges and plates in my shop and get the doors so they are roughly positioned. But I wait to make the final adjustments until the cabinet is set up in its final position. Then it's easy to line everything up and retighten the screws.

STYLES. European hinges are available in a variety of styles depending on the design of your door and cabinet. You can find them in full overlay (shown here), half overlay, or inset. Most have a self-closing feature so you don't need additional catches. For sources of European hinges, see page 126.

ADJUSTING EUROPEAN HINGES



INSTALLING EUROPEAN HINGES

When it came time to install the European hinges on the modular cabinets, I found it easiest and most accurate to make a simple jig (see drawing at right).

MAKING THE JIG. The jig is built in a giant "I" shape. I cut the center (vertical) piece from some scrap 3/4" stock. The length matches the height of the doors.

Next I screwed on a pair of horizontal "wings" made from 1/4" hardboard. The bottom edge of the top wing and the top edge of the bottom wing indicates the centerline of the hinges and plates. For the Modular Cabinet, this measurement is 4" from the top and bottom of the door.

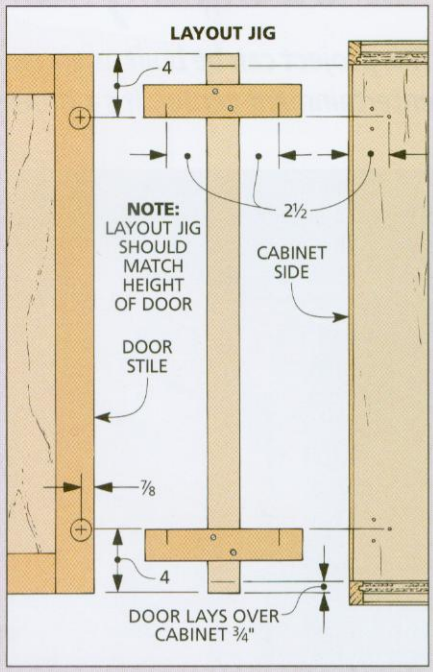
Once the jig was screwed together I added a few reference lines. First add a couple of lines to the center piece 3/4" from the top and bottom ends. These will indicate the *inside* (top and bottom) of the cabinet (refer to *Step 3* below).

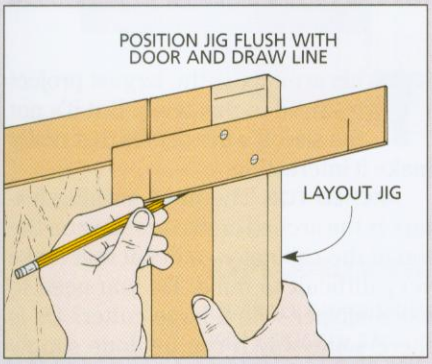
Then I added reference lines on the wings 2 1/2" from the center piece. These indicate the back screw location of the mounting plate on my hinges. By marking both sides of the wings, you can use the jig for the left or right side of the cabinet.

Note: The locations of the mounting plate screws and location and depth of the hinge mortises can vary from one European-style hinge to another. This depends on the manufacturer and the specific design of the hinge. These measurements should come with the hinges you purchase.

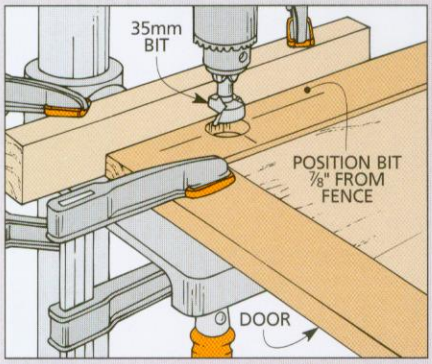
USING THE JIG. Once the jig is complete, you can use it to lay out the location of the mortises on the stiles *(Step 1)*. Then the 35mm (or 1 3/8") mortises can be drilled on the drill press *(Step 2)*.

Now use the jig to mark the location of the mounting plate *(Step 3)*. Finally install the mounting plate *(Step 4)* and the hinge *(Step 5)*. Then snap the hinge and the plate together and add the last two screws *(Step 6)*.

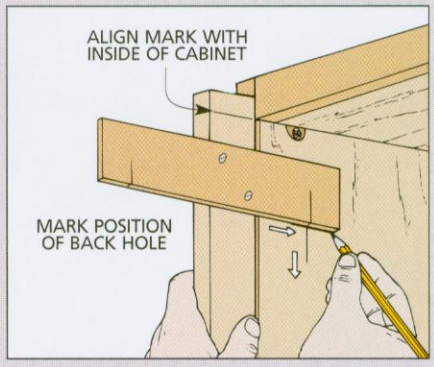




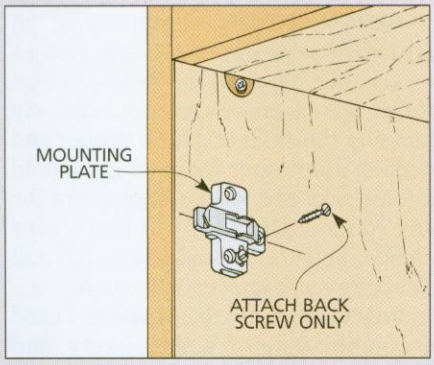
1 *Hold the layout jig so the top and bottom ends align with the top and bottom of the door. Then mark a centerline for the hinges on the door stile.*



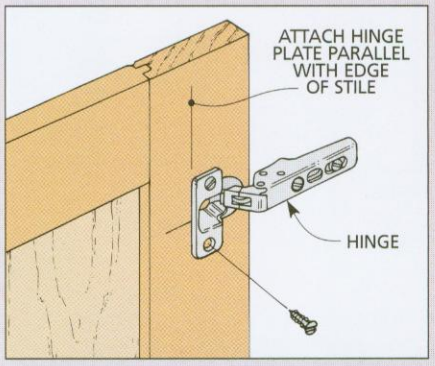
2 *Clamp a fence to the drill press table 7/8" from the center of the bit. Then drill a 1/2"-deep hole. (Note: These measurements may vary; see note in text.)*



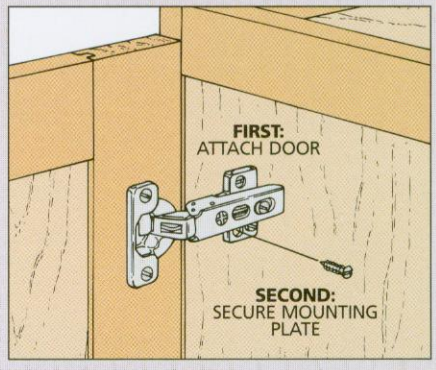
3 *Hold layout jig in the same position as the final position of the door. Then mark centerlines for the back screw of the mounting plates (inside the cabinet).*



4 *Now screw the mounting plate to the inside of the cabinet with the back screw only. (The other screws will be added later.)*



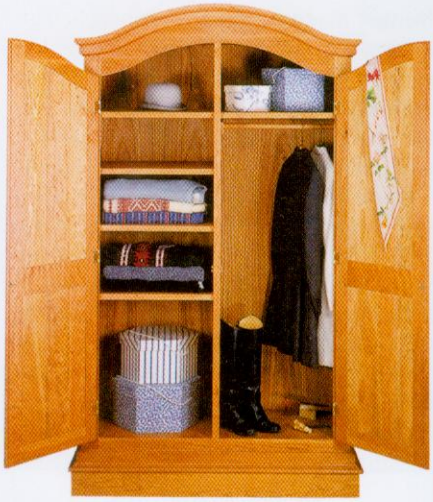
5 *Position the hinge in the round mortise drilled in the door stile so the plate is parallel with the edge. Then screw it in place with two screws.*



6 *Now snap the hinges and mounting plates together. Finally, add the last two screws in the plate and adjust the doors as explained on the opposite page.*

Cherry Armoire

This project can be built as either a traditional armoire for clothes and accessories or a modern entertainment center. It's a timeless piece that's sure to become an heirloom.



This armoire is the largest project featured in this book. But it's not the size, it's the details that really make it interesting.

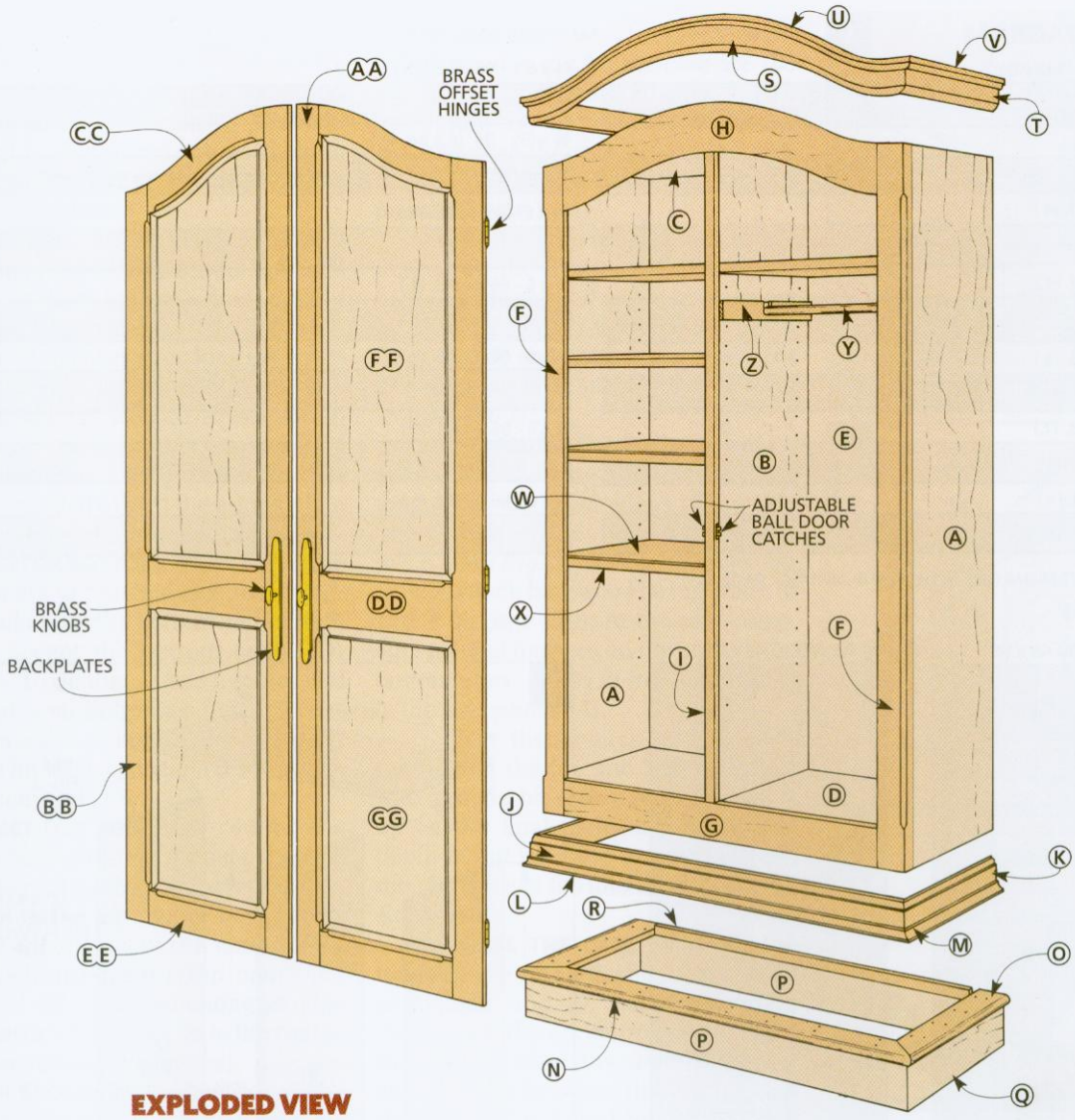
ARCHED TOP. The most striking feature is the arched crown molding on the top of the cabinet — a detail that looks very difficult to build. Do you need to use a shaper with a huge cutter? Or is there some way it can be done simply with a router?

Actually it's easier than it looks. It's done by building up and shaping pieces of $\frac{3}{4}$"-thick stock with the help of a template, a router, and two common bits.

DESIGN OPTION. Traditionally, an armoire was designed to store clothes — sort of a closet in the bedroom. But we've added an interesting twist. By building the cabinet a little deeper and making a few other changes, it can hold a television and stereo equipment for any room in the house. If that's your choice, be sure to read pages 120 and 121 before you start construction.

WOOD. To build the armoire, I used a combination of solid cherry and cherry plywood.

FINISH. I finished the armoire with three coats of tung oil, hand-rubbing it in to bring out the beauty of the cherry.



EXPLODED VIEW

OVERALL DIMENSIONS:
84H x 51½W x 22D

MATERIALS LIST

CASE

A	Sides (2)	¾ ply - 19½ x 73
B	Divider (1)	¾ ply - 19¼ x 67¾
C	Top (1)	¾ ply - 19 x 46½
D	Bottom (1)	¾ ply - 19¼ x 46½
E	Back (1)	¼ ply - 47 x 73
F	Stiles (2)	¾ x 3 - 74 rough
G	Bottom Rail (1)	¾ x 4½ - 41½
H	Arched Top Rail (1)*	¾ x 13½ rough- 41½
I	Divider Cap (1)	¾ x 1¼ - 69 rough
J	Ogee Frt. Mld. (1)	¾ x 2⅝ - 49
K	Ogee Side Mld. (2)	¾ x 2⅝ - 20¾
L	Cove Frt. Mld. (1)	⅝ x ⅝ - 50¼
M	Cove Side Mld. (2)	⅝ x ⅝ - 21⅜

* Parts H, S, U, FF, and GG are made from edge-glued blanks.

BASE

N	Bullnose Front (1)	¾ x 2¾ - 51½
O	Bullnose Sides (2)	¾ x 2¾ - 22
P	Kickbd. Fr./Bk. (2)	¾ x 4¼ - 50½
Q	Kickbd. Sides (2)	¾ x 4¼ - 21½
R	Back Filler Strip (1)	¾ x 1¼ - 46

CROWN MOLDING

S	Base (Front) (1)*	¾ x 3¼ - 51½ rough
T	Base (Sides) (2)	¾ x 3¼ - 22 rough
U	Trim (Front) (1)*	¾ x 1¼ - 51½ rough
V	Trim (Sides) (2)	¾ x 1¼ - 22 rough

SHELVES AND ROD

W	Shelves (7)	¾ ply - 18½ x 22½
X	Shelf Edging (7)	¾ x 1 - 22½
Y	Clothes Rod (1)	1" dowel x 22⅛
Z	Rod Supports (2)	¾ x 2 - 19

DOORS

AA	Inside Stiles (2)	¾ x 3 - 69 rough
BB	Outside Stiles (2)	¾ x 3 - 64 rough
CC	Top (Arch) Rails (2)	¾ x 3 - 14⅝
DD	Middle Rails (2)	¾ x 4½ - 14⅝
EE	Bottom Rails (2)	¾ x 3 - 14⅝
FF	Top Panels (2)*	¾ x 15¼ - 36 rough
GG	Bottom Panels (2)*	¾ x 15¼ - 24⅜

HARDWARE SUPPLIES

(55) No. 6 x ⅝" Fh woodscrews
(22) No. 8 x 1¼" Fh woodscrews
(38) No. 8 x 1½" Fh woodscrews
(3 pr.) ⅜" brass offset hinges
(2) Brass knobs with brass backplates
(2) Brass adj. ball door catches w/strikes
(28) Pin-type shelf supports
(4) ¼"-dia. dowel pins, ¾" long

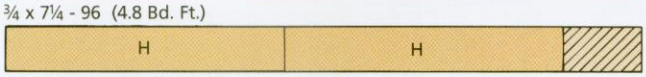
CUTTING DIAGRAM

¾ x 7½ - 96 (5 Bd. Ft.)

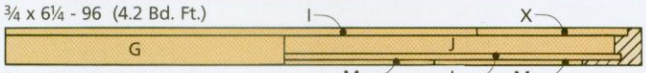
¾ x 6 - 96 (4 Bd. Ft.)

¾ x 6½ - 96 (4.3 Bd. Ft.)

¾ x 7¼ - 96 (4.8 Bd. Ft.)



¾ x 6¼ - 96 (4.2 Bd. Ft.)



¾ x 6½ - 96 (4.3 Bd. Ft.)

¾x 6½ - 96 (4.3 Bd. Ft.)

¾ x 6½ - 96 (4.3 Bd. Ft.)

¾ x 6½ - 96 (4.3 Bd. Ft.)

¾ x 6 - 96 (4 Bd. Ft.)

¾ x 6 - 96 (4 Bd. Ft.)

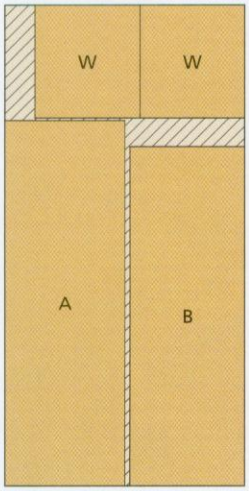
¾ x 6 - 96 (4 Bd. Ft.)

¾ x 6 - 96 (4 Bd. Ft.)

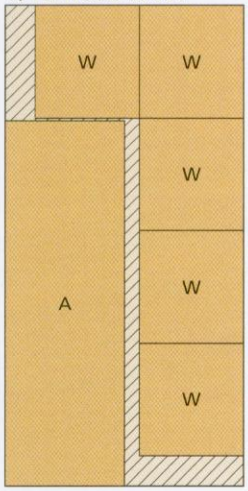
¾ x 6 - 96 (4 Bd. Ft.)

*PARTS S, U ARE CUT FROM ONE GLUED-UP BLANK (SEE PAGE 113)

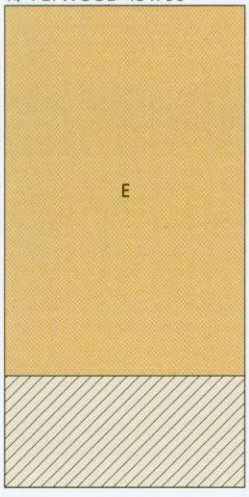
¾" PLYWOOD 48 x 96



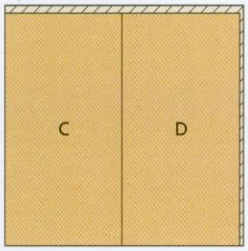
¾" PLYWOOD 48 x 96

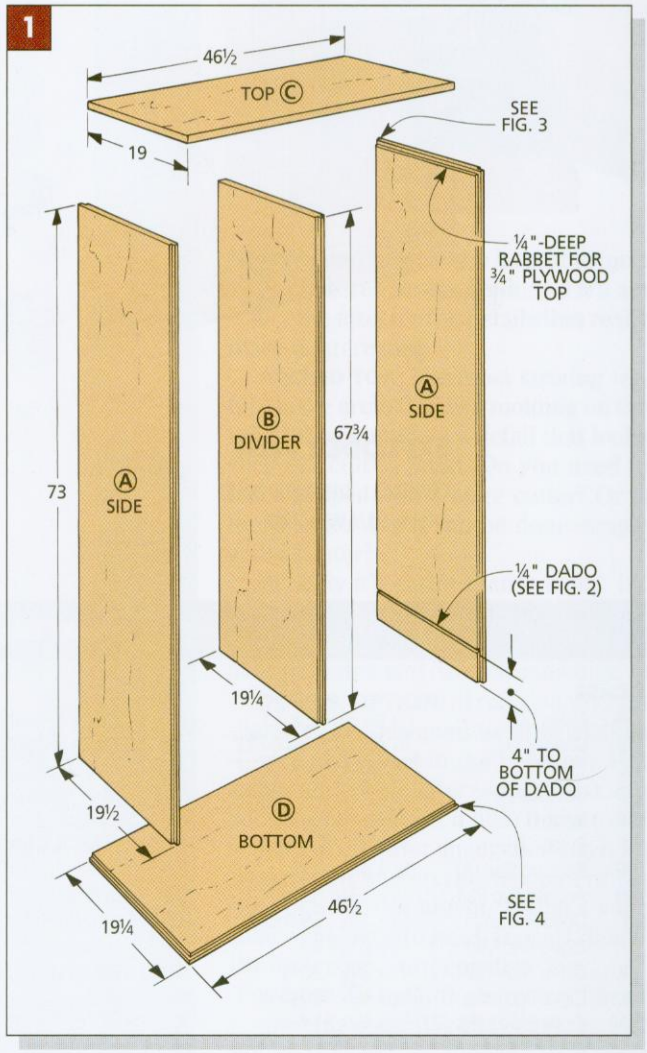


¼" PLYWOOD 48 x 96



¾" PLYWOOD 48 x 48





CASE

I began building the armoire by cutting the parts for the case from 3/4" plywood. Plywood is stable and not as likely to warp as solid stock, so it's a good choice for the large pieces.

SIDES. I started by making the two side panels (A) (*Fig. 1* on the opposite page). Cut them both to a final width of 19 1/2" and length of 73".

Note: If you plan on making the entertainment center, the side panels will have to be cut wider to accept a TV set, and an extra dado cut in each one to accept a shelf. For more information on the changes needed to turn the armoire into an entertainment center, see page 120.

DADO FOR BOTTOM. After cutting the side panels to finished size, cut a 1/4"-deep dado near the bottom end of each one to accept the bottom panel (D) *(Fig. 2)*. To do this, I used a router and clamped a straightedge fence across the plywood. Locate the fence so a 1/4" straight bit will be positioned 4" up from the bottom end *(Fig. 1)*.

RABBET FOR TOP. After routing the dado in both of the side panels, the next step is to rout a rabbet 1/4" deep and 3/4" wide along the top end of both panels (on the same face as the dado). This rabbet will accept the top panel (C) *(Fig. 3)*. I did this by mounting an edge guide and a 1/2" straight bit in the router, and then making two passes.

ROUT BACK RABBET. After the rabbets are routed for the top, there is still one more rabbet needed on each side panel. This one is a 1/4" x 1/2" rabbet on the *back* edge to attach the case back *(Fig. 3)*.

Note: Mark these back rabbets on both the right and left panels *before* you start routing so you will end up with a mirrored set of side panels.

DIVIDER. Once the rabbets are routed for the case back, cut a divider (B) from 3/4" plywood *(Fig. 1)*. Since the cabinet back fits behind it, cut the divider 1/4" less in width than the side pieces. (This meant I cut my divider 19 1/4" wide.)

The divider is screwed in place between the top piece (C) and the bottom piece (D). So, to determine the length of the divider, measure the distance between the dado and the rabbet on the side pieces (68"), and then subtract 1/4". This will leave room for the tongue that will be cut on the ends of the bottom piece. (In my case, I cut the divider 67 3/4" long.)

TOP AND BOTTOM. The last pieces of 3/4" plywood to cut for the case are the top (C) and bottom (D) *(Fig. 1)*. To determine the width of the top piece (C), measure the side panels and subtract 1/2". (In my case this made the top piece 19" wide.)

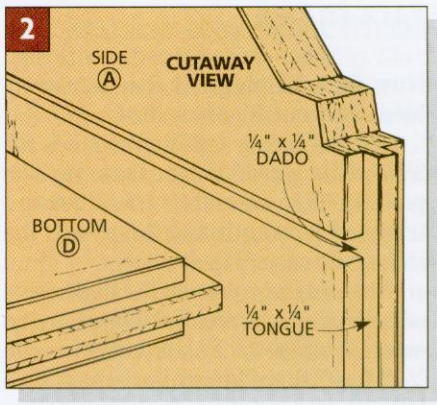
The bottom piece (D) has a 1/4" tongue on the front edge to accept a hardwood facing rail added later, so cut it 1/4" wider (19 1/4") than the top piece. After the top and bottom pieces are cut to width, cut both pieces to a uniform length of 46 1/2".

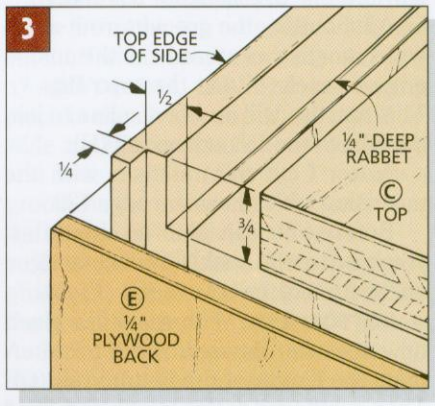
CUT TONGUES. The final step before assembling the case is to cut 1/4"-thick tongues on the front edges of the side panels (A), divider (B), and bottom piece (D) *(Fig. 4)*. These tongues are used to attach hardwood facing (refer to *Fig. 6* on page 110). At the same time, cut identical tongues on the ends of the bottom piece (D) to fit into the dadoes in the side panels (A).

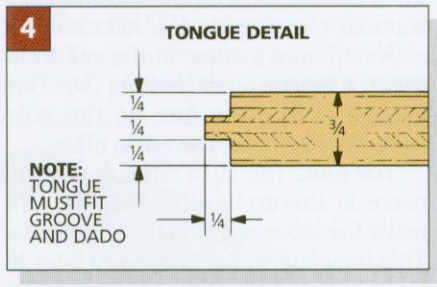
To make the tongues, rout 1/4"-wide rabbets on the top and bottom edges with a router bit and edge guide. Sneak up on the final fit by increasing the depth of cut until the tongue between the rabbets just fits into the dado in the side panel.

ASSEMBLE THE CASE. After all the tongues are formed, the case can be assembled *(Fig. 5)*. Start by standing the divider (B) on its front edge (with the tongue facing down) and screwing and gluing it between the top (C) and the bottom (D). I used No. 8 x 1 1/2" flathead woodscrews.

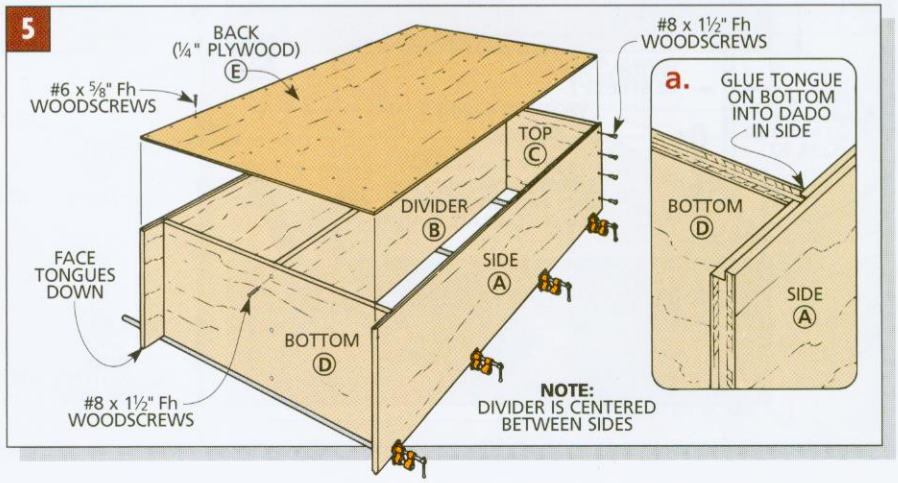
Next, add the side panels (A). Glue the tongue on the bottom into the dado in each side *(Fig. 5a)*. Then screw the side panels into the top (C). (These screws will be covered later by a molding strip.)







BACK PANEL. To square up the case, I cut a plywood back (E) from 1/4" cherry plywood. It fits between the rabbets and flush with the top and bottom ends of the side panels *(Fig. 3)*. Then screw the back panel to the case with No. 6 x 5/8" flathead wood screws *(Fig. 5)*.



FACE FRAME

Now that the plywood case is assembled, the front edges can be faced.

STILES. Start by cutting two stiles (F) $3\frac{1}{16}$" wide and 1" longer than the side pieces. After assembly, the stiles are trimmed to length and flush with the side of the case *(Fig. 8a)*.

Next, cut a groove on the inside face of each stile to fit over the tongue on the side (A) *(Fig. 7)*. Position the tongue $\frac{5}{16}$" from the edge of the stile. (This leaves a $\frac{1}{16}$" overhang for trimming.)

After cutting the grooves, rout a $\frac{1}{4}$"-wide mortise centered on the inside edge of each stile at the top *(Fig. 8)*. This mortise will accept a spline to join the stile to the arched top rail (H).

Note: I cut the mortises with the mortising table shown on page 123.

Before you can glue on the stiles, you have to trim back $2\frac{1}{4}$" of the tongue on the front of the bottom (D) *(Fig. 6)*.

BOTTOM RAIL. With the stiles glued on, measure between them to determine the length of the bottom rail (G). Then cut the rail to this length and $4\frac{9}{16}$" wide. (It's trimmed to $4\frac{1}{2}$" later.)

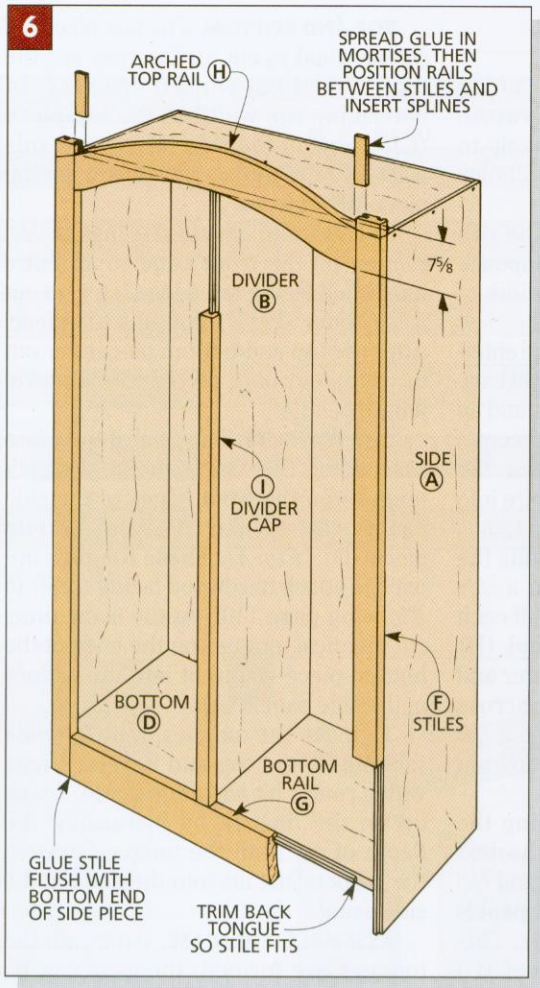
Next, cut a groove in the rail to fit over the tongue on the bottom (D). This groove is like the one on the stile *(Fig. 7)*. Then glue the rail in place.

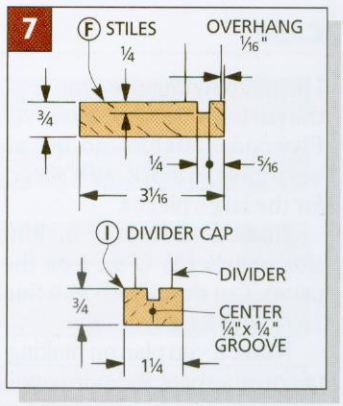
TOP RAIL. The most difficult piece to make is the arched top rail (H). To make the job easier, I made a template. This template will also be used later to make the moldings that are glued on top of the rail.

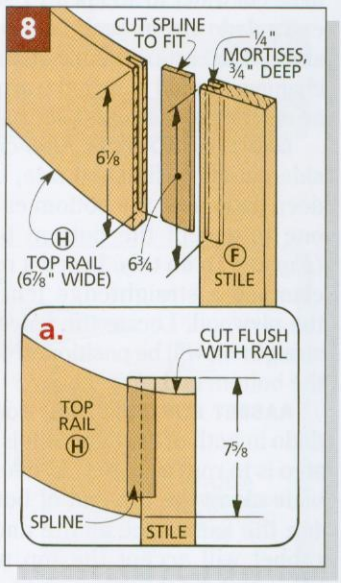
TEMPLATE. I made the template out of $\frac{1}{4}$"-thick hardboard. Begin by cutting the hardboard $13\frac{1}{2}$" wide and $51\frac{1}{2}$" long *(Step 1 in Fig. 9)*. This makes the template long enough to use on both molding pieces (S, U) as well as the top rail (H).

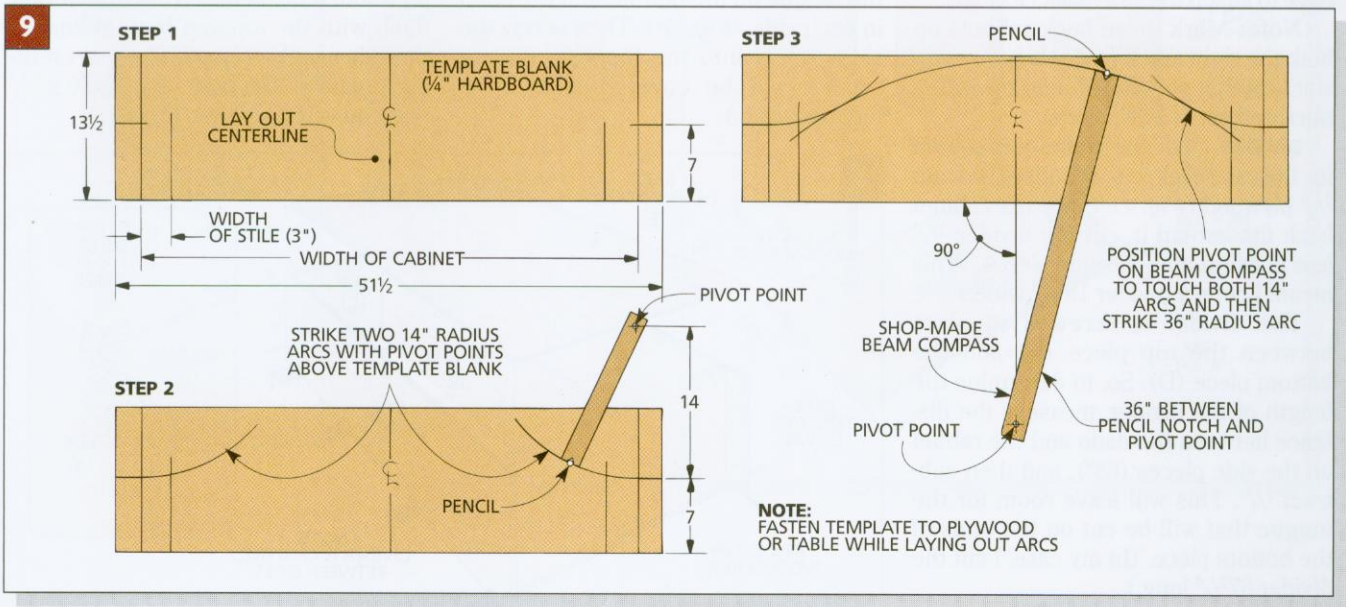
By laying out reference lines on the template with measurements taken from the cabinet, the template becomes a "story stick."

First mark a centerline on the length of the template blank *(Step 1)*. Then









mark vertical reference lines at both ends to indicate the width of the cabinet (47½" in my case).

Next, mark a second set of vertical lines to indicate the door openings. To determine this measurement, I measured in from the first set of lines the final width of the stiles (3").

Finally, mark horizontal lines at both ends 7" up from the bottom.

Now the arched curve can be laid out by drawing three arcs using shop-built beam compasses (refer to the Shop Tip on page 26).

First, two small arcs are laid out from above the left and right corners of the template *(Step 2)*. Then a large connecting arc is laid out from below the bottom edge of the template *(Step 3)*.

Next, cut the arched top of the template a little oversize with a sabre saw or band saw and sand right up to the line.

MAKE RAIL BLANK. Now you can use the template to make the top rail (H). Begin by gluing up a 13½"-wide blank from ¾" stock to fit between the cabinet stiles (41½" long in my case) *(Fig. 10)*. Then mark a centerline on the blank.

CUT OUT ARCH. After the centerline is marked, lay the template on top of the blank and align the bottom edges and centerlines *(Fig. 10)*. Then draw the outline of the arch on the blank.

Next remove the template and cut out the shape, staying about ⅛" outside the pencil line *(Fig. 10a)*.

FLUSH TRIM SMOOTH. Now, here's the trick for making the top rail the exact same shape as the template.

First, screw the template to the blank, aligning the bottom edges and centerlines *(Fig. 11)*. The screw holes will be covered later by moldings if you position them 1¾" down from the arched edge *(Fig. 11a)*.

Next, turn the blank and template upside down and clamp them down to your bench *(Fig. 12)*. Then mount a flush trim bit in your router and lower the bit so the bearing rides against the template *(Fig. 12a)*.

Now, when you run the bearing along the template, the bit will trim the edge the same shape as the template.

CUT OFF BOTTOM. With the top edge cut, the bottom edge of the rail can be cut parallel to the top. (Even though the edges are parallel, the radius for the bottom edge is different from the top, so you *can't* use the same template.)

To mark the bottom edge, I used a scribing stick. This scribing stick is just an 8"-long piece of hardboard with two nails driven through at one end *(Fig. 13a)*.

Now, with both nails riding along the top of the arch, scribe the bottom edge on the blank *(Fig. 13)*. Then cut it slightly oversize and sand up to the line.

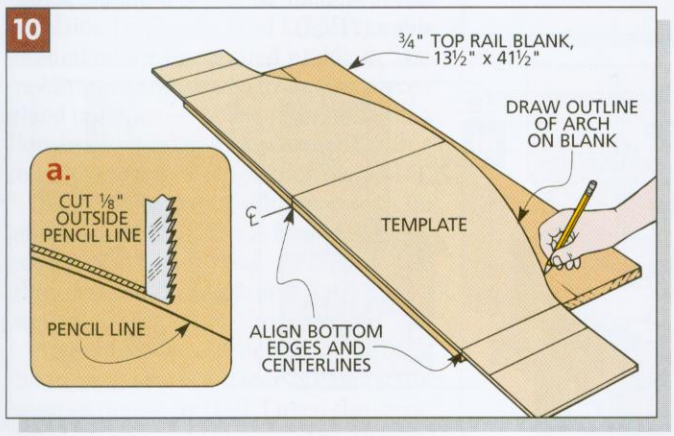
ROUT MORTISES. After the rail was cut to shape, I routed mortises on both ends to match the ones in the stiles *(Fig. 8)*. Then brush glue into all the mortises and fit the top rail between the stiles. Finally, slide splines into the mortises from the open top end *(Fig. 6)*.

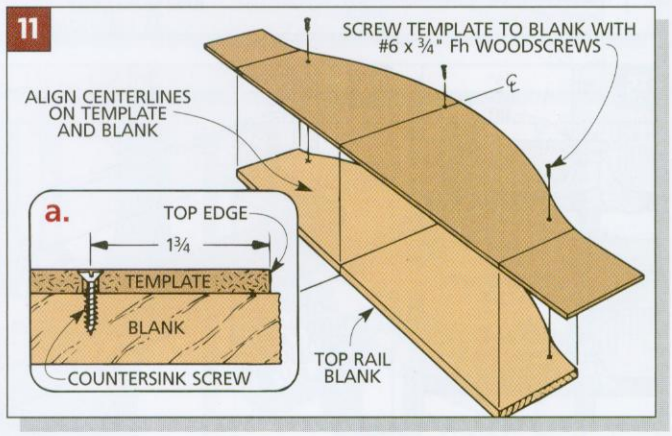
Once the glue dries, extend the curve from the top onto the stiles, and cut it off with a sabre saw *(Fig. 8a)*.

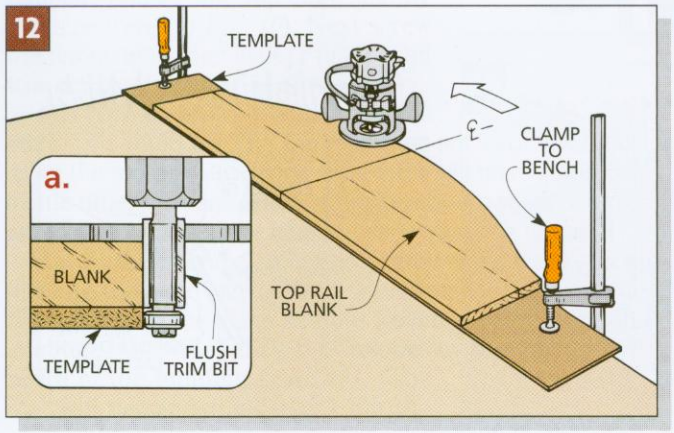
ADD DIVIDER CAP. The last facing piece is the divider cap (I). It's cut 1¼" wide and to length to fit between the top and bottom rails *(Fig. 6)*. Then cut a groove on the inside of the cap to fit over the tongue on the divider *(Fig. 7)*.

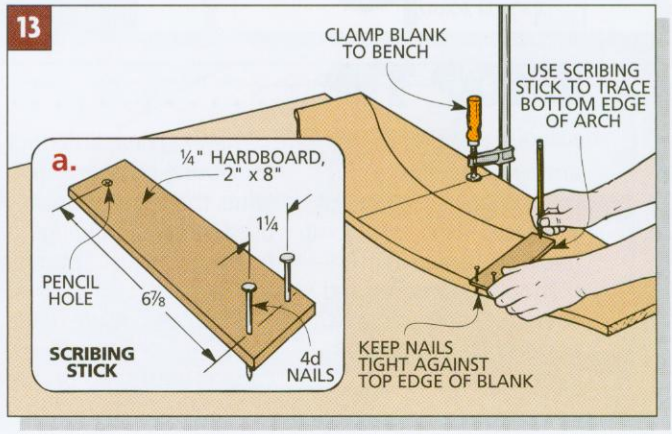
TRIM FACING FLUSH. After the cap is glued on, you can trim the stiles (F) flush with the outside of the side pieces. And trim the bottom rail (G) flush with the top of the bottom piece. To do this I used a router and flush trim bit.

Note: On the top of the bottom rail, the bit won't cut square into the inside corners. I cleaned these up with a chisel.









BASE

After adding the face frame to the case, I began work on the base. The base is a bullnose frame glued on top of a kickboard frame *(Fig. 14)*.

TOP FRAME. To make the bullnose frame, rip a front (N) and two sides (O) to a final width of 2¾" *(Fig. 14)*. Then rough cut the front 53" long and the sides 23" long.

Before cutting the pieces to final length, use the router table to rout a bullnose edge on the pieces. First, rout a ½" roundover on the top edge *(Step 1 in Fig. 15)*. Then, rout a ¼" roundover on the bottom edge *(Step 2)*.

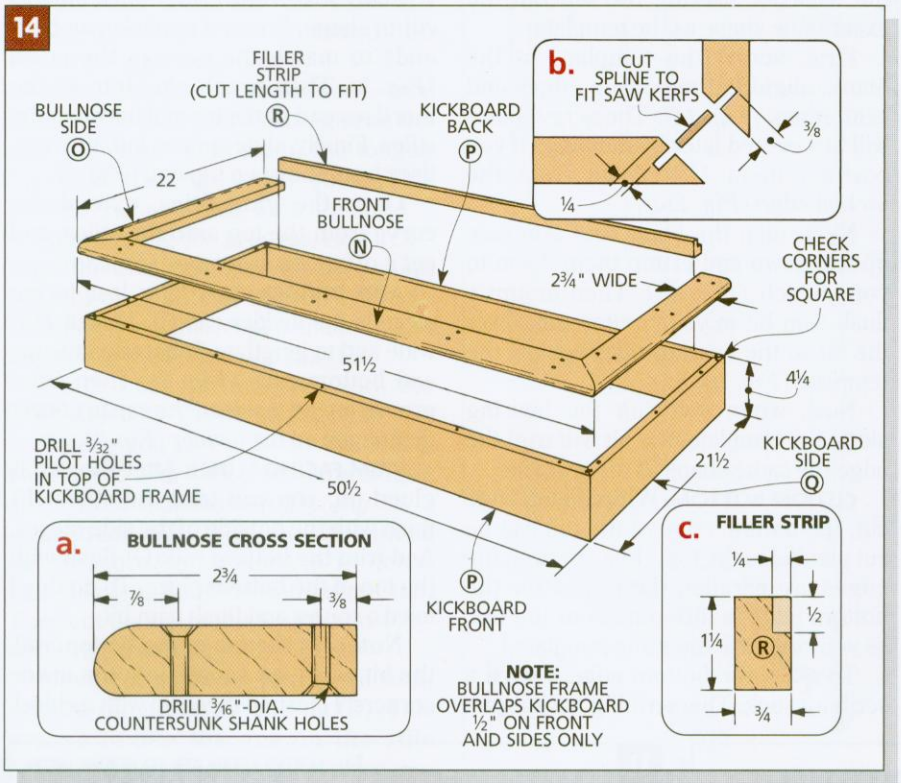
After the pieces are routed, miter both ends of the front piece (N) 4" longer (51½") than the width of the plywood case. Then miter the front end of each side piece (O) and cut the back end square so it's 2" longer (22") than the depth of the plywood case.

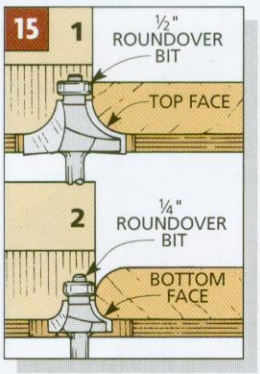
Before gluing the bullnose pieces together, I drilled a series of countersunk screw holes through each of them *(Fig. 14a)*. Flathead screws will be used to mount the bullnose frame down to the kickboard frame and up to the bottom of the plywood cabinet *(Fig. 16a)*.

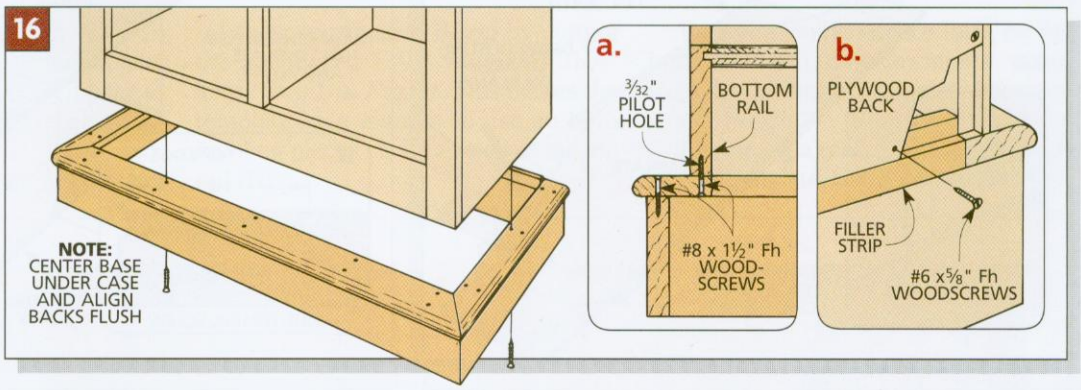
Now glue the miters together to form the three-sided frame. (Just hold the pieces until the glue sets.)

KICKBOARD. The rest of the base consists of a kickboard front, back (both P) and two sides (Q). Rip these pieces to a width (height) of 4¼" *(Fig. 14)*.

Then miter both ends of the kickboard front and back pieces (P) so the length of each is 1" shorter than the bullnose frame (50½"). Next, miter both ends of each side (Q) so the length is ½" shorter than the bullnose frame sides (21½").







SHOP TIP . . . . . Burnishing a Miter

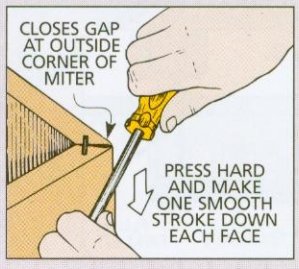
As I was building the armoire, I ran into a problem at one corner of the base — the miter joint had a slight gap in it.

Should I start over and cut new pieces to make it perfect? Or is there an easy way to fix it?

There's a neat little trick for closing outside miter joints that's commonly used on base moldings in houses. You just "burnish" the corners.

When an outside miter has a 1/16" or less gap you can roll both sides of the joint over to fill the gap. To burnish a miter like this I simply use a screwdriver.

Hold the screwdriver at a very slight angle to the workpiece. Then press down hard to bend the fibers slightly as you stroke down the joint.



To help keep the miters aligned, I cut a kerf in each miter *(Fig. 14b)*. Then I cut a spline to fit the kerfs.

Now the kickboard frame can be glued together. (If you have any gaps in your miter joints, see the Shop Tip at the bottom of the opposite page.)

Then glue and screw the bullnose frame to the top of the kickboard frame *(Fig. 14)*.

FILLER STRIP. One final step on the base is to cut a filler strip (R) to fit on top of the kickboard back *(Fig. 14c)*. Before gluing the filler strip in place, cut a $1/4$" x $1/2$" rabbet along the top edge of the strip to accept the $1/4$" plywood cabinet back *(Fig. 16b)*.

BASE TO CASE. After the base is complete, it can be attached to the case *(Fig. 16)*. To do this, I laid the case down on its back.

Now center the base on the case and align it flush across the back *(Fig. 16b)*. Next, drill pilot holes through the shank holes in the bullnose frame and into the bottom of the case *(Fig. 16a)*. Then screw them together and the plywood back to the filler strip *(Fig. 16b)*.

ARCHED MOLDING

On the armoire, the arched top rail (explained on pages 110-111) serves as a foundation for the arched molding. The molding itself is made from two pieces glued together — a base piece (S) with a Roman ogee and a trim piece (U) with a roundover (refer to *Fig. 21* on page 114).

CUT OUT BLANK. Both pieces can be laid out and cut from one large $3/4$"-thick edge-glued blank *(Fig. 17)*. After the glue dries and it's planed flat, draw a vertical centerline on the blank.

TOP EDGE. The process for cutting the top edge of each piece is exactly the same as on the top rail. I used the same template and cut the top edge slightly oversize (refer to *Fig. 10*). Next screw the template to the blank *(Fig. 11)* and trim the piece flush *(Fig. 12)*.

BOTTOM EDGE. To cut the bottom edge, you could use the same process as on the top rail. But I tried something a little different here. Since both pieces are narrower, I used the band saw.

To do this, clamp a pointed guide block to the band saw table so the distance between the blade and the block is about $1/16$" wider than the finished width of the molding *(Fig. 18)*. (The $1/16$" will be sanded off later.) For the base molding (S), clamp the block $3\,5/16$" from the blade.

Now cut the bottom edge of the molding by running the top (routed) edge against the guide block.

SECOND MOLDING. After cutting the base strip (S), you can follow the whole procedure over again for the trim strip (U). When cutting this piece, clamp the guide block $1\,5/16$" from the blade.

SAND TO WIDTH. At this point, each molding piece should be fairly uniform in width, but about $1/16$" oversize and have a rough bottom edge from the band saw cut. I smoothed the bottom edge with a sanding drum on the drill press *(Fig. 19)*.

To do this, clamp a curved (convex) guide block to the drill press table and feed the molding strip between the block and the sanding drum. The convex curve on the guide block should match the concave curve on the top edge of the molding.

Note: For the guide block I used a convex section of the waste left over from cutting the strips from the blank.

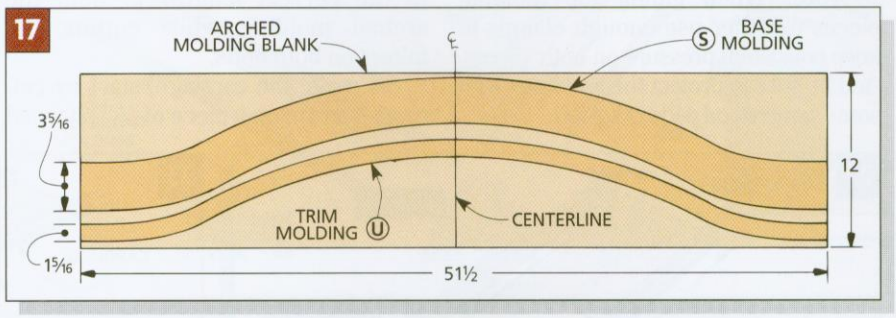
Clamp the block so the sanding drum will sand the molding strip very lightly. Then feed the strip with a steady movement from left to right. (Don't stop or you'll get a divot in the molding.)

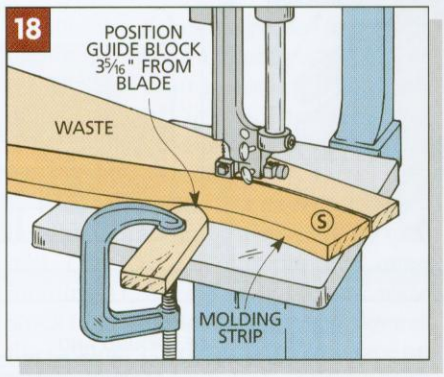
Take a couple of passes at each setting, then move the guide block slightly closer to the sanding drum and repeat the procedure. Once the bottom edge is smooth and the strip is the correct width ($3\,1/4$" or $1\,1/4$"), stop sanding.

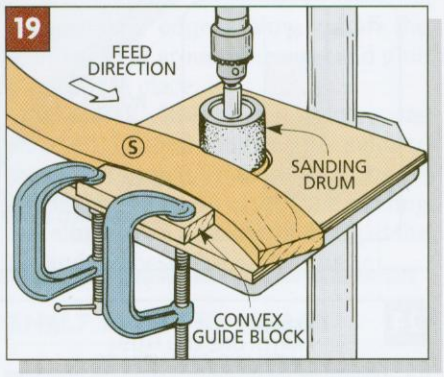
ROUT PROFILES. Before gluing the moldings together, I routed profiles along the bottom edges *(Fig. 20)*.

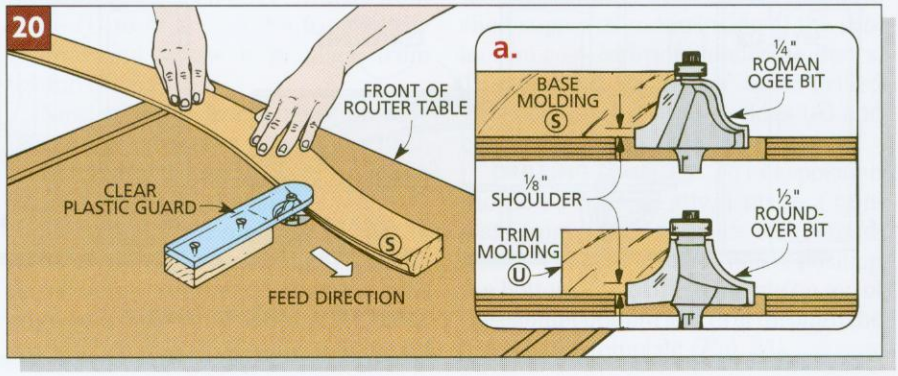
For the base strip (S), I used a Roman ogee bit along the bottom edge. To prevent chipout, rout in a series of passes until there's a $1/8$" shoulder at the bottom of the cut *(Fig. 20a)*.

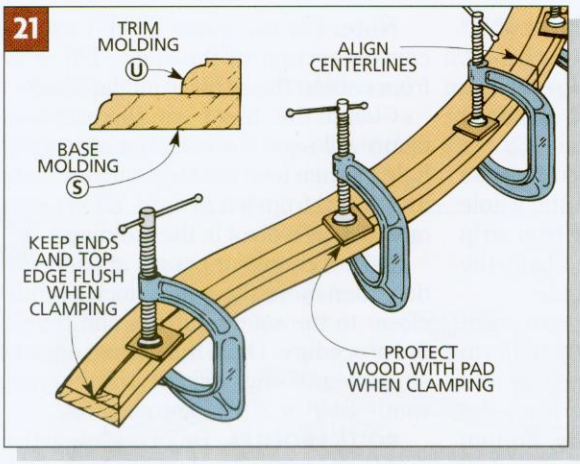
On the trim strip (U), I routed a roundover with a shoulder *(Fig. 20a)*.











GLUE TOGETHER MOLDING. After the profiles are routed on the arched molding pieces, the pieces can be glued together. The trick here is to make sure that the top edges and ends align. I found that the easiest way to do this was to align the centerlines that I had previously marked on both pieces *(Fig. 21)*.

Note: When gluing the molding pieces together use enough clamps to keep consistent pressure on both pieces. And be sure to protect the moldings with some scrap wood pads *(Fig. 21)*.

MITER ENDS. Once you've glued the two arched molding strips together you're faced with another interesting challenge. How do you cut clean, straight miters on the ends of a piece that's 1½" thick, 51½" long, and shaped like a boa constrictor?

And, if that's not enough of a problem, the two miters have to be the correct distance apart or the molding won't fit the cabinet you've already assembled.

MITERING CARRIAGE. To solve all of this, I approached the last problem first. I figured if I could cut miters the correct distance apart on the ends of a *straight* board, I could transfer this measurement to the arched molding. That led to the idea of using a simple carriage (cut to the correct length) to hold the arched molding while cutting the miters on both ends.

To make the carriage, start by cutting a base from a piece of ¼" plywood or hardboard. I cut the base to a width of 11" and 48" long *(Fig. 22)*.

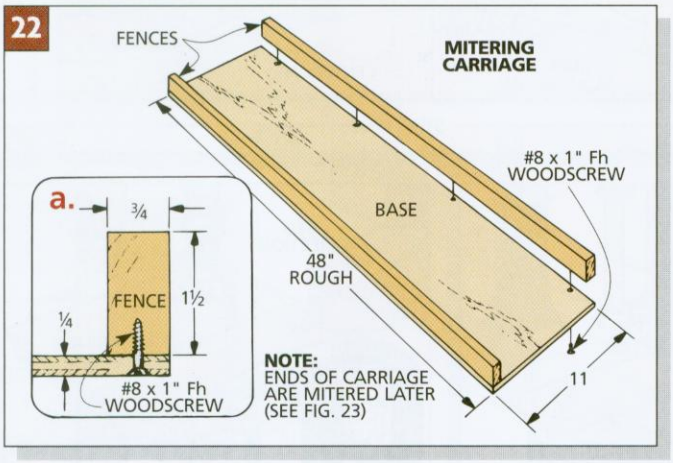
Then screw ¾"-thick fences on top of the base along the front and back edges *(Fig. 22a)*. Keep the screws at least 2" from each end so you won't hit them when cutting the carriage to its final length.

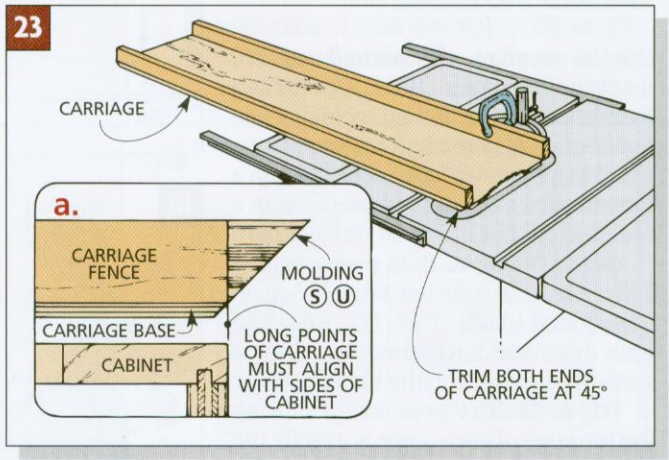
MITER ONE END. Next, clamp your table saw miter gauge to the back fence near one end of the carriage and set the carriage on top of the saw *(Fig. 23)*. Then tip your saw blade to 45° and trim just a little bit off one end of the carriage. (Don't cut the molding yet, just cut the carriage for now.)

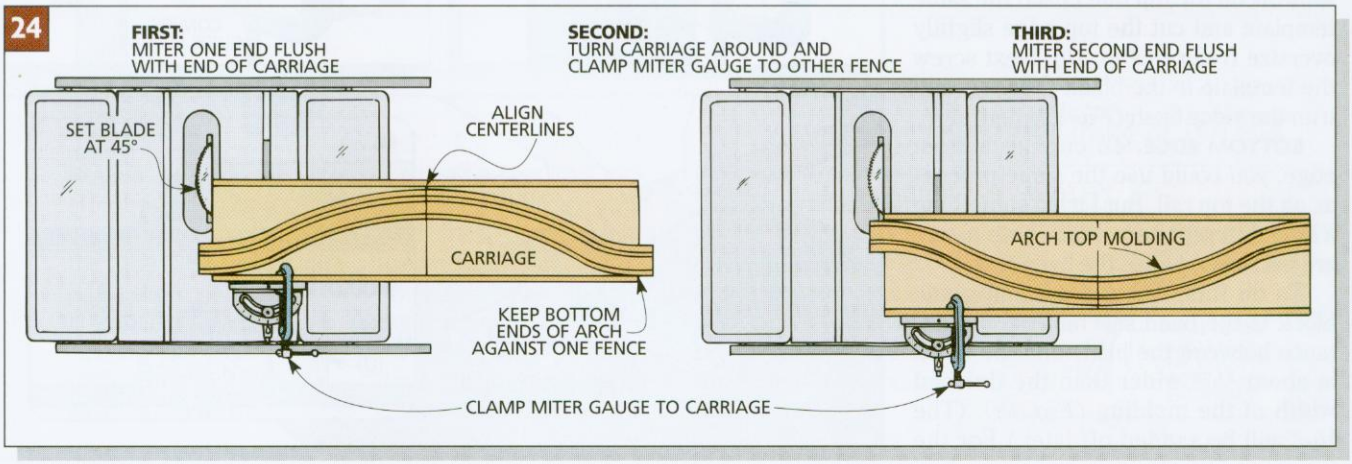
Note: You can also use this carriage on a radial arm saw without a miter gauge. Just tip the blade to 45° and hold the carriage tight against the fence when cutting.

MITER TO LENGTH. The trick comes in cutting the miter on the other end of the carriage to the correct length. To determine the finished length of the molding, measure the outside width of the cabinet. (In my case, 47½".)

Then, to cut the carriage to this length, I unclamped the miter gauge







and turned the carriage around so the other fence is against the miter gauge. Next, make a series of cuts, sneaking up on the final dimension until the distance from *long point-to-long point* of the miters measures the same as the outside width of the cabinet *(Fig. 23a)*.

Wait a minute. I thought you said you were going to cut the carriage the same length as the finished molding. To fit the cabinet, wouldn't that be from *short point-to-short point* of the miters?

This may seem a little confusing. But remember, you're going to be setting the molding on *top* of the carriage for cutting. So the long points on the top of the carriage base will actually become the short points on the back of the molding *(Fig. 23a)*.

MOUNT THE WORKPIECE. Once the carriage is cut to the correct length, draw a line across it centered on the length *(Fig. 24)*. Then you can mount the molding on top of the carriage.

To cut an even amount off both ends, align the centerlines on the molding with the centerline on the carriage *(Fig. 24)*. And keep both "feet" of the arch (low points) tight against one of the fences.

Note: I used carpet tape to hold the molding in place, but you could screw up from the bottom of the carriage into the back of the molding.

MITER ONE END. After the molding is in position, clamp the miter gauge to the back fence so the saw blade aligns with the miter cut on the end of the carriage *(Fig. 24)*. Then trim one end off the molding at a 45° angle.

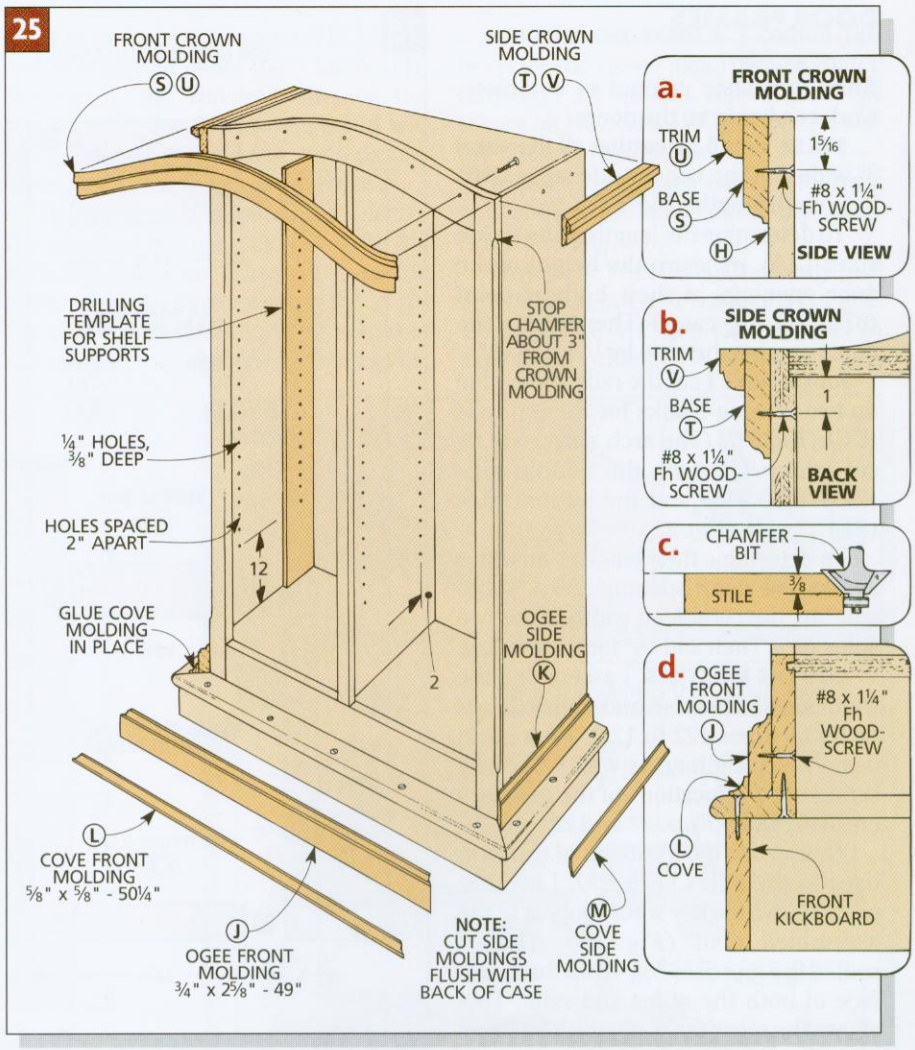
CUT TO LENGTH. Next, turn the carriage completely around and clamp the miter gauge to the other fence so the blade aligns with the miter on the other end. Then cut the molding to the finished length. Now the short points on the molding should just fit the outside edges of the cabinet.

SCREW IN PLACE. After the arched front crown molding is cut to fit the cabinet, it can be screwed to the front of the top rail (H) *(Fig. 25a)*.

OTHER MOLDINGS

Now there are a few more moldings to add to the top and bottom of the cabinet.

SIDE CROWN MOLDING. First there are two side crown molding strips (T,V) that have the same profile as the arched front molding *(Fig. 25b)*.



After the pieces are routed and glued together, miter the front ends and cut the back ends off square with the back of the cabinet *(Fig. 25)*. Then screw the side molding to the side of the cabinet from inside *(Fig. 25b)*.

BASE MOLDING. The next molding to be added is around the base of the cabinet *(Fig. 25)*. To make the ogee molding (J, K), cut enough 2⅝"-wide stock to fit around the front and sides of the cabinet. Then rout a Roman ogee on the top edge of each piece. Miter a front piece (J) to fit across the front of the cabinet and screw it in place from behind *(Fig. 25d)*.

Now, miter the front ends of the side pieces (K), and then cut off the back ends flush with the back of the case. Screw these pieces in place as well.

Next, add cove molding (L, M) in front of the ogee molding. To make these strips, rout a ½" cove on each edge of a 1½"-wide strip of ⅝"-thick stock. Then rip the ⅝"-wide molding off the outside edges. Now miter the molding to fit around the case and glue the strips in place.

CHAMFER. After all the molding was attached, I added another little detail to the case. I routed ⅜" stopped chamfers on the front corners of the case starting and stopping 3" from the molding at the top and the base *(Figs. 25 and 25c)*.

SHELF SUPPORT HOLES

It's easiest to drill holes for pin-type shelf supports on the inside of the cabinet now — *before* you add the doors. The supports fit into ¼" holes drilled ⅜" deep into the cabinet sides (A) and center divider (B) *(Fig. 25)*.

DRILLING TEMPLATE. To help position the holes consistently, I made a template from a 4"-wide piece of ¼" hardboard. Then, to drill the holes, position the bottom end of the template on top of the cabinet bottom and drill through the holes in the template *(Fig. 25)*.

DOOR FRAMES

After the basic cabinet is complete, work can begin on the doors.

STILES. Begin by cutting all the stiles 3" wide and the two outside stiles (BB) to a rough length of 64" *(Fig. 26)*.

To determine the length of the inside stiles (AA), measure the height of the door openings at their highest point ($67\frac{5}{8}$" in my case.) Then, since the doors overlap the case by $\frac{1}{4}$", add $\frac{1}{2}$".

RAILS. Next, I cut the rails. First, glue up two 9"-wide blanks for the top rails (CC) *(Fig.27)*. (The arch shape will be cut later.) Then rip the middle rails (DD) $4\frac{1}{2}$" wide and the bottom rails (EE) 3" wide *(Fig. 28)*.

To determine their lengths, measure across the door opening ($20\frac{1}{8}$") and subtract the combined width of the two stiles (6"). Then add $\frac{1}{2}$" for the overlap.

CUT THE MORTISES. I assembled the frames with mortise and spline joints (refer to pages 122 to 125). (You could use a biscuit joiner as well.) Start by laying out the locations of the mortises on all the rails *(Figs. 27 and 28)*.

To transfer the locations of the mortises to the stiles *(Fig. 29)*, I laid the pieces down as they would appear in the assembled door *(Fig. 26)*. Then I routed the mortises $\frac{3}{16}$" from the inside face of both the stiles and rails. This allows the mortises to align with a panel groove routed later.

Now, cut splines to fit the mortises and dry assemble the door frames.

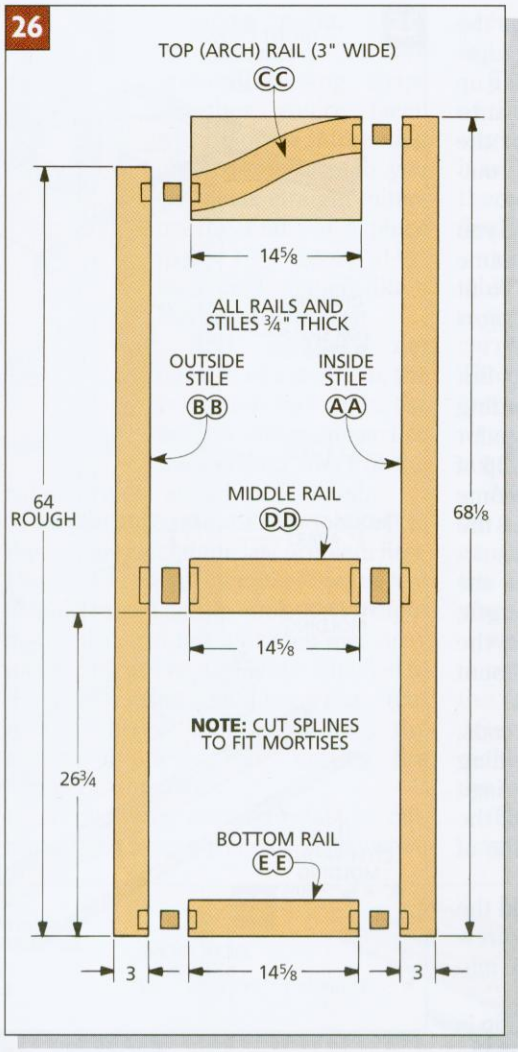
CUT THE ARCH. The next step is to cut the top door rails (CC) to their arched shape. To do this I made a cardboard template by tracing the arched door opening *(Fig. 30)*. Then cut out the template and transfer the shape to the rail and outside stile *(Fig. 31)*.

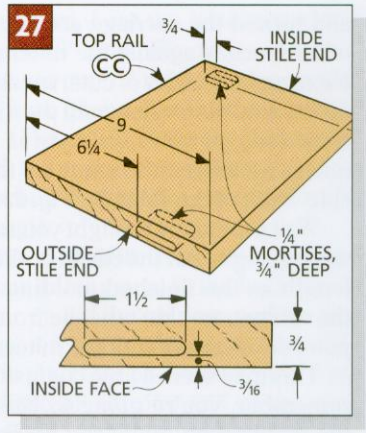
After cutting the top edge of the rails and top end of the outside stiles to shape, cut the bottom edge of the arched rails using the band saw and sander technique shown on page 113.

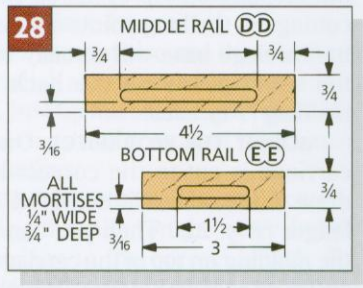
PANEL GROOVES. Now grooves can be routed around the inside of the stiles and rails for the raised panels *(Fig. 32)*. I cut the grooves with a $\frac{1}{4}$" slot cutter.

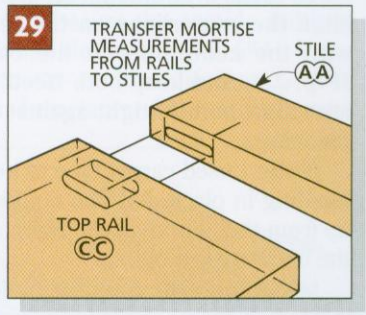
To do this, raise the bit until it's aligned with the mortises. Then, rout the grooves along the inside edges of the rails. On the stiles, don't rout beyond the mortises *(Fig. 32a)*.

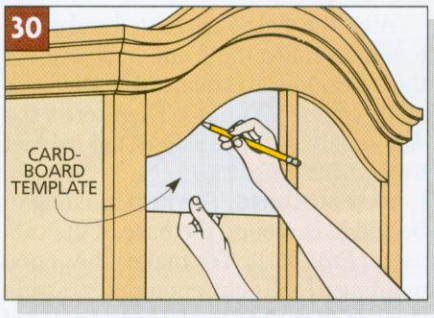
STOPPED CHAMFERS. Next, I dry assembled the frames and routed

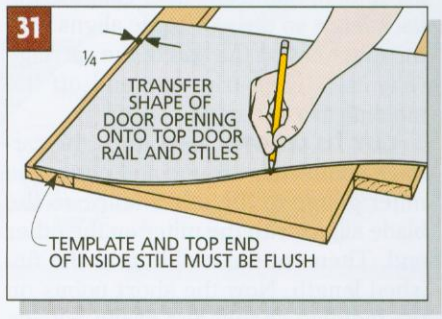


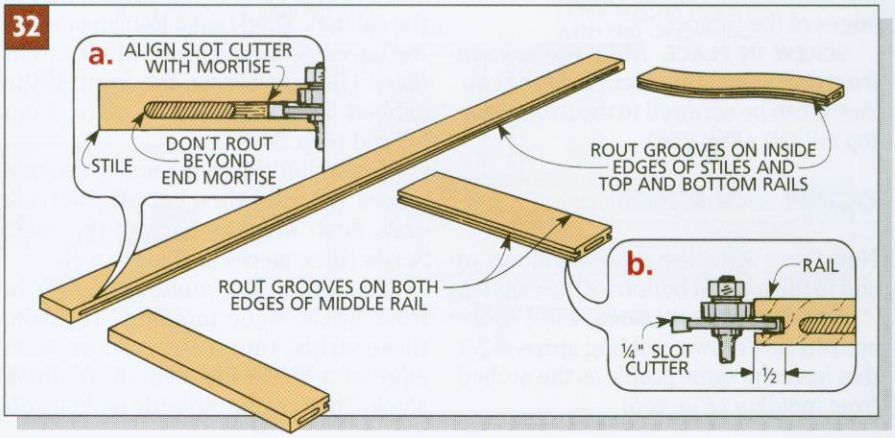












stopped chamfers around the inside of each frame *(Figs. 33 and 34)*.

Note: To stop the chamfer 5/8" from the corner, place a 1 1/4" x 1 1/4" square of 1/4" hardboard into the grooves at each corner. Then the router bearing will hit the square and stop the chamfer.

DOOR PANELS

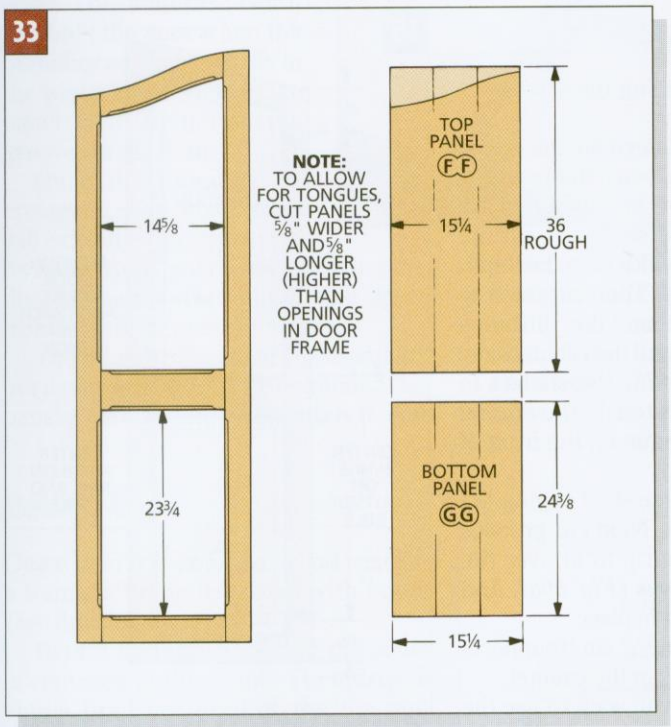
Now work can begin on the door panels. Start by edge-gluing enough 3/4"-thick stock to make two top panel (FF) blanks and two bottom panel (GG) blanks. To determine the finished size of the panels, measure the openings and add 5/8" to the height and width for tongues. Then, cut the bottom panels to size.

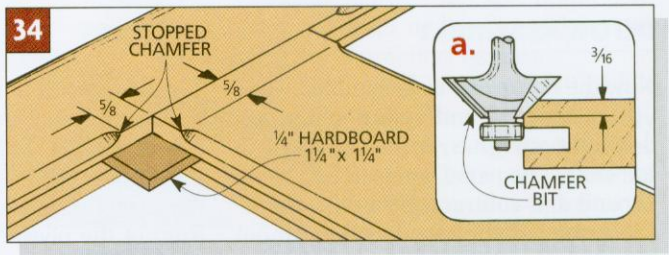
To lay out each top panel (FF), center the panel on the opening and trace the arch onto the panel. Then cut along the curved line. To determine where to cut the bottom edge, measure the height of the opening and add 5/8" for the tongues.

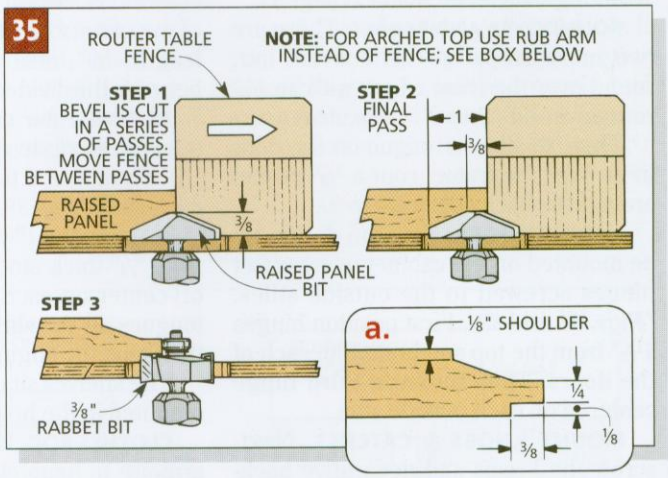
RAISING THE PANELS. I routed the bevel for the raised panel using a router table and a 1 7/16"-dia. raised panel bit (Sears bit No. 25465) *(Fig. 35)*. Also see the Shop Tip box below.

RABBET. Next, turn each panel over and rout a rabbet around the back *(Step 3 in Fig. 35)*.

Note: The panel is cut to fit only 5/16" into the slot, but a 3/8" rabbet is cut in it. This allows a 1/16" gap for the panel to expand with changes in humidity.







SHOP TIP ..... *Using a Rub Arm for Raised Panels*

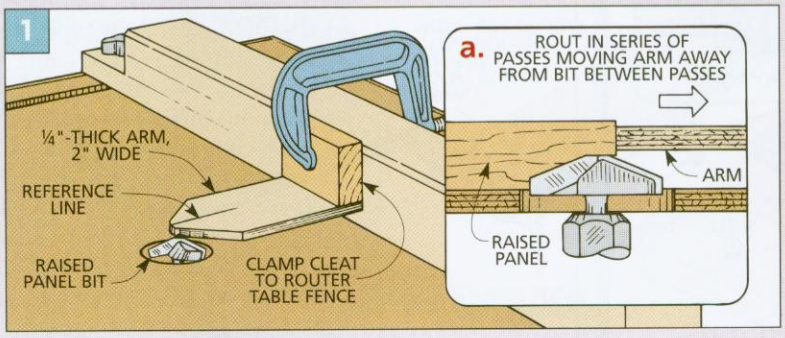
Cutting profiles on arched raised panels is usually done with shaper cutters or expensive router bits. These bits have bearings that follow the shape of the arch.

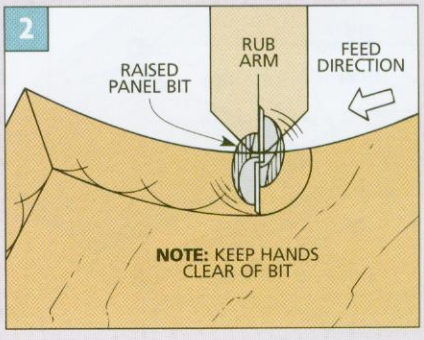
However, on the armoire I tried a less expensive bit that doesn't have a bearing.

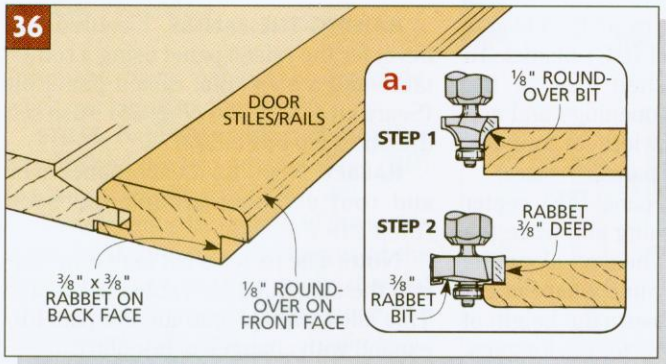
For the straight sections of the panels, I used the router table fence.

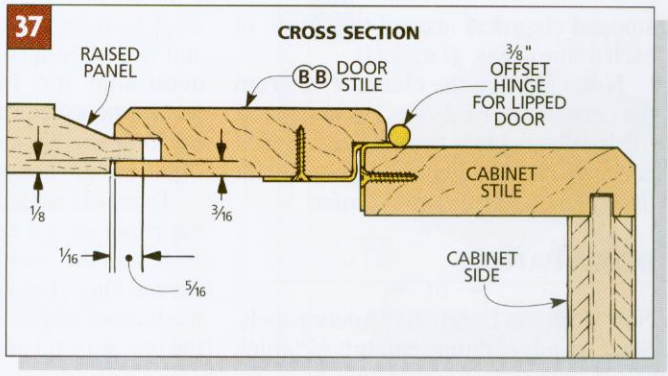
But for the arched top edge I added a rub arm positioned over the top of the bits *(Fig. 1)*.

To rout the beveled edge, draw a reference line on top of the rub arm. Then, to maintain a consistent width on the profile, move the workpiece so the edge is perpendicular to that line *(Fig. 2)*.









DOOR ASSEMBLY

Now the doors can be assembled. Glue up the mortise and spline joints, but don't put any glue on the panels or in the slots. The panel needs to be able to expand and contract within the frame. (See the Technique section about "Floating Panels" on the next page.)

ROUNDOVER AND RABBET. There are two more steps on the doors. First, round over the front edges with an ⅛" roundover bit *(Step 1 in Fig. 36a)*.

Then, to allow a tongue on the door to lie over the frame, rout a ⅜" rabbet around the back edges *(Step 2)*.

MOUNT DOORS. Now the doors can be mounted on the cabinet using offset hinges screwed to the outside stiles. *(Figs. 37 and 38)*. First position hinges 4½" from the top and bottom of each of the doors. Then mount a third hinge centered on each outside stile.

MOUNT KNOBS & CATCHES. Next, screw the knobs and decorative backplates to the inside door stiles *(Fig. 38)*. (Also refer to the Exploded View on page 107.)

Finally, mount the adjustable ball catches behind the doors on the side of the divider cap (I). Then position the matching strikes on the back of the door.

SHELVES

The last step in building the armoire is to make the shelves.

CUT TO SIZE. To determine the size of the shelves (W), measure the inside of the case. But to allow for edging on the front of the plywood shelves, I cut the shelves ½" *less* in width than the depth of my case *(Fig. 39)*. Then cut them to length ⅛" less than the distance between the divider and the cabinet side.

EDGING. After cutting the shelves to size, the next step is to add the edging (X). First, rout a tongue on the front of each shelf *(Fig. 39)*.

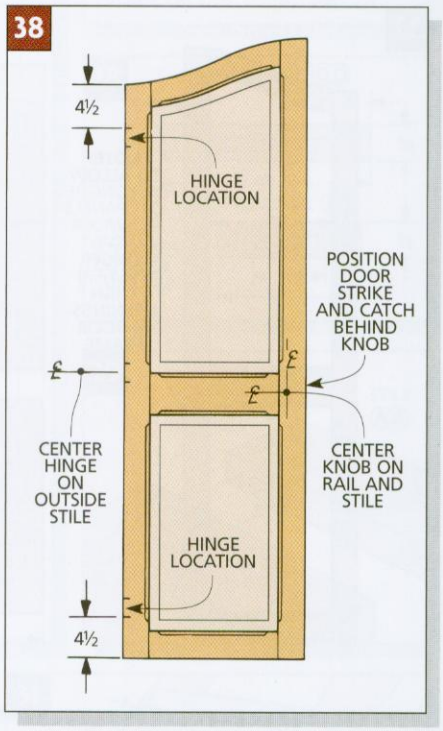
Now cut the 1"-wide shelf edging (X) from ¾"-thick stock. Next cut grooves off-center on each strip to fit over the tongues on the shelves *(Fig. 39a)*. And then glue the edging in place.

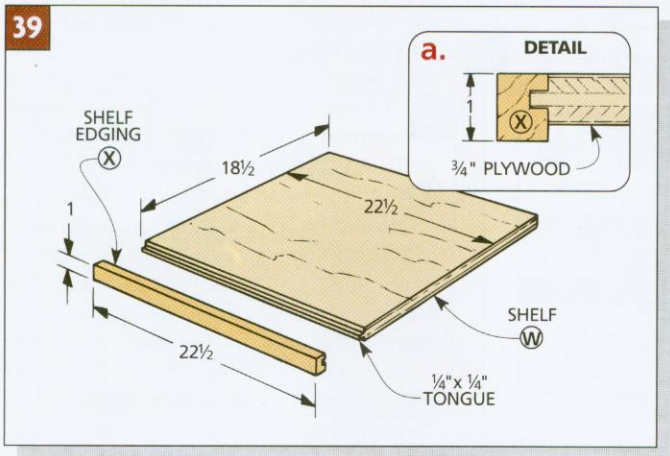
The shelves sit on ¼" shelf supports mounted in the holes in the cabinet.

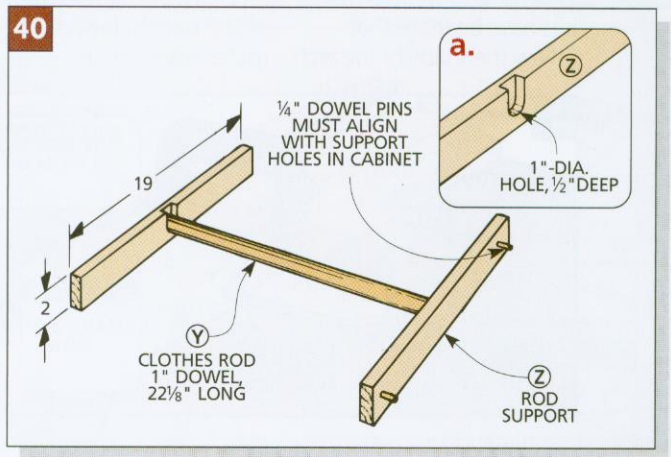
CLOTHES ROD. If you want to use the armoire to hang clothes, you will have to add a rod (Y) *(Fig. 40)*. I supported the rod with two rod supports (Z). Each support is held in place with two ¼" dowels that fit into the shelf support holes.

Cut the supports from ¾"-thick stock and drill 1" holes, only ½" deep centered on each piece. Then rout an "escape" area for the rod to be removed above one of the holes *(Fig. 40a)*.

Now drill holes and mount ¼" dowel pins on the back side of each support to align with the holes in the cabinet. Finally, cut a 1"-dia. dowel so it wedges between the supports *(Fig. 40)*. ■







TECHNIQUE . . . . . Floating Panels

Raised panel doors are beautiful. But if they're not built correctly, you're going to be faced with some surprises once the humidity changes in your house.

PROBLEMS. One problem that can occur is that the door frame joints can blow apart. This might happen if you built the door when the humidity was low (usually in the winter), *and* you cut the panel to fit tight into the grooves in the frame.

Once the humidity increases, a solid wood panel will expand — mostly across its width. And then the joint holding the door frame together might split apart from the pressure in the wood.

The other problem isn't as dramatic, but it may be a little more common. The panels can become uncentered and rattle around in the frames. This happens if you build the doors when the humidity is high. Then, once the humidity drops, the panels shrink.

SOLUTIONS. There are a couple of things you can do to prevent these problems. First, cut the panel to fit a little loose in the frame. I allow at least a 1/16" gap on each side (1/8" overall).

Next, always assume that there will be movement in a solid wood panel. So *never* glue the panel into the grooves. The panel has to be allowed to expand and contract or it will crack as the humidity changes.

But if the panel is built "loose" and it isn't glued in, what keeps it centered in the frame? There are a couple of techniques shown below to "anchor" a floating panel.

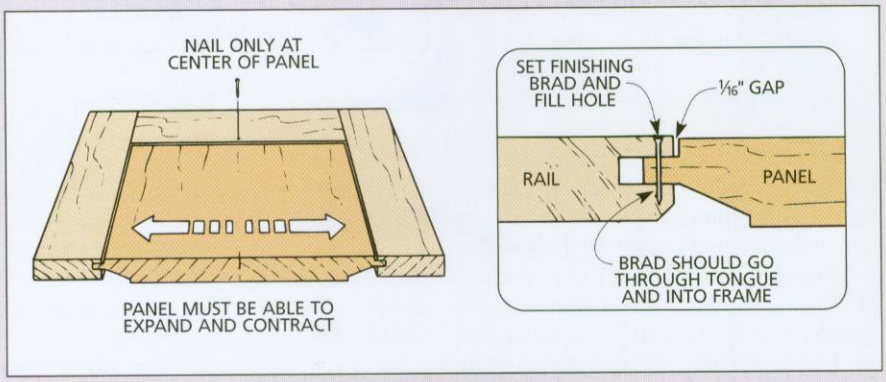
One more thing. Always apply finish to a solid wood panel *before* assembly. If you finish the whole project *after* assembling the frames and panels, and a panel shrinks, there will be a noticeable unfinished line around the panel.

BRADS

One way to secure a solid wood panel in a frame is to pin the panel with brads (see drawing at right).

Before nailing, check that the panel is centered in the frame. Then drive a single brad centered at the top and bottom of each panel (not the sides). The brads should go through the tongue and into the rail on the other side of the groove (see detail).

With the panel nailed at the center of the frame, it can expand and contract in both directions from the center.

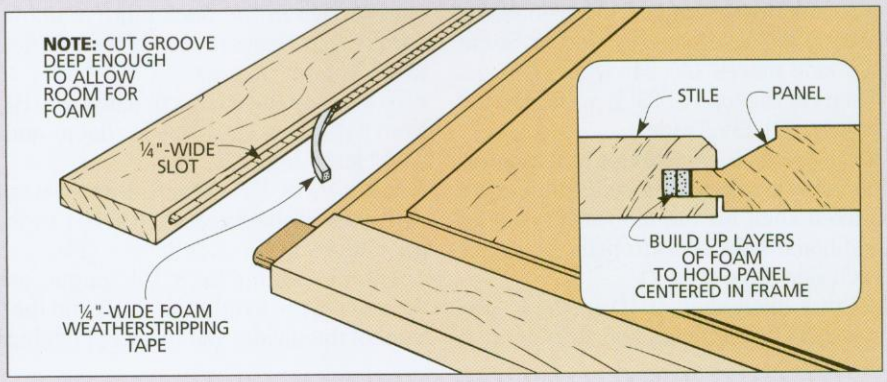


FOAM

Another method to keep a panel from rattling in a frame but still allow it to expand and contract is to use foam rubber in the grooves (see drawing).

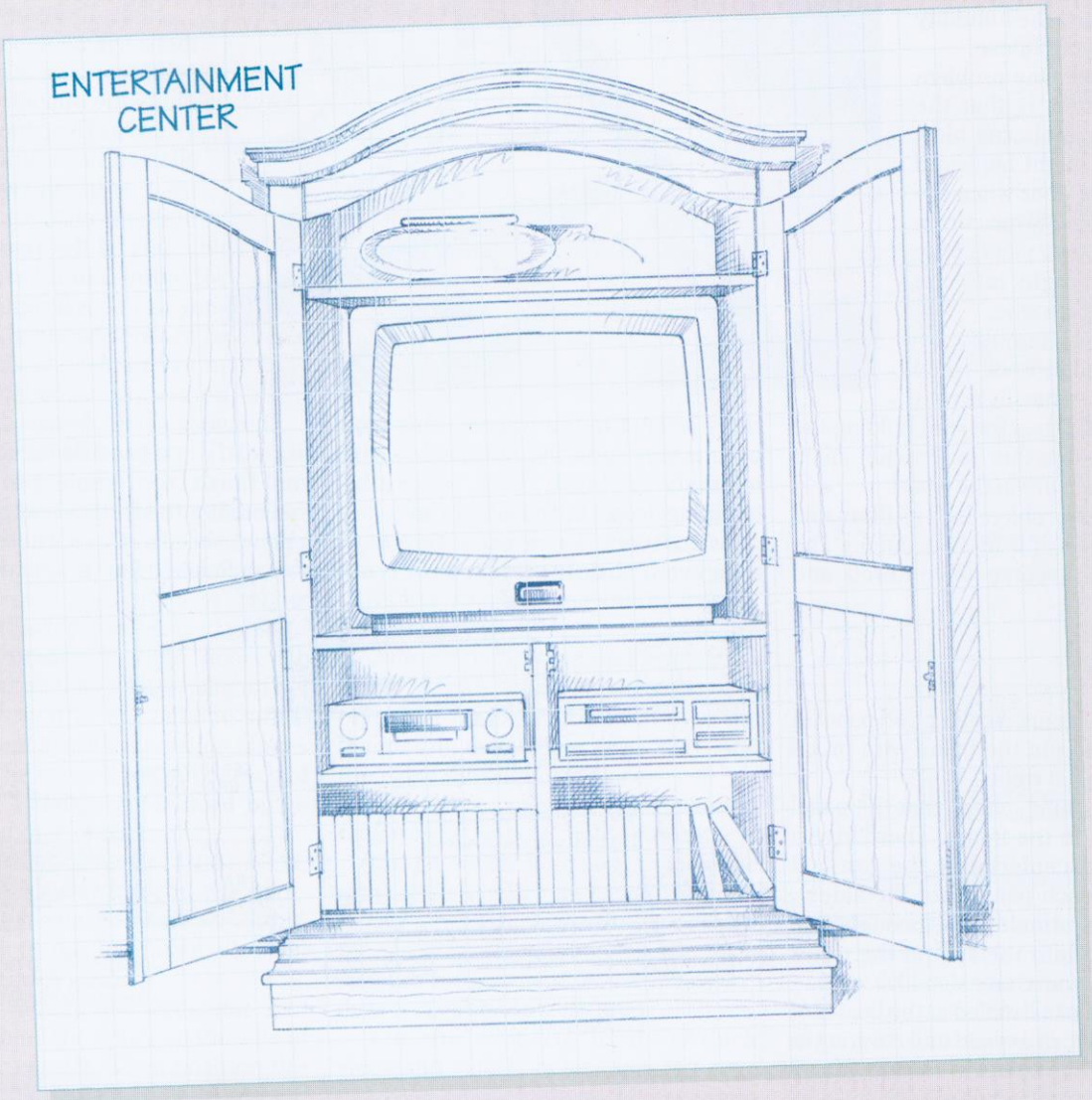
Putting foam rubber in the grooves keeps the panel centered, and when the panel expands, the foam compresses.

I've found 1/4"-wide foam weatherstripping tape with an adhesive back fits perfectly in a 1/4" groove. And you can build up as many layers as you need (Just be consistent so the panel stays centered; see detail).



DESIGNER'S NOTEBOOK

Here's how to open up the design of the traditional Cherry Armoire and turn it into a convenient Entertainment Center that will highlight your television or sound system.



CONSTRUCTION NOTES:

■ To hold most standard televisions, the cabinet will have to be 4½" deeper. So cut the side pieces (A) 24" wide *(Fig. 1)*. Then cut the top (C) 23½" wide, and the bottom (D) 23¼" wide.

■ Cut the dadoes, rabbets, and tongues on these pieces as before. But to accept a fixed shelf for the television, rout an additional dado 28" up from the bottom of each side piece *(Fig. 1)*.

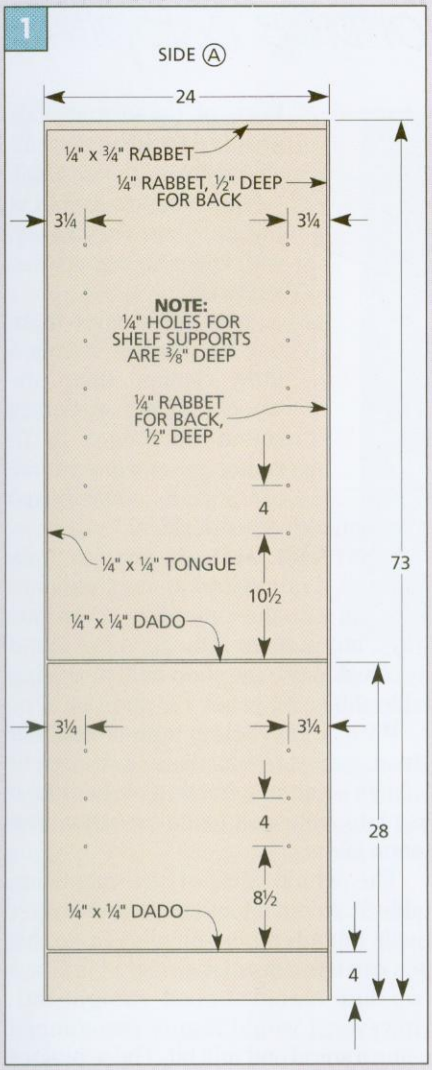
■ Cut a fixed shelf (HH) from ¾" plywood, 23" wide (deep) and 46½" long. If you plan on having electronic components (such as a VCR) below the shelf, cut notches in the back edge to allow cords to pass from the top of the cabinet to the bottom *(Fig. 2)*.

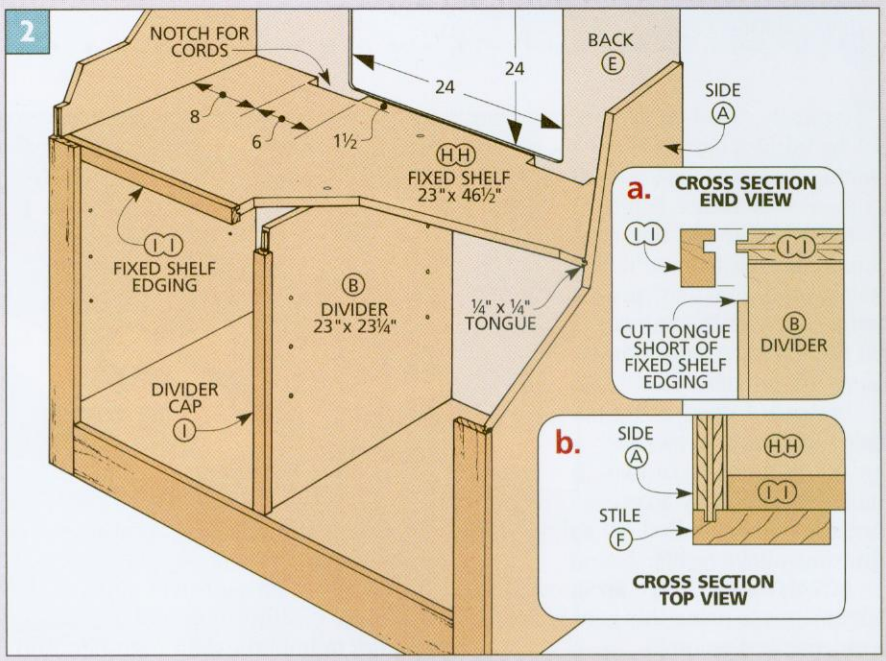
■ To support the shelf, cut a divider (B) from ¾" plywood, 23" wide (deep) and 23¼" long (high).

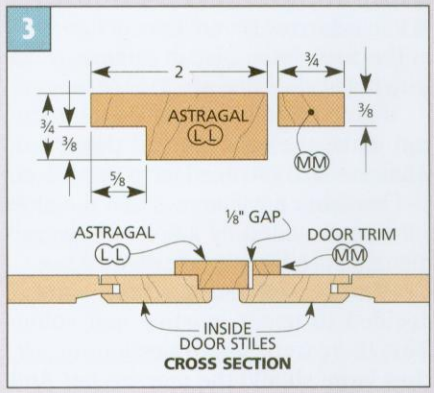
■ Cut a ¼" x ¼" centered tongue on each end of the fixed shelf (HH) to fit the dadoes in the side pieces *(Fig. 2)*. Then cut another ¼" x ¼" tongue on the front of the fixed shelf (HH) and the front of the divider (B) to accept edging added later. Trim back the tongue on the top of the divider ¾" to allow room for the edging on the shelf *(Fig. 2a)*.

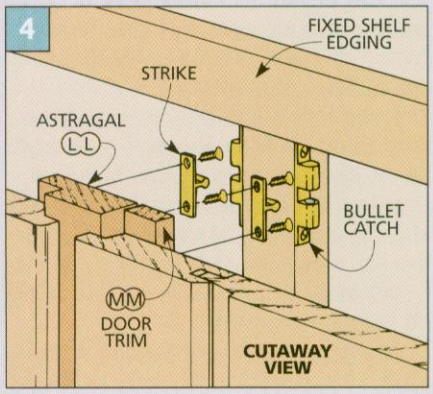
■ Before assembly, cut a ¾" x 1¼" piece of edging (II) for the front of the fixed shelf. Rout a ¼" groove on the back to fit over the shelf *(Fig. 2a)*. The groove is offset so the edging will be flush with the top of the shelf. Cut the edging to length to match the shoulder-to-shoulder length of the fixed shelf (46"). Then glue it to the front of the fixed shelf.

■ Now assemble the case. Start by









gluing the fixed shelf between the two side panels (A). Then add the top (C) and bottom (D) pieces.

- Center the divider below the fixed shelf and screw it in place with counterbored screws. Fill or plug the holes.
- To allow for ventilation and room for the television to extend outside the cabinet (if necessary), cut a 24" square opening in the back (E), 29" up from the bottom edge *(Fig. 2)*.
- Cover the divider with a shortened divider cap (I). It should fit between the bottom (D) and the fixed shelf edging (II).
- Proceed with construction of the cabinet, but build the base 4½" deeper (parts O and Q). Then add 4½" to all of the side moldings (K, M, T, V).
- Since the divider doesn't extend into the top of the Entertainment Center (as it did with the Armoire), there's an unfilled gap between the doors. To fill this area, glue a ¾" x 2" astragal (LL) to the back of the left door *(Fig. 3)*. A rabbet cut in the astragal mates with the rabbet in the door.
- To allow the door catch to mount on the same plane for both doors, glue a ⅜"-thick piece of door trim (MM) to the back of the right door *(Fig. 3)*.
- Mount the bullet catches on the divider cap just under the fixed shelf edging *(Fig. 4)*. Then, mount the strikes on the astragal and door trim.
- There may be room above your TV to add a large shelf (JJ). It has edging (KK) on the front like the small shelves.

CHANGES TO MATERIALS

ENTERTAINMENT CENTER:

A	Sides (2)	¾ ply -24 x 73
B	Divider (1)	¾ ply - 23 x 23¼
C	Top (1)	¾ ply - 23½ x 46½
D	Bottom (1)	¾ ply - 23¾ x 46½
I	Divider Cap (1)	¾ x 1¼ - 22¾
K	Ogee Side Mld. (2)	¾ x 2⅝ - 25¼
M	Cove Side Mld. (2)	⅝ x ⅝ - 25⅞
O	Bullnose Sides (2)	¾ x 2¾ - 26½
Q	Kickbd. Sides (2)	¾ x 4¼ - 26
T	Base (Sides) (2)	¾ x 3¼ - 25¼
V	Trim (Sides) (2)	¾ x 1¼ - 26
W	Small Shelves (2)	¾ ply - 21 x 22½
X	Sm. Shelf Edg. (2)	¾ x 1 - 22½

NEW PARTS:

HH	Fixed Shelf (1)	¾ ply -23 x 46½
II	Fixed Shelf Edg. (1)	¾ x 1¼ - 46
JJ	Large Shelf (1)	¾ ply -21 x 45⅞
KK	Lrg. Shelf Edg. (1)	¾ x 1 - 45⅞
LL	Astragal (1)	¾ x 2 - 69 rough
MM	Door Trim (1)	⅜ x ¾ - 69 rough

PARTS NOT NEEDED:

W	Shelves (Only 2 of 7 required)
Y	Clothes Rod
Z	Rod Supports

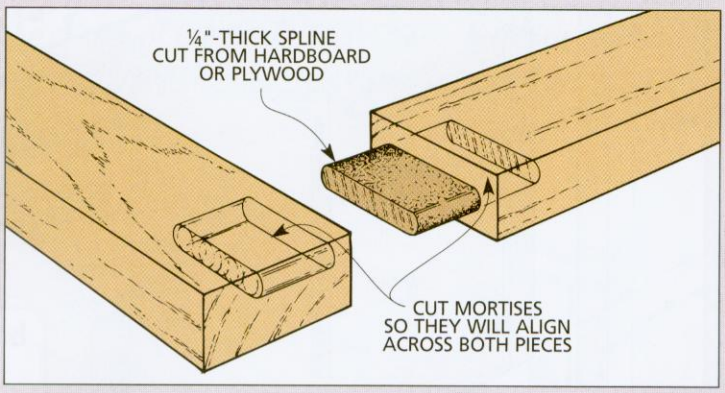
HARDWARE:

Only 12 pin-type shelf supports required
¼"-dia. dowel pins not needed

JOINERY . . . . . Mortise & Spline

Typically, when I have to build a frame and panel, the joint I would choose first is the traditional mortise and tenon joint. Although I could have used mortise and tenon joints for the frames on the Armoire shown on page 106 — I didn't.

Instead, I used a "hybrid" joint, a mortise and *spline*. It consists of two mortises joined by a connecting piece called a spline (see drawing, above right).



ADVANTAGES. There are a couple of advantages to using this joint instead of a mortise and tenon.

First, if you're building a project with angled rails or legs, angled tenons are required. These are not only difficult to cut, but also difficult to fit.

But there's another reason. When cutting a tenon on the end of a large piece like the arched top rail of the Armoire, the operation can be awkward and dangerous on a table saw. A mortise and spline joint is a better choice.

DOWELS. Wouldn't it be easier to drill holes and use dowels?

I've never been very fond of dowels. First, it's difficult to drill holes in opposing pieces so that they align accurately. Second, as dowels dry they tend to "oval-out" in the round hole resulting in a weak joint. And, finally, dowels don't provide as much glue surface as a spline (see photos below).

BISCUIT JOINTS. What about using a biscuit (plate) joiner?

Biscuit joiners work great on some projects. But there are a couple of drawbacks. First, on a project such as the armoire, biscuits may not be strong enough to hold the door together. And, second, you can't generally use biscuits to join a narrow frame. Except for some of the new detail biscuit joiners, most joiners cut slots that are 1¾" or longer.

With a mortise and spline joint you can make the mortise and the spline whatever size you need for your project.

One other advantage is that the glue surface provided by a spline is larger than that of a biscuit (see photos).

MORTISE AND SPLINE. Okay, once I decided to use a mortise and spline joint, there were some questions to ask. How large should the mortise be? And what's the best material for splines?

SIZE OF MORTISE. As a rule of thumb, mortises are usually one third the thickness of the stock to be joined. For example, when working with ¾"-thick stock, I cut ¼"-wide mortises.

SPLINES. As for the splines, I use either ¼"-thick plywood or hardboard. Both of these materials are ideal because they are slightly less than ¼" thick — which means they fit in the mortises very easily, with room for a good glue surface.

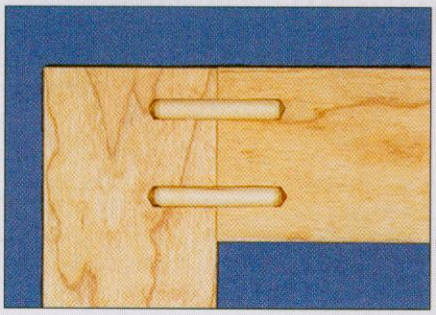
My preference is to use hardboard. It cuts a little cleaner than plywood and it's easier to round the edges to fit router-cut mortises. I use tempered hardboard that's smooth on both sides.

MORTISING TABLE . As you can probably tell, I'm excited about this joint. You can cut the mortises in various ways, but in many situations I've found it easiest to use the shop-built mortising table shown on pages 123 and 124.

With a mortising table I can cut clean, accurate mortises to fit pre-cut splines — all in a fraction of the time it used to take me to cut mortise and tenon joints.

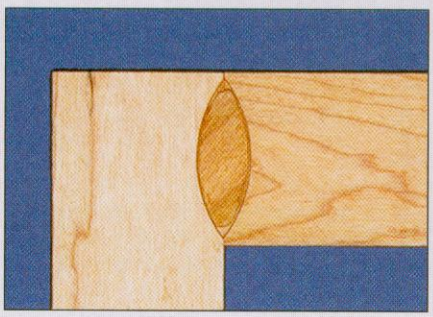
The whole idea of the mortising table is to cut mortises with a router that's mounted horizontally. To do this you can use a regular straight bit (like a two-flute carbide-tipped straight bit). However, I would highly recommend using a spiral end mill bit. These bits are specifically designed to make plunge cuts and rout side-to-side much easier than straight bits.

STEP-BY-STEP. Once you have the mortising table and the bits, it's a simple matter to cut the mortises. You'll find complete step-by-step instructions on page 125.



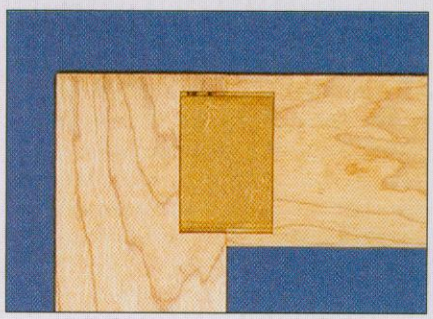
DOWELS

Of all the joints shown, this is the most familiar. However, alignment can be difficult and there's very little glue surface.



BISCUIT JOINT

This relatively new joint is easy to make, but it requires a special machine. And the size of the biscuits limits their use.

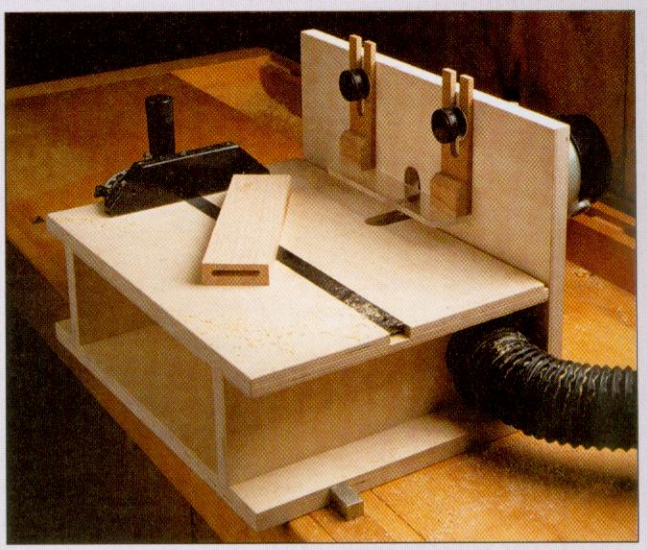


MORTISE AND SPLINE

The connecting spline of this joint provides a large gluing surface. Plus the size can be varied to fit many applications.

SHOP JIG . . . . . Mortising Table

This table for mortising is just a plywood box with a high back panel. Then a router is mounted to the back. The real advantage of using it for cutting mortises is that the workpiece can lie flat. For more on using the table, see page 125.



BASE FRAME

To make the base, start by cutting the top (A) and bottom (B) from $\frac{3}{4}$" plywood, $11\frac{1}{2}$" wide and $15\frac{3}{4}$" long *(Fig. 1)*.

SIDES AND DIVIDER. Next, cut two sides (C) $4\frac{1}{4}$" wide by $11\frac{1}{2}$" long. I also cut a $3\frac{3}{4}$"-wide by $11\frac{1}{4}$"-long center divider (D) to form an enclosed box so I could use a vacuum to remove chips *(Fig. 1)*.

If you're using a shop vacuum, cut a hole in one of the side pieces (C) to accept the end of the hose. If you're not going to use a vacuum, leave out the center divider.

Now cut $\frac{1}{4}$"-deep dadoes in the top (A) and bottom (B) to accept the sides (C). Then, if using the center divider (D), dado the sides to accept the divider.

TOP. To complete the top, first cut a slot to fit *your* table saw's miter gauge. Then, rabbet the back edge of the top to act as a sawdust relief *(Fig. 1a)*.

Finally, cut a 1"-wide notch on the back edge of the top (A) to provide an opening for sawdust and chips to fall through *(Fig. 1b)*.

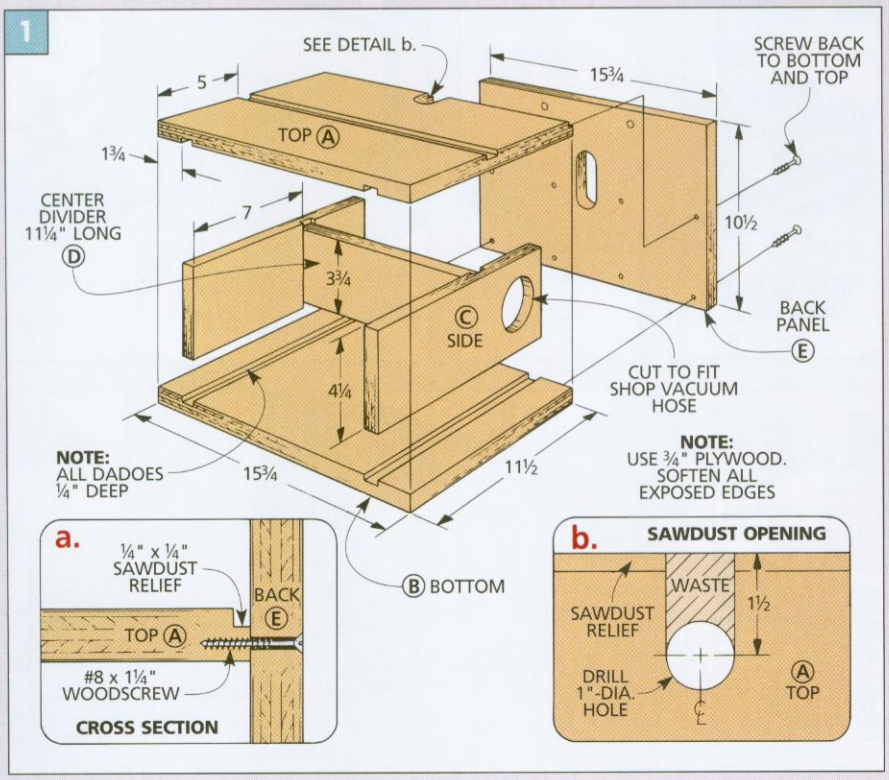
BACK PANEL. Now a back panel (E) can be made. This panel provides a vertical surface for the router, and a fence for the workpiece to ride against.

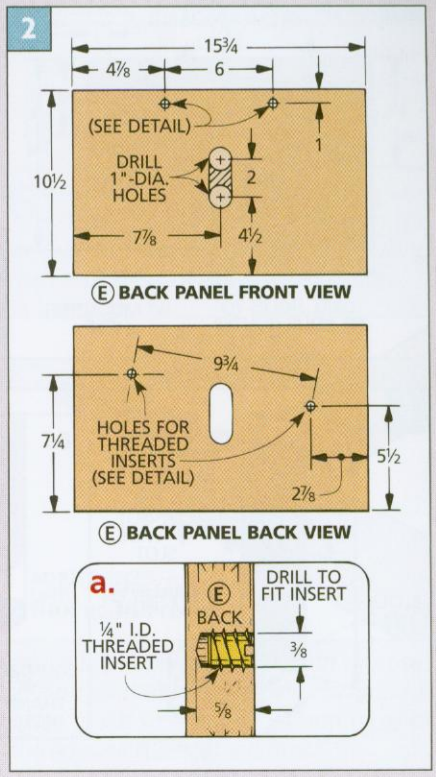
To make the back panel, first cut a piece of $\frac{3}{4}$" plywood, $10\frac{1}{2}$" wide and $15\frac{3}{4}$" long *(Fig. 2)*. Then cut a slot in the middle of the panel for the router bit. To do this, drill two 1"-dia. holes and then cut out between the holes.

THREADED INSERTS. With the slot completed, the next step is to install four $\frac{1}{4}$"-I.D. (inside diameter) threaded inserts in the back panel (E) *(Fig. 2a)*. Two of these inserts are located on the front face for the guard adjustment knobs, and the other two are on the back face to allow the router to be adjusted up and down.

Note: Be sure that the centers of the two holes on the back are $9\frac{3}{4}$" apart. If not, a base plate (added later) won't fit.

ASSEMBLY. After the threaded inserts are installed, glue up all the base frame pieces. Then drill and countersink eight shank holes into the back panel (E) and screw it to the base *(Figs. 1 and 1a)*.





ROUTER BASE PLATE

After completing the base frame, I made a new base plate for my router. This base plate provides a large surface to hold the router to the back panel (E).

CUT TO SIZE. To make the base plate (F), I started with a 1/4"-thick piece of hardboard and cut it 7 3/4" wide and 11 3/4" long *(Fig. 3)*.

Note: You could also use 1/4"-thick plastic such as acrylic or phenolic for the base plate.

After the base plate is cut to size, drill a 1 3/4"-dia. hole in the center for the router bit to fit through. The hole doesn't have to be perfectly round, so if you don't have a hole saw or a large drill bit you can cut it with a sabre saw.

Next, drill and countersink holes in the plate so you can attach it to your router. To lay out the holes, use the plastic base from your router as a template.

DRILL HOLE. To mount the plate to the vertical back panel, first drill a 1/4"-dia. mounting hole 3" down and 1" in from the right side of the base plate to align with the corresponding hole in the back of the mortising table *(Fig. 3)*.

CUT ADJUSTMENT SLOT. Now that the mounting hole is drilled through the plate, cut a 3/8"-wide adjustment slot in the base plate *(Fig. 3)*. This slot provides a simple and accurate way to adjust the position of the router.

I cut this arched slot on a drill press by using the 1/4" mounting hole as a pivot point *(Fig. 4)*. To do this, first drill a 1/4"-dia. hole in a scrap piece of plywood and push a 1/4" dowel into this hole. Then slip the mounting hole in the base plate (F) over the dowel.

Next, mount a 3/8"-dia. drill bit and position the plywood so the distance from the center of the dowel to the center of the bit is 9 3/4". Then clamp the plywood to the drill press table.

Now drill a series of overlapping holes to create an arched slot *(Fig. 4)*. Then remove the base plate and clean out the slot with a file.

With the slot finished, I mounted the base plate (F) to the back panel with two plastic knobs and washers *(Fig. 5)*.

Note: You could use 3/4"-long hex head bolts and washers instead of the plastic knobs.

GUARD

All that remains to complete the jig is a guard. Don't leave this guard off. It protects your fingers, and is needed to align your cuts *(Fig. 7)*.

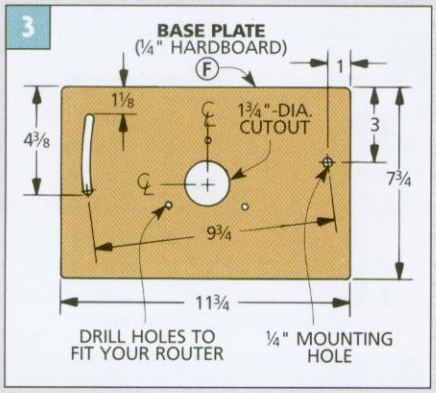
UPRIGHTS. To make the guard, cut two uprights (G) from 1/4"-thick hardboard, and then cut a 1/2" slot in each upright for knobs *(Figs. 6 and 7)*. To attach the guard plate, glue a 1/2"-thick block (H) to the bottom of each upright.

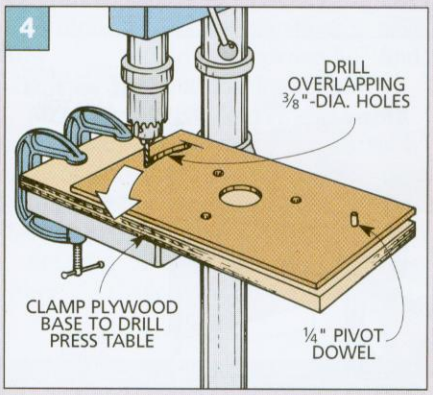
GUARD PLATE. Next, I cut a guard plate (I) from 1/4"-thick acrylic plastic 1 1/2" wide and 7 1/2" long. (Note: If you can't find 1/4"-thick clear plastic, you can glue together two pieces of 1/8"-thick plastic.) Then I sanded a 1/2" radius on the two outside corners and lightly sanded the front edges.

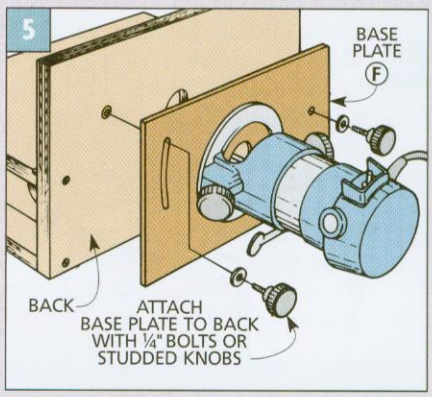
To mount the plastic guard plate to the uprights, drill countersunk holes on the bottom side of the plate and screw it to the blocks *(Fig. 6a)*.

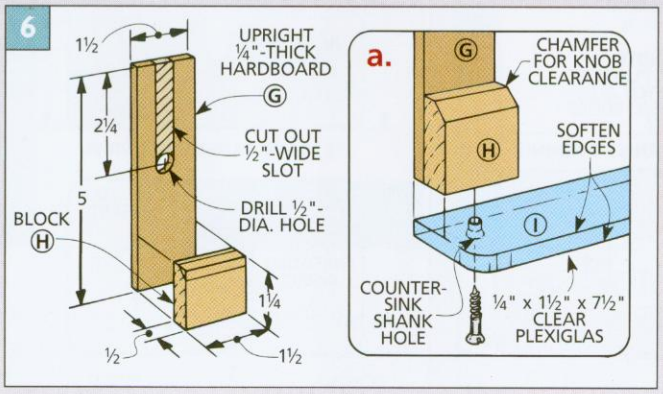
When the guard is screwed together, position it over the bit *(Fig. 7)*. Then mark the location of two lines on the bottom of the guard to align with the bit *(Fig. 7a)*. Now use a utility knife to scribe the lines on the bottom of the plastic. By using the lines as a guide, I know exactly where to start and stop a cut.

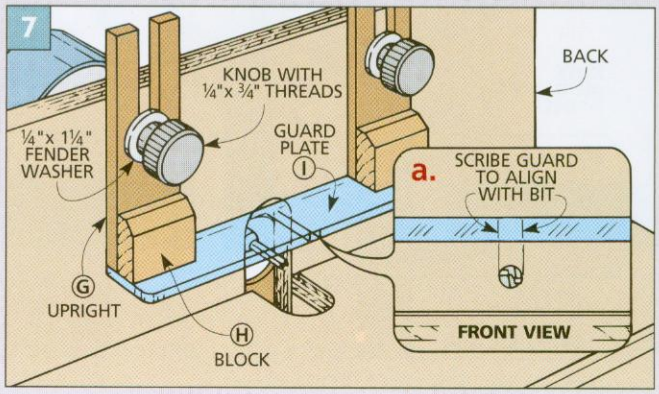
Note: A complete kit of all of the hardware and plastic parts for the mortising table is available (see page 126).











MAKING MORTISE & SPLINE JOINTS ON THE MORTISING TABLE

To make mortise and spline joints on the mortising table, start by adjusting the router bit's height and depth *(Step 2)*.

Then adjust the guard so the scribed lines are directly above the bit. This provides a reference for locating the ends of the mortise *(Step 3)*.

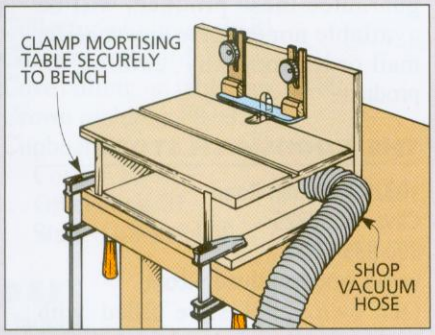
Now use a square to lay out the joint on both pieces *(Step 4)*. One advantage of this joint is that the mortises align automatically. Just mark the face side of both pieces and cut and assemble them with the marked sides facing *up*.

Finally, before you start cutting mortises, be aware of the correct feed direction. Because the router is horizontal, the stock must be fed from left to right. This is the opposite of a router table.

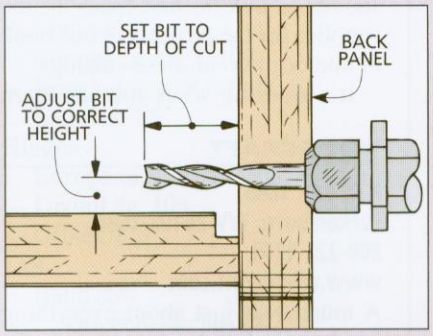
To cut end mortises, I use my table saw's miter gauge to support the workpiece *(Step 5)*. On edge mortises, I make a series of shallow cuts between the layout lines, pulling the piece away from the bit between each pass *(Step 7)*.

All that's left is to rip material for the splines 1/8" narrower than the length of the mortise *(Step 8)*. Then cut the splines to length 1/8" shorter than the combined depths of the mortises.

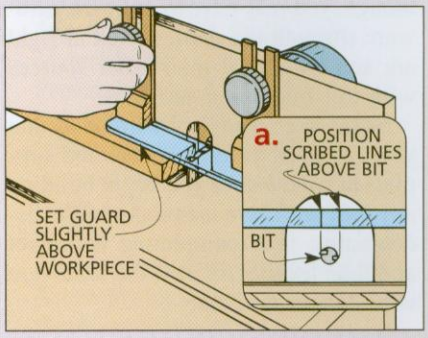
To glue up the joint, "butter" the inside of the mortises with a small artist's brush. Then, apply a thin film of glue to the spline, and clamp *(Step 9)*.



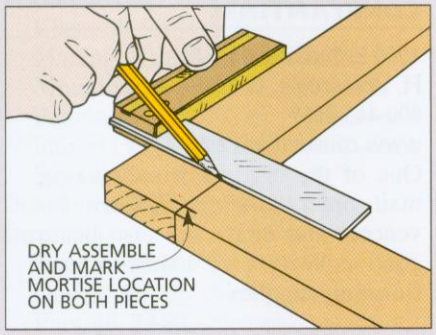
1 *To have access to the front and left (feed) side of the mortising table clamp it to the left corner of the bench. Insert vacuum hose into hole in the side.*



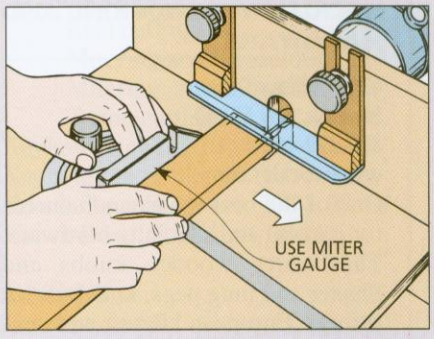
2 *Spiral end mill bits work best. Adjust bit to produce the correct depth of cut. Then, adjust the router up or down until the bit is at the correct height.*



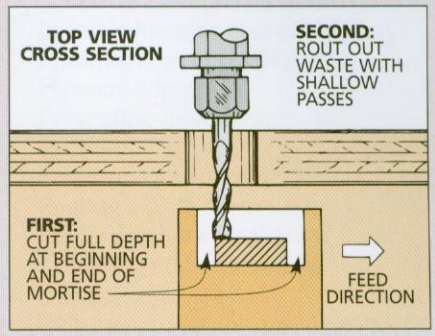
3 *Tighten down the clear plastic guard plate so it's slightly above the workpiece, and the scribed lines in the plate are directly above the router bit.*



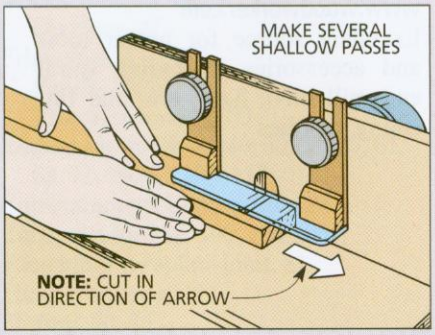
4 *To mark the limits of both mortises, hold the pieces in their final position (at a right angle to each other), and draw lines across both faces.*



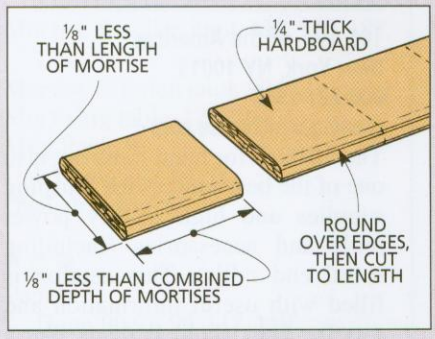
5 *Guide workpiece with miter gauge. (If end of workpiece is angled, angle miter gauge.) Then make two full-depth plunge cuts to define ends of mortise.*



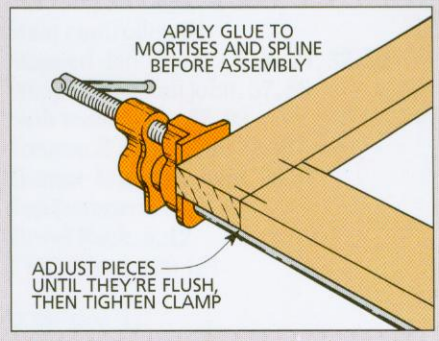
6 *To complete the mortise, make several shallow cuts while moving the workpiece from left to right, and pulling the workpiece away between passes.*



7 *When cutting a mortise on the edge of a board, make shallow cuts, working from left to right. Use marks on guard to start and stop on the layout lines.*



8 *Cut spline material into strips 1/8" narrower than length of mortise. Round over edges. Cut splines to length 1/8" less than combined depth of mortises.*



9 *Finally, apply glue into both mortises and on the spline. Before clamping in place make sure the edges and faces of the adjoining pieces are flush.*

SOURCES

One of the first things we take into consideration when designing projects at *Woodsmith* is the hardware. Does it complement the project and is it appropriate? Is it affordable? And, most important, is it commonly available?

You'll probably be able to find most of the hardware and supplies for the projects in this book at your local hardware store or home center. Sometimes, though, you may have to order the hardware through the mail. Listed at right are some national mail order sources with toll-free phone numbers.

Note: We *strongly* recommend that you get all of your hardware and supplies in hand *before* you begin building any project. There is nothing more discouraging than completing a project and then finding out that the hardware is no longer available.

MAIL ORDER SOURCES

Some of the most important "tools" you can have in your shop are mail order catalogs. The ones listed below are filled with special hardware, tools, finishes, lumber, and supplies that can't be found at a local hardware store or home center. You should be able to find many of the supplies for the projects in this book in one or more of these catalogs.

It's amazing what you can learn about woodworking by looking through these catalogs. If they're not currently in your shop, you may want to have them sent to you.

Note: The information below was current when this book was printed. August Home Publishing does not guarantee these products will be available nor endorse any specific mail order company, catalog, or product.

WOODCRAFT

P.O. Box 1686
Parkersburg, WV 26102-1686
800-225-1153
www.woodcraft.com

A must! Has just about everything for the woodworker including tools, bits (spiral end mills), hardware, Shaker pegs, connector bolts, and finishing supplies.

ROCKLER WOODWORKING AND HARDWARE

4365 Willow Drive
Medina, MN 55340
800-279-4441
www.rockler.com

One of the best all-around sources for general and specialty hardware. They carry wooden knobs and Shaker and mug pegs, knock-down fittings, European hinges, and connector bolts. Also a variety of tools and bits (including spiral end mills), finishes, lumber, and veneer.

GARRET WADE

161 Ave. of the Americas
New York, NY 10013
800-221-2942
www.garrettwade.com

The "Bible" for hand tools but also one of the best sources for finishing supplies and high quality power tools and accessories (including spiral end mills). This catalog is filled with useful information and tips for your shop. It reads like a good woodworking book.

THE WOODSMITH STORE

10320 Hickman Road
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Our own retail store filled with tools, hardware, books, and finishing supplies. Though we don't have a catalog, we do send out items mail order. Call for information.

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One of the original woodworking mail order catalogs. Known for veneers and inlays but also has a good collection of hardware and finishing supplies.

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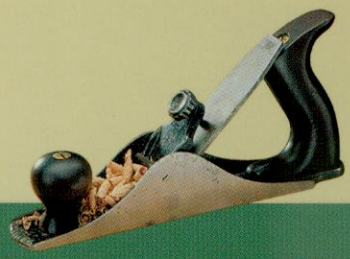

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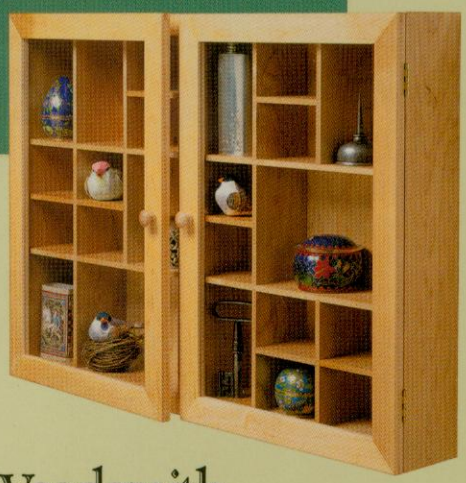

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