NO. 49 NOTES FROM THE SHOP $2.50

Woodsmith®

Woodsmith

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All back issues of *Woodsmith* are still available. Send for a free booklet describing the contents and prices of all back issues.

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If you have a friend who would like to see a copy of **Woodsmith**, just send the name and address, and we'll send a sample (at no cost).

Sawdust

ABOUT THIS ISSUE. I think I've finally discovered the secret of master craftsmen. It's *not* that they already know every trick and technique there is to know about woodworking. It's that they have fun learning them.

The little tricks often become critical to the success of a project. How do you cut a groove so it's exactly centered on the edge of a workpiece? Or how do you cut a rabbet on plywood and prevent the edge of the plywood from splintering?

Whenever I discover the answers to these kinds of questions, it makes me feel like I'm really beginning to learn something. And that I'm making some progress at getting better at what I'm doing.

The interesting part of all this is how the discovery happens. It's almost always out of necessity, and it almost never happens right away.

For example, there's a trick to cutting a rabbet on plywood without splintering the edge (shoulder). If you score the shoulder line first (with a knife cut), the router bit (or saw blade) won't splinter the surface of the plywood.

But knowing that alone doesn't solve the problem. For this to work, the score line has to be exactly on the shoulder — exactly where the bit is going to cut. That little detail created a problem that for years I could never solve.

Then all of a sudden, click. The light went on and I discovered a neat little trick for making that score line. (It's shown on page 22.) That one little discovery made my day.

We try to include as many of these tips as we can in each issue. Most of them are tucked away somewhere in the midst of the artwork for the projects, or referred to in the text. But in this issue, we had more than we could get in the project articles so we expanded the Talking Shop section to include a few more tips.

PUBLISHER'S STATEMENT. Each year in this issue we are required by the Post Office to publish the Statement of Ownership shown below. Basically, it shows that our circulation was up to 269,000 as of October of last year. That compares to 236,000 the year before.

Although it's fun to look at the numbers and see growth, growth has never been the goal of *Woodsmith*. When it started in 1979, I decided the *only* goal of the magazine (and of the whole company for that matter) was one thing: service to woodworkers.

If we spent a lot of time and effort looking at the circulation and constantly trying to increase it, we would certainly loose sight of our real purpose. I felt if service came first, circulation (and maybe even profits) would surely follow.

But once a year when I have to fill out this form, it's fun to see the numbers grow — and know the reason behind the growth.

INDEX. Also in this issue we've included a four-page index to all the articles, projects, and information shown in the 48 issues of *Woodsmith* published to date. As we did last year, the index is divided into two parts: the first section lists general information and techniques, while the second section lists all the projects.

NEXT MAILING. The next issue of *Woodsmith* (No. 50) will be mailed during the week of April 27, 1987.

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION

(Required by 39 U.S.C. 3685)

1. Title of Publication: Woodsmith. 1a. Publication No.: 0164-4114. 2. Date of Filing: October 1, 1986. 3. Frequency of issue: Bimonthly. 3a. No. of issues annually: six (6). 3b. Annual subscription price: $10.00. 4. Complete mailing address of known office of publication: 2200 Grand Avenue, Des Moines, (Polk County), Iowa 50312. 5. Complete mailing address of the headquarters of general business offices of the publisher: 2200 Grand Avenue, Des Moines, Iowa 50312. 6. Complete address of publisher, editor, and managing editor: Publisher: Donald B. Peschke, 2200 Grand Avenue, Des Moines, Iowa 50312, Editor: (same as publisher), Managing Editor (none). 7. Owner: Woodsmith Publishing Co., 2200 Grand Avenue, Des Moines, Iowa 50312; Donald B. Peschke, 2200 Grand Avenue, Des Moines, Iowa 50312; Theodore M. Kralicek, 2200 Grand Avenue, Des Moines, Iowa 50312. 8. Known bondholders, mortgagees, and other security holders owning 1 percent or more of total amount of bonds, mortgages or other securities: None. 9. (Does not apply) 10. Extent and nature of circulation:

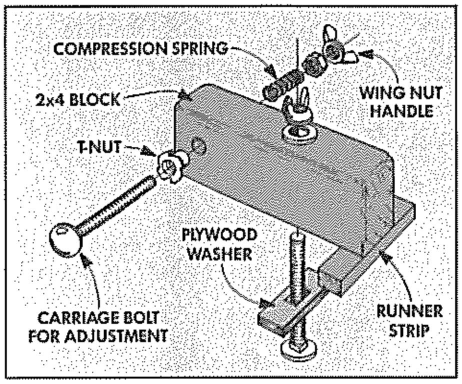
	Average no. copies each issue during preceeding 12 months	Actual no. copies of single issue published nearest to filing date (Sept. 1986)
A. Total no. copies printed (net press run)	277,655	302,480
B. Paid and/or requested circulation		
1. Sales through dealers and carriers, street vendors and counter sales	4,283	4,394
2. Mail subscriptions (paid or requested)	261,972	265,071
C. Total paid and/or requested circulation	266,255	269,465
D. Free distribution by mail, carrier or other means, samples, complimentary, and other free copies	103	96
E. Total distribution	266,358	269,561
F. Copies not distributed		
1. Office use, left over, unaccounted, spoiled after printing	11,090	32,636
2. Returns from news agents	207	283
G. Total	277,655	302,480

11. I certify that the statements made by me above are correct and complete. (signed) Donald B. Peschke, Publisher/Editor

Tips & Techniques

ROUTER TABLE MICRO ADJUSTER

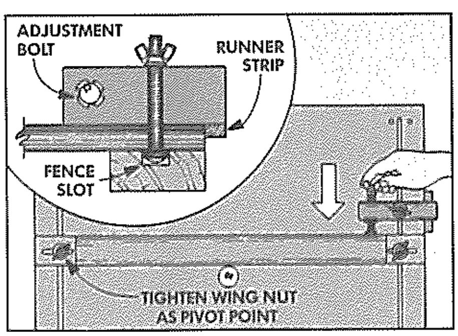
I liked the tip in *Woodsmith* No. 44 for making very fine adjustments on the router table (using playing cards as gauge shims), but I decided to make a permanent micro adjuster for my router table.



To make the micro adjuster, begin by cutting a piece of 2x4 to a width of 2" and length of 6". Then nail and glue a small runner strip under one end of the block to hold the block 90° to the edge of the router table.

The adjuster is held down to my *Woodsmith* router table just like the fence — with a carriage bolt, wing nut, washer, and a plywood washer that fits in the groove cut in the support arm under the table. The distance from the runner strip to the carriage bolt hole should equal the distance from the edge of the table to the fence slot.

The adjustment mechanism is made from another carriage bolt that presses against the back of the router table fence. The bolt fits through a T-nut in the block, and there's a nut and wing nut tightened against each other as a handle on the end of the bolt. I added a compression spring between the nut and the block to put some tension on the bolt and keep it from vibrating loose.



To use the micro adjuster, fit it into the slot in the router table and tighten it down right behind the fence. Now bring the adjustment bolt up tight against the back of the fence.

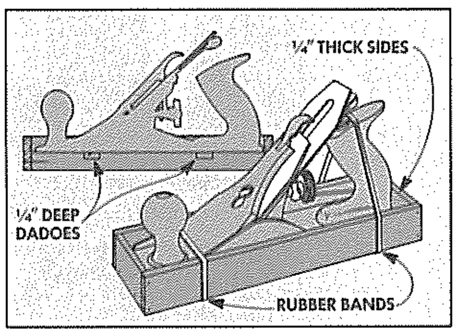
Then, to change the fence setting, keep the wing nut that holds the far end of the fence to the table fairly tight (as a pivot point) and loosen the wing nut on the near end of the fence. To move the fence closer to the bit, turn the adjustment bolt clockwise. To move the bit away from the fence, hold the fence tight against the bolt with one hand and turn the adjustment bolt counterclockwise with the other. Once the fence is in its new position, lock it down tight.

You can really sneak up on a cut since a full turn of the adjustment bolt equals less than 1/32" movement at the bit.

T.A. Igneczi
Goffstown, New Hampshire

PLANE SHOE

Recently I "fine tuned" my plane and wanted to keep the cutting edge and sole in top condition. So I decided to spend a few more minutes and make a wooden shoe (what I call a "sole mate") to protect the plane.



The shoe is simply a low box with a couple 1/4"-deep dadoes across the bottom. The distance from the center of the dadoes to the ends of the box should equal the distance from the nose of the plane to the plane iron. Then the plane can be set into the shoe with the iron projecting down into the dado without damaging it. If the plane is put into the shoe "backwards," there's another dado to accept the iron.

To make a shoulder around the bottom, I boxed in the sides and ends with 1/4"-thick wood strips.

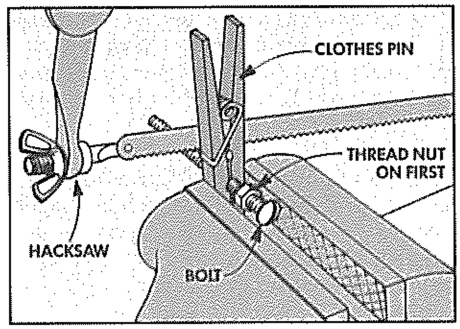
When it's necessary to carry the plane in a toolbox with other tools, secure the shoe to the plane with rubber bands.

Gilbert G. Strubel
Cherry Hill, New Jersey

PROTECTING THE THREADS

When I hacksaw off the end of a too-long bolt or cut off the head, it's usually easiest to hold the bolt securely in a machinist's vise. The problem is that the metal faces on a vise can damage the threads on the bolt.

I recently found a solution for this problem as I walked through the laundry room on the way to my shop. I use a spring-type clothes pin to grab the bolt before putting it in the vise. This protects the threads and keeps the bolt from turning or slipping. (On a wooden bench vise, it protects the wood faces from the threads.)



Whenever I cut a bolt like this, the threads always get goofed up a little right at the cut line. To restore the threads, turn a nut on the bolt *before* cutting it off. Then when you unscrew the nut, it "cleans" the threaded end.

Saul Isler
Cleveland Heights, Ohio

TEMPLATE IDEAS

We recently received a couple good tips on making templates for marking parts:

Lawrence Kroesing of Pendleton, Oregon makes his templates from 3/16" clear Plexiglas. The clear plastic comes with a protective paper on it so you can easily draw the pattern on the paper, cut and sand the plastic to shape, and then remove the paper. Since it's clear, you can see knots, flaws, and grain pattern you may want to use or avoid when laying out pieces.

Chip Schmidt of Cedar Falls, Iowa uses plastic laminate scraps for his templates. Plastic laminate is colorful so it doesn't get lost among the wood scraps, and you can label it or make notes on it with a pencil. The laminate is so thin that you can drill a tiny hole in it and stick a pencil lead through the hole to mark screw hole locations.

SEND IN YOUR IDEAS

If you'd like to share a woodworking tip with other readers of *Woodsmith*, send your idea to: *Woodsmith*, Tips & Techniques, 2200 Grand Ave., Des Moines, Iowa 50312.

We pay a minimum of $10 for tips, and $15 or more for special techniques (that are accepted for publication). Please give a complete explanation of your idea. If a sketch is needed, send it along; we'll draw a new one.

Crystal Table Clock

A LOOK INTO TIME

As a kid I always wondered what it would be like to be *inside* a clock. All those gears, springs, hammers, and chimes working together in perfect harmony. Though I can't actually get inside this clock, looking in may be the next best thing.

The clockworks, pendulum, and brass bob of this table clock are housed in a four-sided glass case. And the glass we used (see Sources, page 24) is beautiful hand-cut beveled glass.

To add another interesting feature, we've designed the clock around four columns — miniatures of the type of stately columns you would expect to find in front of an elegant mansion. And that's where I started construction — making the columns.

COLUMN BLANKS

Begin work on the four columns (A) by cutting eight pieces of 4/4 stock (13/16" actual thickness) to rough dimensions of 1½" wide and 13" long.

Then glue the pieces into pairs to form four column blanks, see Fig. 1. Try to line up the pairs so the grain direction (and, if possible, color) of the pieces match. Then the columns can be cleanly routed and each column will appear as one solid piece. (Note: Instead of gluing up blanks, you could use 6/4 stock.) I also took the time now to glue up an extra blank to be used as a test piece to set up the router table.

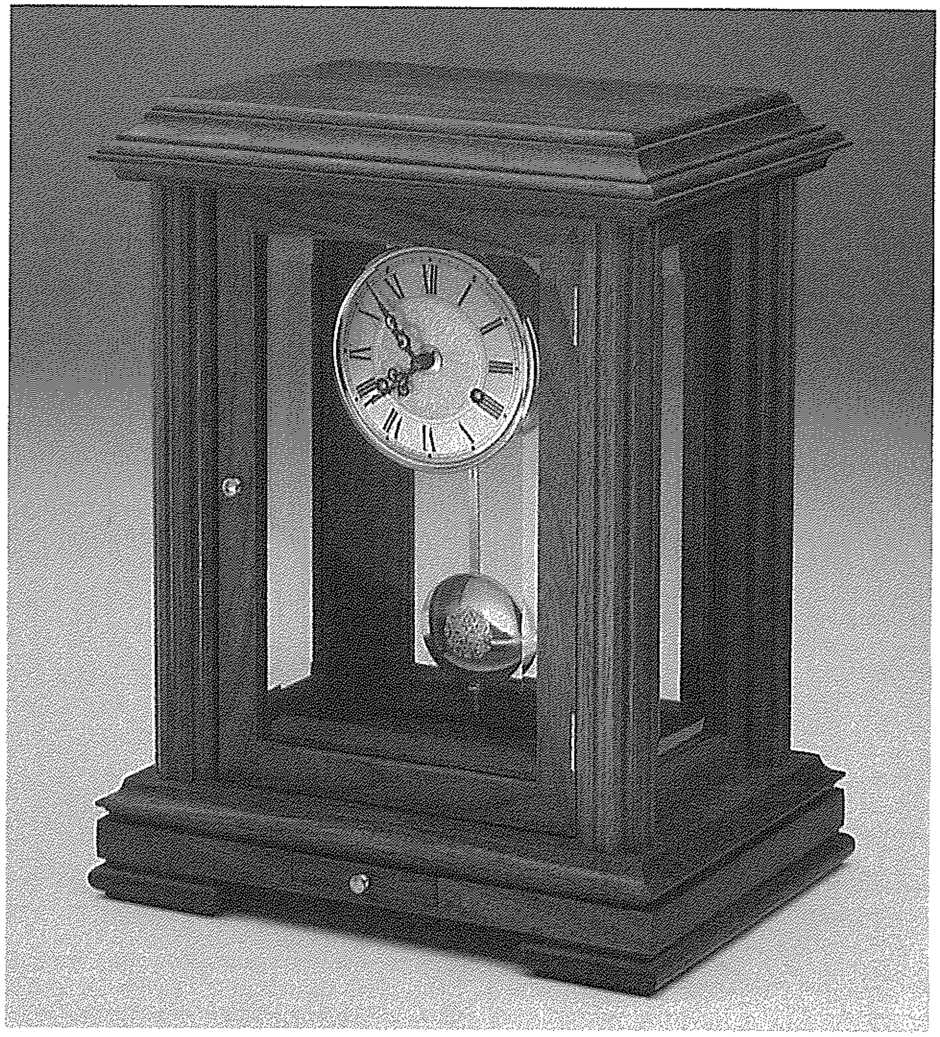
After the glue dries, square up the blanks to 1¼" square, see Detail in Fig. 1. (Shop Note: Before squaring up the blanks, it's important to spend a few minutes to make sure your rip fence and saw blade are 90° to the table.)

CHAMFER

The columns almost appear as though they are round, maybe even turned on a lathe. The trick here is to start by making each blank into a heptagon (a seven-sided object). This isn't as difficult as it sounds because in this case the heptagon is just a partially completed octagon — or really a square with three corners chamfered off.

LAYOUT. To make the heptagon, first mark a centerline on one end of the test blank, see Detail in Fig. 1. Then measure ¼" each direction from the centerline and place a mark. The distance between these marks (½") is equal to one face of the heptagon.

There are a couple things to note here. First, only five of the seven faces of the column are equal — it's an irregular heptagon. The other two faces are wider, refer to Fig. 4. Second, because of the geometry



MATERIALS LIST

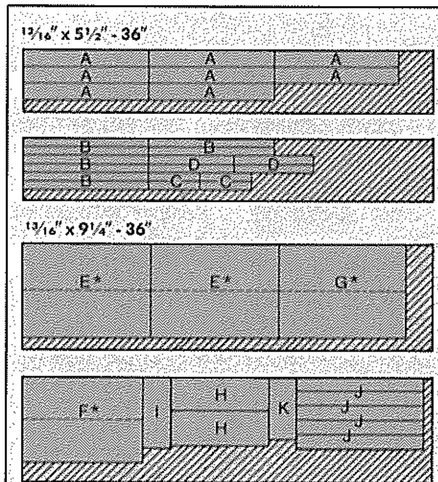
Overall Dimensions: 11½" w x 8 7/16" d x 15 1/16" h

A	Columns (4)*	1¼ x 1¼ - 11
B	Door/Side Frame Stiles (8)	13/16 x 13/16 - 11
C	Side Rails (4)	13/16 x 13/16 - 4 7/16
D	Door Rails (4)	13/16 x 13/16 - 7½
E	Case Top/Bottom (2)**	13/16 x 8 3/16 - 11¼
F	Top Cap (1)**	13/16 x 7 7/16 - 10½
G	Drawer Base (1)**	13/16 x 8 3/16 - 11¼
H	Feet (2)	13/16 x 2¾ - 8 7/16
I	Key Drawer (1)	½ x 6 - 2 15/16
J	Glass Stop	¼ x ¼
K	Spacer Block (1)	½ x 4 7/16 - 2¾

* Build up columns from two pieces of 4/4 stock.

** Edge-glue pieces to form Case Top/Bottom, Top Cap, and Drawer Base.

CUTTING DIAGRAM



* Rip and edge-glue these pieces

involved, the *actual* width of each of the five equal faces is just a little (.03") greater than ½", but for all practical purposes we can refer to this as ½".

TEST CUTS. To cut the ½" faces, mount a chamfer bit in the router table and raise the bit about ¼" above the table, see Fig. 2. Now cut about 1" along one corner of the test blank, see Step 1 in Fig. 3. Next turn the blank counterclockwise 90° and make a 1" cut along that corner, see Step 2. (I only cut in an inch so I didn't ruin the entire blank if the setting was too deep.)

When the second cut has been made, measure the three faces. The two chamfered faces will probably be less than ½" wide and the one in the middle more than ½". (It won't quite reach the layout lines.) Now raise the chamfer bit *very slightly* and repeat the cuts. The object is to sneak up on it until the three faces are equal, see End View Detail in Fig. 2.

CHAMFER THE BLANKS. Once the router bit was set to the correct height to get equal faces, I routed the actual blanks. It's just a matter of chamfering the first two corners like the test piece, but push the workpiece all the way through. Then turn the blank another 90° and rout a third chamfer, see Step 3 in Fig. 3.

FLUTES

When the five faces were the same width, I routed ¼" flutes in each face. To do this, mount a ¼" core box in the router table and raise it 3/32" above the table. Next, center the bit on the width of the blank (5/8" from the fence), see Fig. 4.

TEST CUT. Once the bit is centered on the blank, it will also be centered on all of the chamfered faces. To test if the bit is centered on a chamfered face, rout about 1" on the test piece. Now, measure the shoulders on either side of the flute to see if they are uniform. If the shoulders are uniform, the flute is centered on the face. If it's not, move the fence slightly in or out and try again on the test piece. (Note: There's a good tip for micro-adjusting the router table fence on page 3.)

ROUTING THE FLUTES. After the bit was centered on the chamfer, I began routing the columns. Start by facing the 90° inside corner *away* from the fence, see Step 1 in Fig. 5. Now make one pass the complete length of the column.

Next, rotate the column counterclockwise and rout the second flute, see Step 2 in Fig. 5. Continue this process for the third and fourth flutes, see Steps 3 and 4.

There's an extra step for the fifth flute. If you were to continue to turn the piece counterclockwise, the inside (90°) corner would be against the fence and the bit wouldn't be centered on the last face. Instead, turn the piece end for end so the inside (90°) corner faces away from the fence again and rout the last flute, see Step 5.

FIGURE 1

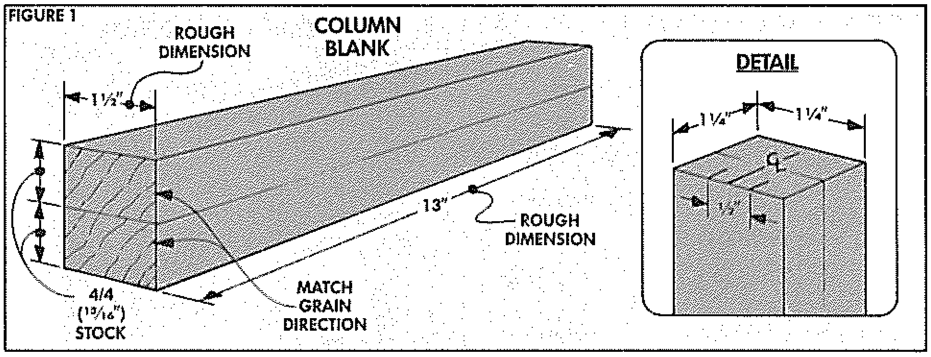


FIGURE 2

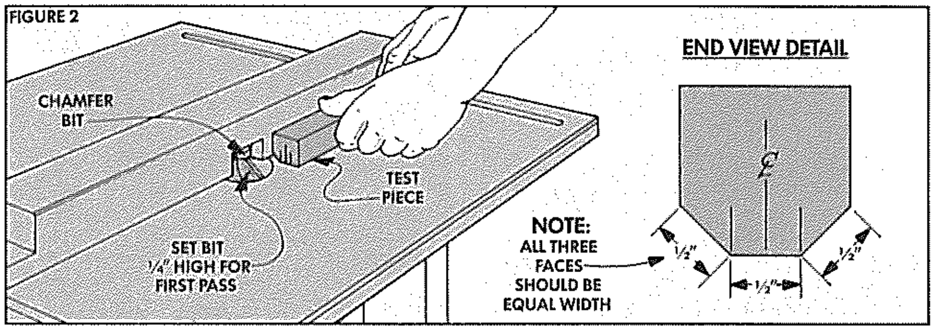


FIGURE 3

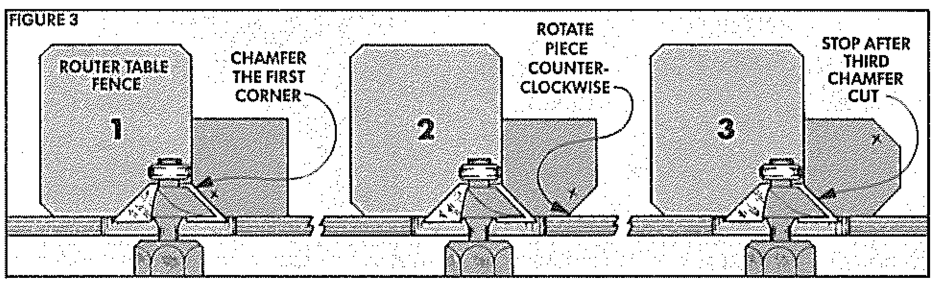


FIGURE 4

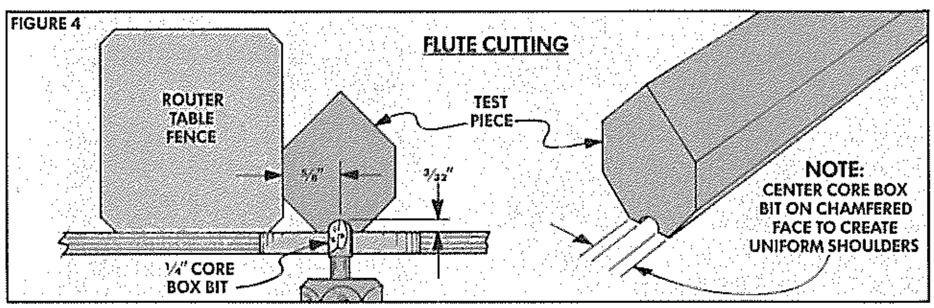
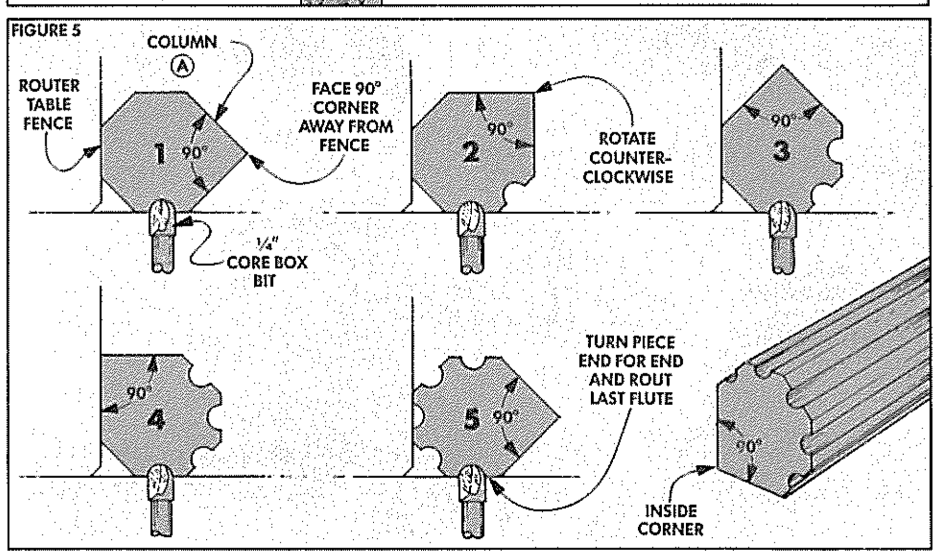


FIGURE 5



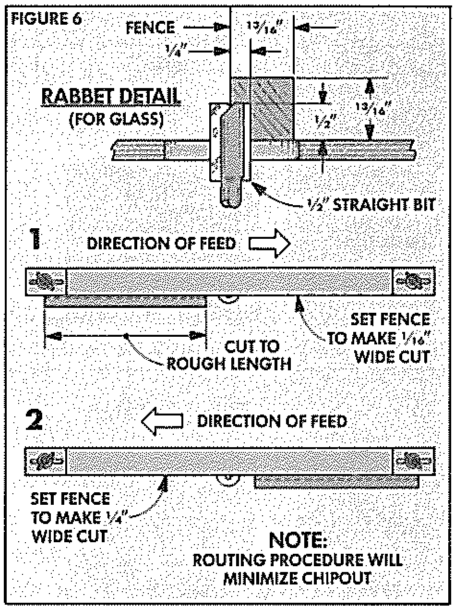


FIGURE 6

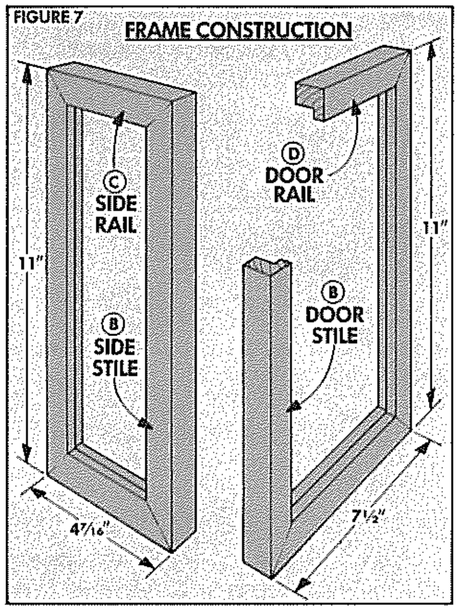


FIGURE 7

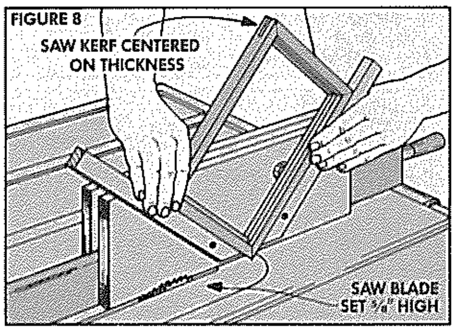


FIGURE 8

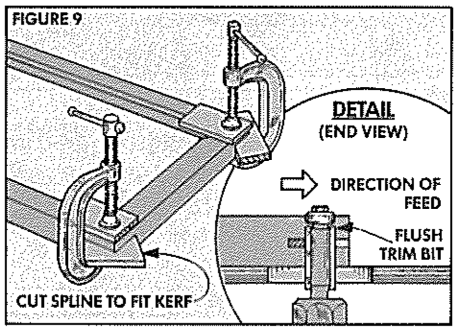


FIGURE 9

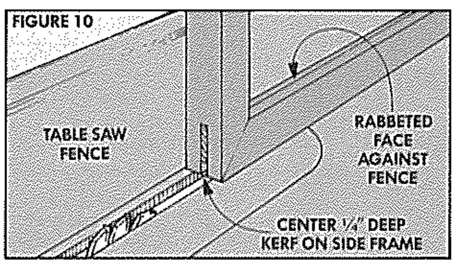


FIGURE 10

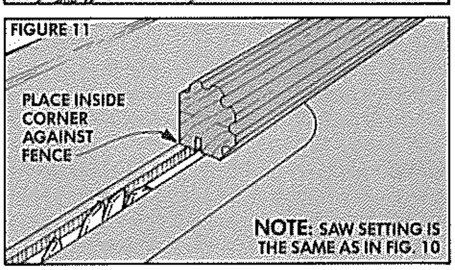


FIGURE 11

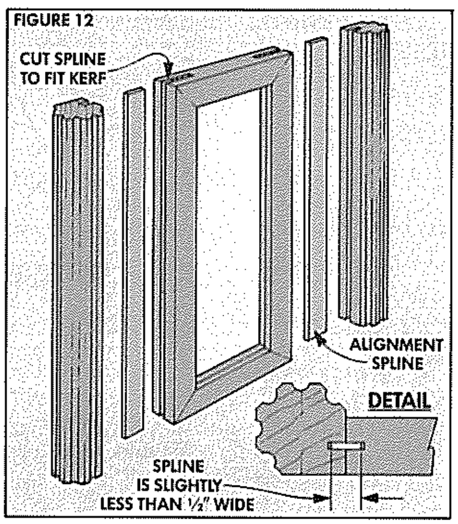


FIGURE 12

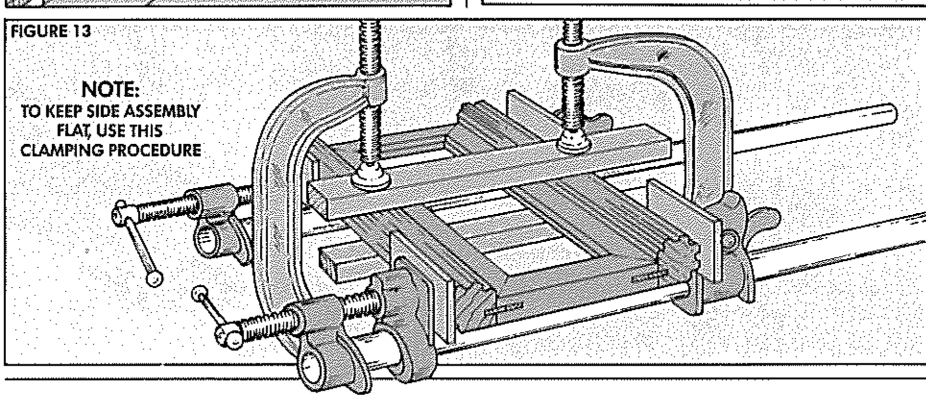


FIGURE 13

After the columns are complete, work can begin on the glass case that houses the clockworks. The case is made from four frames — two identical side frames and two identical hinged front/back door frames.

CUT OUT STOCK. Start work on the four frames by cutting all the stiles and rails from 4/4 stock to 13/16" square. Now cut eight stiles (B) to a rough length of 12". Then cut four side rails (C) to a rough length of 6" and four door rails (D) to a rough length of 9".

GLASS RABBET. Before mitering the frame pieces to final length, I routed rabbets for the glass on the back edges with a 1/2" straight bit, see Fig. 6.

To keep the bit from chipping out the exposed surface, rout in two passes. First, set the fence to take a light 1/16" "skim cut" and make a backward (left to right) pass, see Step 1, Fig. 6. (Hold the wood securely as the bit tends to pull the wood.)

To finish the rabbet, move the fence to take a full 1/4"-wide cut and make a normal right to left pass, see Step 2.

MITER TO LENGTH. Once the rabbets are cut, miter the pieces to final length — making sure the rabbets are on the *inside* of the frames. (Shop Note: The dimensions given in Fig. 7 are what we needed to hold the beveled glass. It's best to order the glass first and cut the frames to fit the glass.)

ASSEMBLY. Once all the frame pieces are cut to length, glue each frame together checking all the corners for square.

SPLINE. To strengthen the miters, I added an open spline across each corner. To do this, hold the frame firmly in a holding jig and cut a single kerf at each corner, see Fig. 8. Now cut splines the thickness of the kerf and glue one into each corner, see Fig. 9. (For a complete explanation on making this joint, see *Woodsmith* No. 36.)

Next, I usually saw off the "ears" of the splines close to the frame and then sand or chisel them level. But with 16 splines to clean up, I decided to try a new approach.

First I sawed the ears off close as usual. But then I mounted a flush trim bit in the router table and routed the splines off flush, see Detail in Fig. 9. (To prevent chipout, rout from the corner toward the center.)

ASSEMBLY

Once the splines are flush with the frames, cut the columns to the same finished length as the frames (11"). Then the columns are glued to the sides of the frames.

SPLINES. To help line up the columns and side frames, I added alignment splines. To do this, cut a 1/4"-deep kerf centered on the width of each side frame, see Fig. 10. Then, without changing the saw, cut a kerf in *one* side of each column with the inside (90°) corner against the fence, see Fig. 11. Now cut splines to fit the kerfs, see Fig. 12.

CLAMPING. Next, insert the splines between the frames and the columns, and then glue and clamp together a side assembly (one side frame and two columns). To keep the side assembly flat, I C-clamped a couple of pieces of scrap above and below the frame, see Fig. 13.

HINGES AND CATCH

When the side assemblies are dry, locate the door hinges on the back of each assembly. Position the back of the hinge ⁵⁄₁₆" from the joint line and mark the screw holes with an awl, see Fig. 14. Then drill ¹⁄₁₆"-dia. pilot holes ¼" deep into the column.

Now drill a hole for a bullet catch on the back of the other column, see Fig. 14. Center the hole on the length of the column and ⅜" from the joint line.

CASE TOP/BOTTOM

Once the bullet catch holes are drilled, the next step is to add the top and bottom pieces (E) to the case. Make blanks for these pieces by edge-gluing two pieces of 4/4 stock (to minimize potential warp). Then dry assemble the case (see Fig. 16) and cut the top and bottom pieces 1¼" larger (in both dimensions) than the case (outside column to outside column).

DRILL HOLES. To screw the top and bottom to the columns, drill countersunk ³⁄₁₆" shank holes near each corner (labeled "A" in Fig. 15). Then to screw on a top cap (refer to Fig. 19), drill four more countersunk shank holes ("B") up from the bottom face of the case top only, see Top Cross Section in Fig. 15. Finally counterbore two holes ("C") near the center of the case top for the screws that attach the clockworks.

To locate the corresponding pilot holes in the top of the columns, dry assemble the case. The easiest way to center the top and bottom on the frames is to mark centerlines on both the frames and the top and bottom. Then line up the centerlines, see Fig. 16. (Also see Talking Shop, page 23.)

Once the centerlines are aligned, mark the location of the pilot holes in the columns with an awl. Then drill ¾"-deep pilot holes into each column with a ³⁄₃₂" bit.

ROUT THE PROFILES. Before screwing the top and bottom pieces to the columns, rout the edge profile on both pieces. To make it easier to rout a piece standing on edge, I screwed a tall auxiliary fence on the front of the router table fence, see Fig. 17.

Now mount a ¼" round-over bit in the router. Then with the workpiece standing on edge and held tight against the fence, rout the profile, see Step 1 in Fig. 18. (Be sure the top face of the top, and bottom face of the bottom are toward the fence.)

Next, lay the workpiece flat on the router table with the round-over profile facing up and rout a ⅜" cove on the opposite edge, see Step 2. Finally, screw (don't glue) the top and bottom pieces to the columns.

FIGURE 14

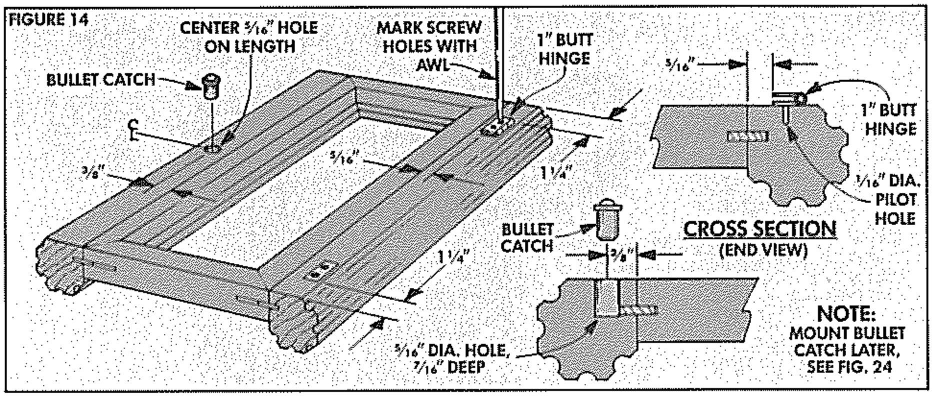


FIGURE 15

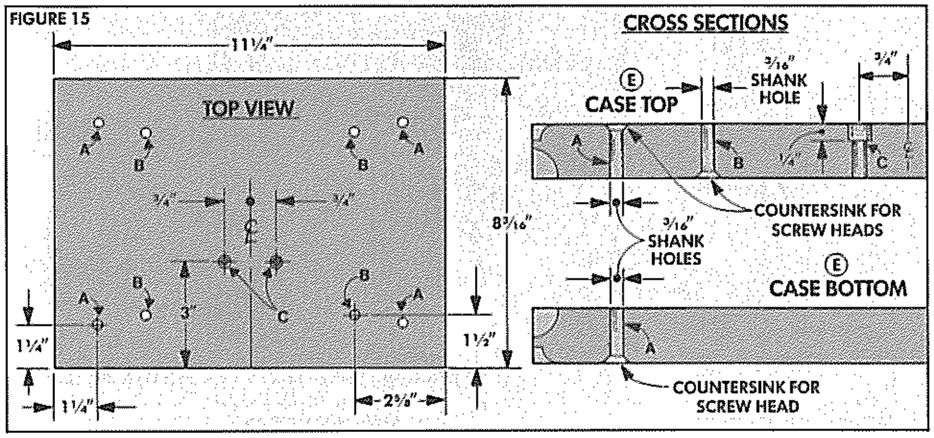


FIGURE 16

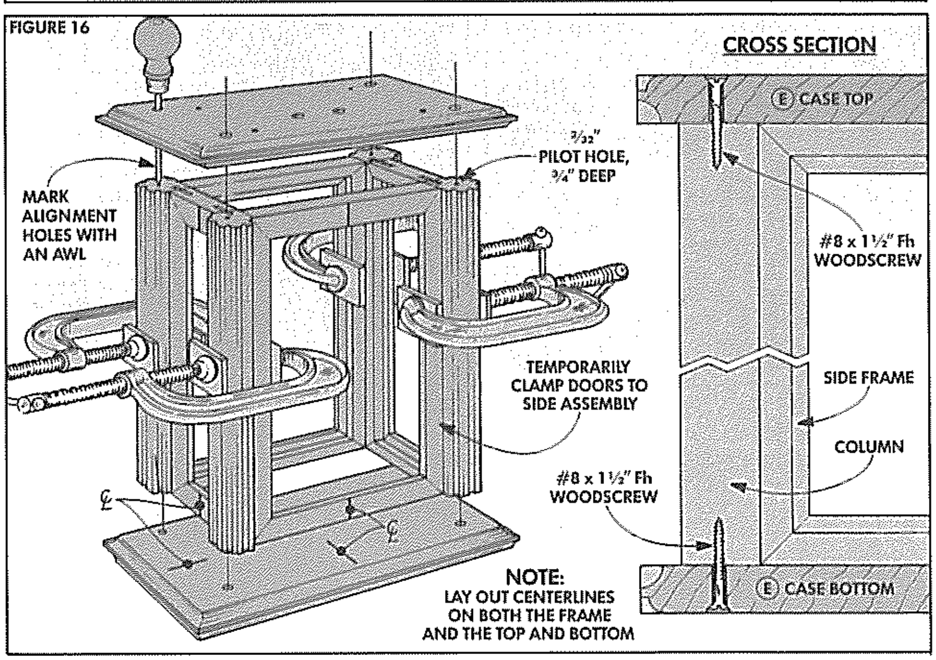


FIGURE 17

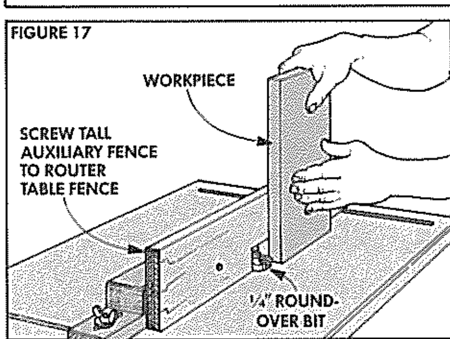
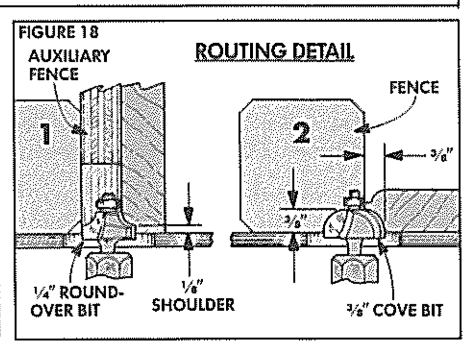


FIGURE 18



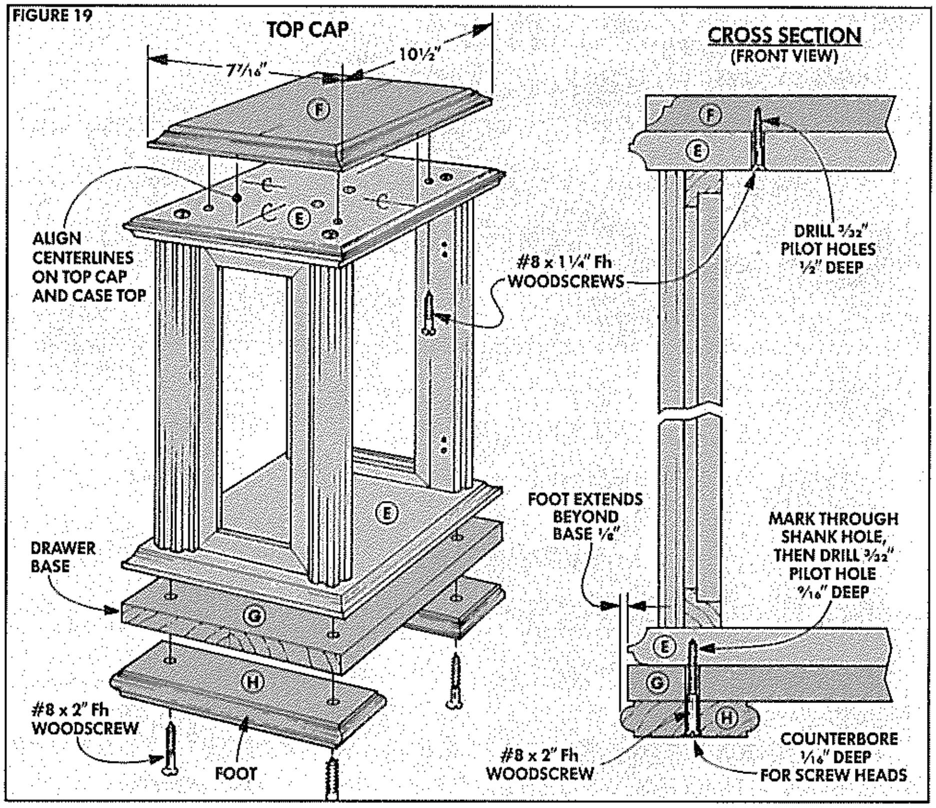


FIGURE 19

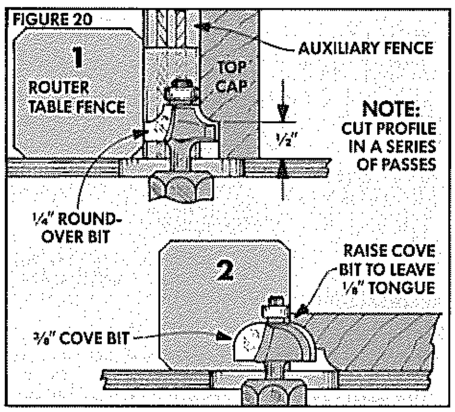


FIGURE 20

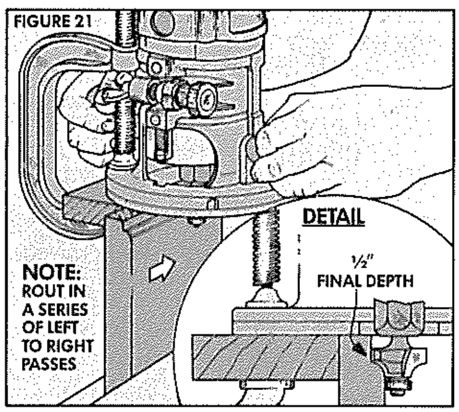


FIGURE 21

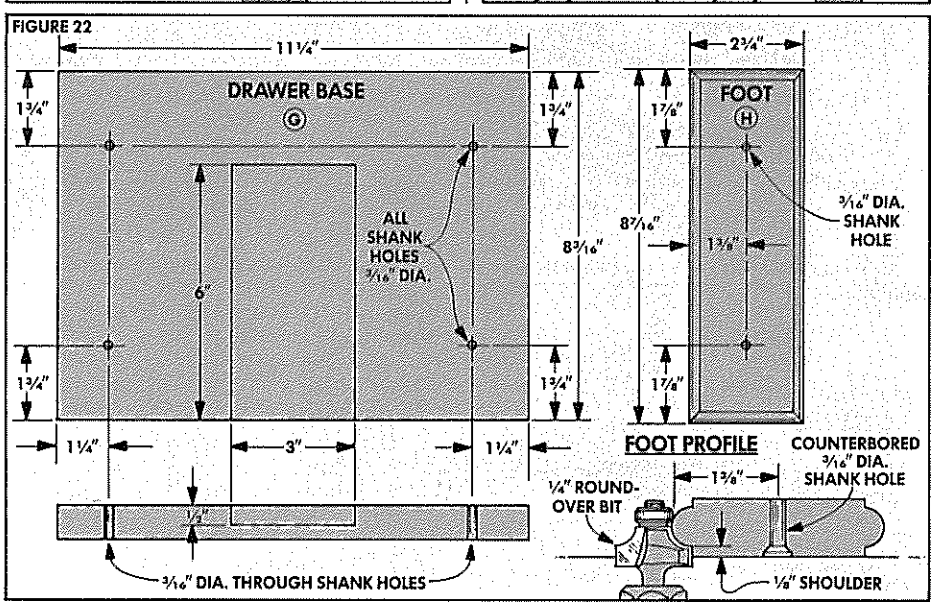


FIGURE 22

TOP CAP

After the main case is assembled, the top cap, drawer base, and feet are added.

CUT TO SIZE. Start by edge-gluing a blank for the top cap (F) from 4/4 stock. Then cut it ¾" smaller (in both dimensions) than the case top (E), see Fig. 19.

LOCATE SCREW HOLES. Next, center the top cap (F) on the top (E) of the case. Then reach inside the case and mark through the holes in the top (E) into the bottom of the top cap (F) and drill 3/32"-dia. pilot holes.

ROUTING THE PROFILE. The edge of the top cap is routed in two steps — a deep ¼" round-over and a ⅜" cove, see Fig. 20. But I ran into a problem when routing the round-over because the bit wouldn't project high enough above the router table.

If your bit will *safely* project high enough (keeping at least ¾ of the shank in the collet), rout the round-over in a series of passes as shown in Step 1 in Fig. 20.

The alternative is to use a hand-held router. But the router has to run on the edge of the workpiece — not a very stable surface. To keep the router from tipping, I C-clamped a block to the router so the workpiece was sandwiched between the bit and the block and routed the round-over in a series of left to right passes, see Fig. 21. (Note: To prevent chipout, rout the ends first.)

Next, rout the cove with the top cap flat on the router table, see Step 2 in Fig. 20.

DRAWER BASE AND FEET

When the top cap is complete, edge-glue a drawer base blank (G) from 4/4 stock and cut it to the same size as the case bottom, see Figs. 19 and 22.

DRAWER RECESS. To hold the clock winding key, I made a drawer that fits into a ½"-deep recess routed in the drawer base, see Figs. 22 and 23. This recess can be routed free-hand with a hand-held router and then cleaned up with a chisel.

FEET. To complete the bottom part of the case, cut two feet (H) from 4/4 stock 2¼" wide and ¼" longer than the width of the drawer base (G), see Fig. 19. Then rout a ¼" round-over with a ⅛" shoulder on both feet, see Foot Profile in Fig. 22.

ASSEMBLY. Now the feet and drawer base can be attached to the case. The base is aligned flush with the case bottom and the feet project ⅛" beyond the front, back, and sides of the base, see Fig. 19.

Once the pieces are positioned, clamp them together and drill countersunk shank and pilot holes. Then screw the feet and drawer base to the bottom. (Note: To allow for wood movement and make it easier to finish, don't glue these parts together.)

KEY DRAWER

Once the pieces are screwed together, I cut a key drawer (I) to fit the recess, see Fig. 23.

When doing this, cut the drawer so that side grain, not end grain, will show on the front of the clock, see Fig. 23.

STOP SCREW. Since the drawer isn't as deep as the recess, I added a roundhead screw as an adjustable stop on the back of the drawer. By turning the screw in or out, the drawer front can be aligned flush with the front of the drawer base, see Fig. 23.

KEY RECESS. Next, drill a series of holes (½", ¾", and 1¼" diameters) to form a recess for the key, see Fig. 23. Then freehand rout out the waste between the holes. (Shop Note: Hold the drawer to the bench with carpet tape while routing.)

To raise up the key so you can get a finger under it, glue two 5/16"-long by ¾"-dia. dowels into the ¾"-dia. holes.

TAPER. Finally, sand a slight taper toward the back of the drawer to keep the drawer from sticking if it swells or cups.

DOORS

Once the drawer is complete, continue work on the doors. First, trim 1/16" off all four sides of each door to fit the opening, see Fig. 24. (See Talking Shop, page 22.)

HINGES. Now screw the hinges into the holes already drilled in the columns and slide the door into place. Then place a shim under the door so there's a uniform gap above and below, locate the hinges, and chisel out the mortises in the door frames.

CATCH PLATE. Once the mortises are cut, center the catch plate for the bullet catch on the opposite door stile and drill the screw holes, see Detail in Fig. 24.

FINISH. Before going any further I took the case completely apart and finished all the pieces with two coats of tung oil.

GLASS STOP. After finishing the case, the glass is mounted in the frames with ¼" x ¼" quarter-round stops (J). To make the stops, round over all four edges of a piece of 4/4 stock, see Step 1 in Fig. 25. Then make four 5/16"-deep kerfs to form an "H-shaped" block, see Step 2. Finally rotate the block on its side and trim off the quarter-round stops, see Step 3. Now miter the stops to fit in the rabbets, and apply tung oil finish.

Instead of using brads to mount the stops, I used another method. Glue 1"-long brown paper strips (from a paper sack) between the stops and the rabbets, see Fig. 26. If the glass needs replacing, simply insert a thin knife blade between the stop and frame and gently twist. The paper will split and the stops can be pulled out.

SPACER. To support the clockworks and act as a stop for both doors, cut a chamfered spacer block (K) to width to fit between the doors, see Fig. 27. Now center the block under the case top (E), drill through the pilot holes for the mounting screws, and glue the block in place.

GIVE IT THE WORKS. The last step is to screw the pieces together and mount the clockworks and hardware, see Fig. 24.

FIGURE 23

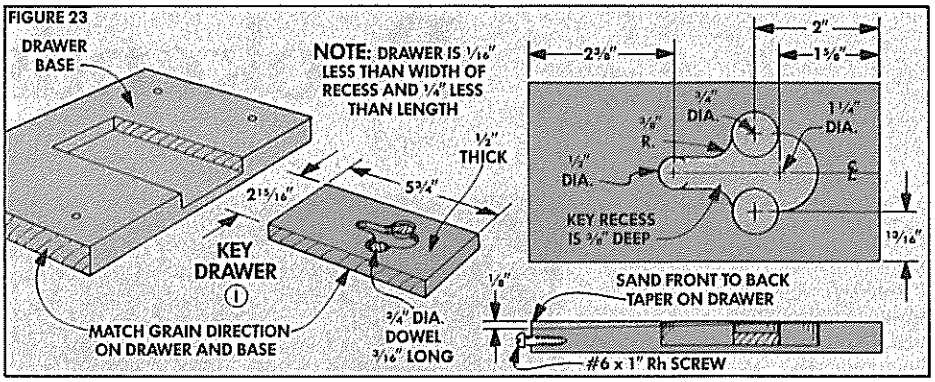


FIGURE 24

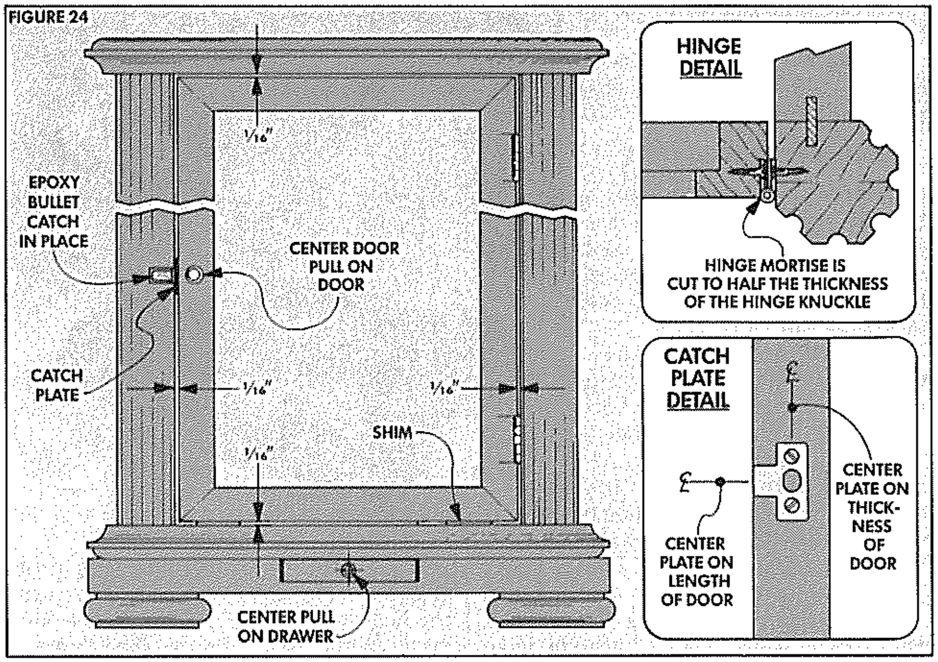


FIGURE 25

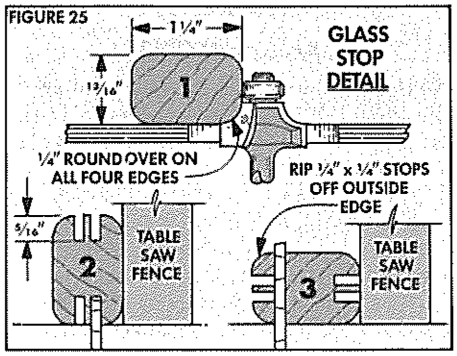


FIGURE 26

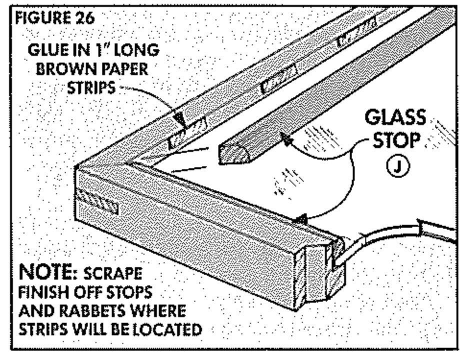
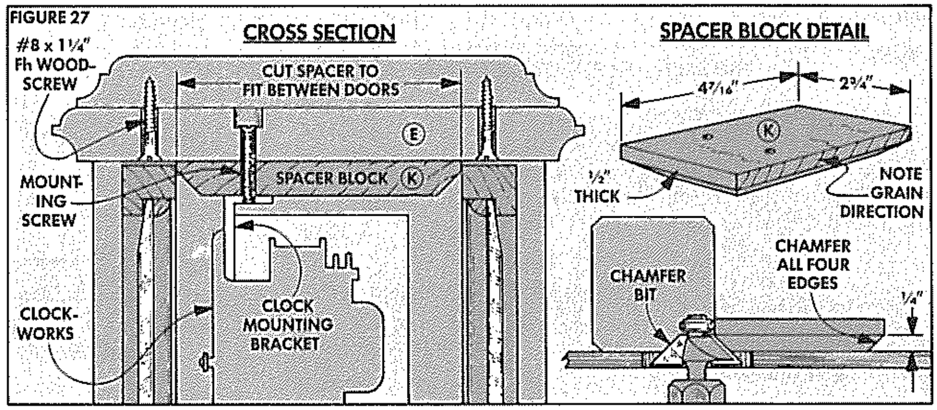


FIGURE 27

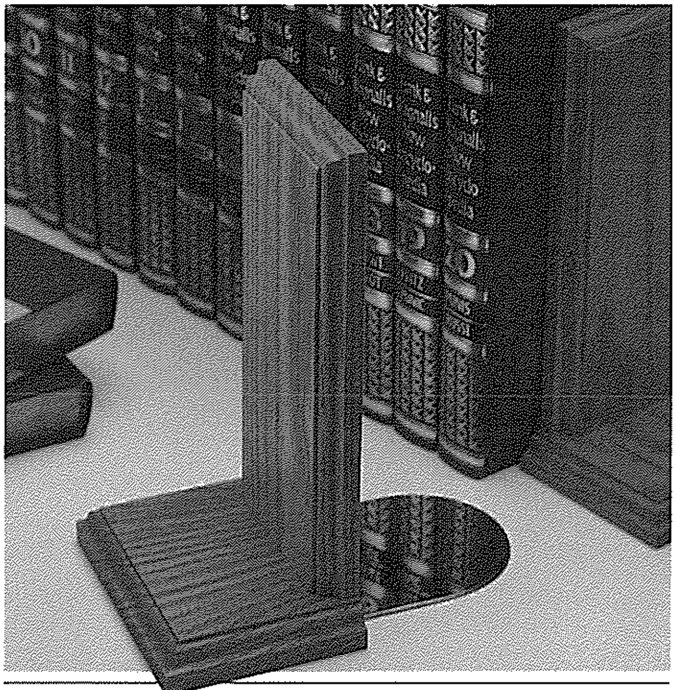


Bookends

SUPPORT YOUR LOCAL LIBRARY

As I started stocking my new bookcase (see page 12) with books on woodworking, I realized I needed some bookends to maintain order. That's when it dawned on me how scarce really good bookends are.

I've seen lots of *good-looking* bookends. But, there's more to a good bookend than good looks. It has a heavy responsibility and has to be designed to hold up.



NOT A MATTER OF MASS

No matter how big the books are, a bookend doesn't have to be massive to do its job. Design, not bulk, is the key. The trick is to let the books supply the weight to hold themselves up.

The easiest way to make a bookend that works is to evaluate why typical bookends — both heavyweights and lightweights — fall down on the job.

HEAVYWEIGHT. Bookends that rely on weight have to be huge to work. If you take a book out, even the heaviest bookends will slide when the library leans.

LIGHTWEIGHT. The most common lightweight bookends are L-shaped, see Fig. 1. They can be scaled to look great and have surfaces that invite decoration. But L-shaped bookends are nothing more than a block with most of the mass removed.

One common solution to make up for the missing mass is to add a non-slip surface to the bottom of the bookend. But this doesn't help. Since friction is directly related to weight, no matter how much "grab" the bottom of a bookend has, the L-shape still slides or tilts because it's not heavy enough to bear down for a good grip.

T-SHAPED BOOKENDS. The bookend design that does the trick is a modified version of the L-shape. If you extend the base with a base plate to give the bookend the profile of an upside down "T", you have the ideal shape, see Fig. 2.

The T-shape works because part of the base plate is under the books. This turns the bookend and the books into one solid mass, so the books rest on the plate and actually support themselves.

BASIC BOOKEND

All basic T-shaped bookends start out about the same. To make the one shown in the photo, I cut the base and back from 4/4 oak, see Fig. 3.

Then to dress it up a little, I used a 5/32" Roman ogee bit on the router table to profile the edges, see Detail A. Finally, I glued and screwed the two pieces together.

Note: To provide clearance for the router bit when routing a base plate recess, counterbore the screw holes 3/8", see Detail B.

BASE PLATE. This produces a basic bookend. To make it functional, a plate is added to the bottom of the base to complete the "T" shape. One end of this plate is covered by the books. The other end is recessed into the base.

MATERIAL. The trick, of course, is to make the plate thin enough to slip under the books. After trying several materials, I settled on two: plastic laminate and 14-gauge sheet brass, see Sources, page 24.

RECESS BASE. No matter which material is used, it's easier to cut the recess first and then cut the plate to fit the recess.

SET DEPTH. To do this, use a 1/2" (or larger) straight or mortising bit in the router table. Adjust the router so the bit sticks up above the table the thickness of the plate, see Fig. 4.

SET FENCE. Then to rout the 2" x 3" recess, I set up the router table using the fence and two stop blocks. To establish the length of the recess, set the fence 2" away from the far side of the bit, see Fig. 5.

SET STOPS. Then stops are used to control the width. I clamped plywood scraps to the router table so their edges were 4" from either side of the bit. Then, I routed the recess, using the fence and stops to control the limits of the cuts, see Fig. 6.

CLEAN UP CORNERS. After the recess is routed, square the corners with a chisel.

MAKE THE PLATE

Now the plate can be installed. This takes two steps: cutting the plate to size and fastening it in position.

CUTTING THIN MATERIAL. Cutting thin material on a table saw is tricky. The problem is the edge that overhangs the slot in the table insert vibrates as the blade cuts and the edge ends up ragged.

FIGURE 1 BOOKENDS WITHOUT BASE PLATE

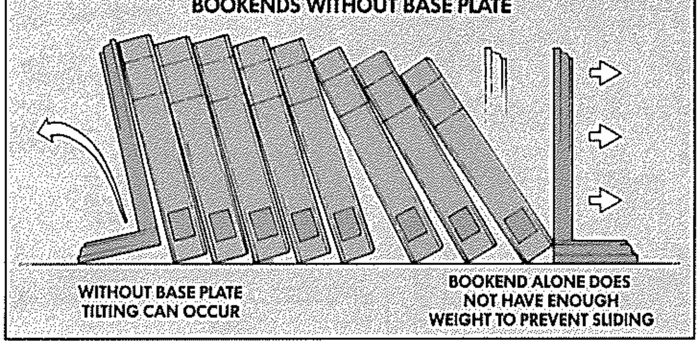
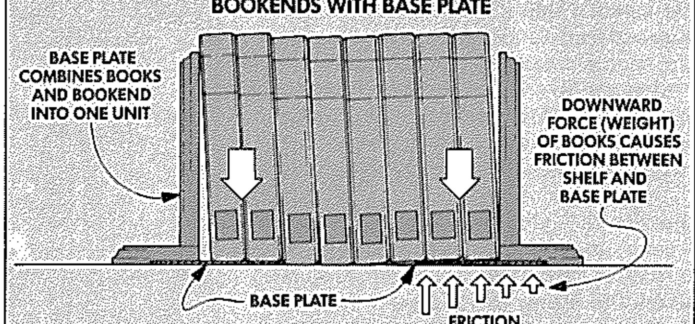


FIGURE 2 BOOKENDS WITH BASE PLATE



MASONITE BACKING. To support the plate all the way to the edge during sawing, I backed it with 1/8" Masonite. To do this, I used a couple strips of carpet tape to stick the plate to the Masonite, see Fig. 7.

CUT TO SIZE. Now cut the plate and Masonite to size on the table saw. Begin by sawing off one side to make sure one edge of the plate and Masonite is even.

Shop Note: Brass is very soft and is easy to cut with a carbide-tipped saw blade, see Sources, page 24.

Next, set the fence to the width of the recess in the base. With the freshly-cut edge against the fence, rip the plate to width. Then cut it to a length of 6".

END PROFILE. After the plate is cut to size, the end that slips under the books is cut to a semicircle with a sabre saw. First, draw the arc on the Masonite backing. Then, clamp the piece with the Masonite side up and cut the curve to shape with a sabre saw and file it smooth, see Fig 9.

CHAMFER EDGES. The last step before installing the plate is chamfering the edges on the router table. To do this, set the height of the chamfer bit so it takes just a tiny cut off the edge, see Fig. 10. Then, with the plate against the table, guide it past the bit with the Masonite riding on the bearing.

Finally, smooth the chamfer with 220-grit silicon carbide paper. Then separate the plate from the Masonite and knock off the other sharp edges with the sandpaper.

MOUNT THE PLATE

After the edges are smooth, the plate can be mounted to the base. This is where the method differs depending on whether the plate is plastic laminate or brass.

PLASTIC LAMINATE. A plastic laminate plate can be glued to the base with epoxy. Begin by roughing up the surface that will be mounted in the recess with 60-grit sandpaper. Then glue the plate in place.

BRASS. To mount the brass plate, I used a trick that dates back to the days when gunmakers inlaid decorative brass patchboxes on the stocks of flintlock rifles. The trick involves fastening the plate with brass screws, then filing off the screw heads flush with the plate.

INSTALL SCREWS. To install the screws, position the plate in the base recess. Then, drill pilot holes through the plate and into the base.

COUNTERSINK. After drilling the pilot holes, countersink just deep enough so the screw head is just part way into the plate, see Fig. 11. (The screw slot should be a little higher than the plate surface.)

FILE FLUSH. After the screws are tightened, file the heads off flush with the plate. This gets rid of the screw slot, leaving a solid brass "rivet" holding the plate to the base. Then sand and polish the bottom of the plate smooth.

FIGURE 3

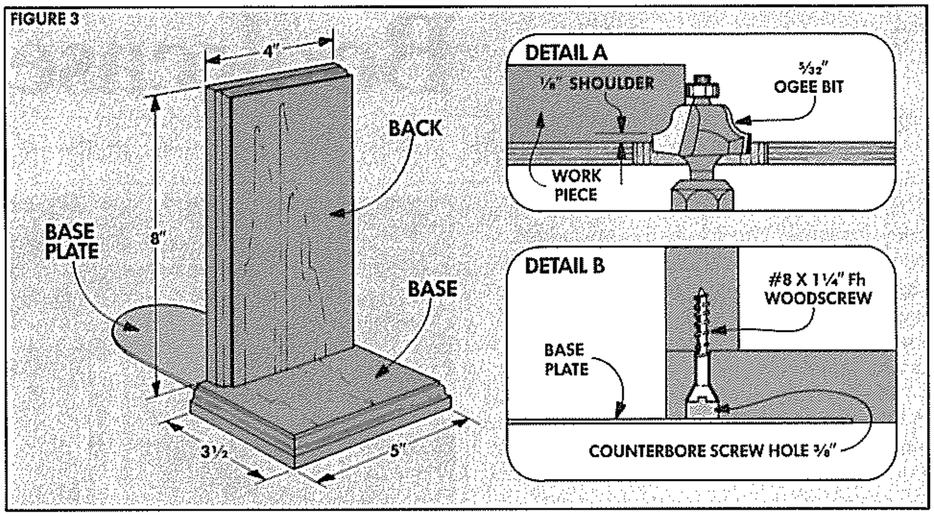


FIGURE 4

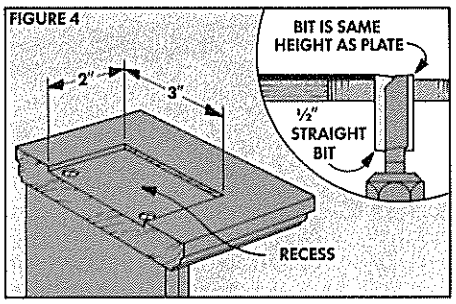


FIGURE 5

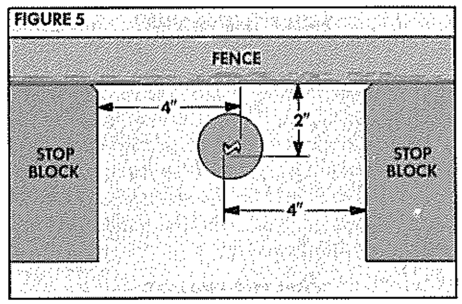


FIGURE 6

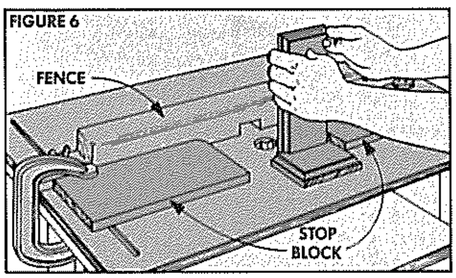


FIGURE 7

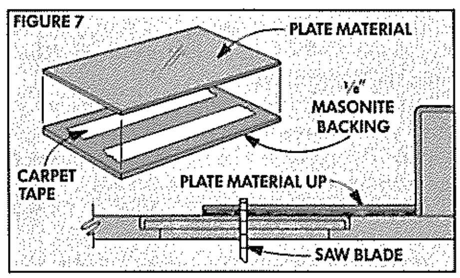


FIGURE 8

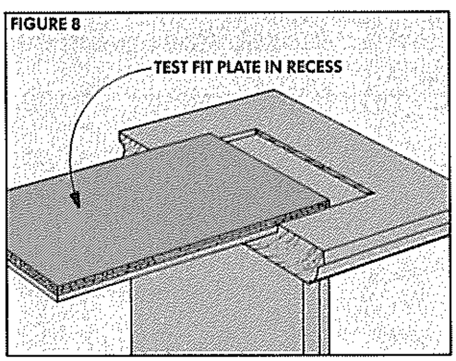


FIGURE 9

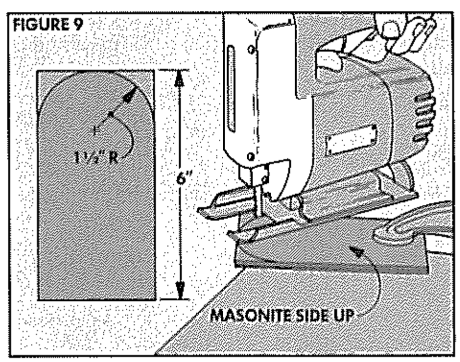


FIGURE 10

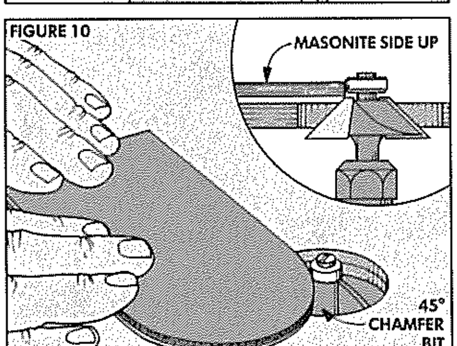
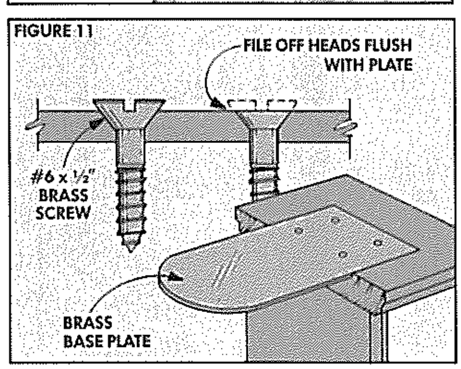
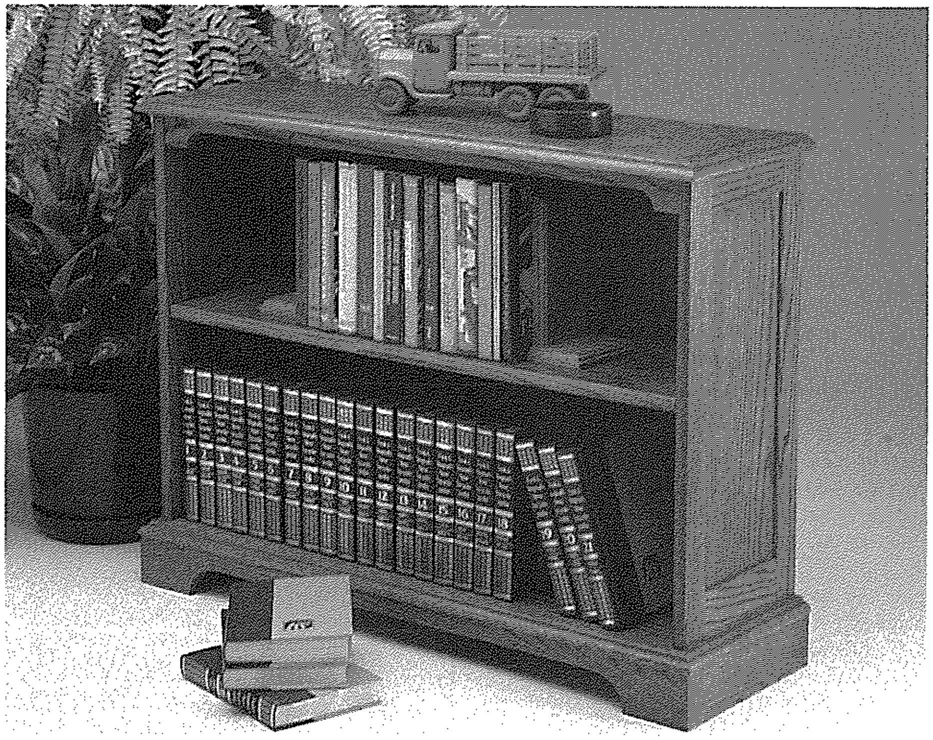


FIGURE 11



Bookcase

A FRAME AND PANEL HOME FOR TOMES



The problem with home libraries is that they keep growing. Encyclopedias are added to National Geographics, and soon a new bookcase is needed. 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.

The traditional bookcase shown here has relatively straight-forward joinery. The sides and back are frame and panel construction. And all parts are interlocked with variations of a tongue and groove joint.

MAKE THE FRAMES

I started construction by making the two side frames and the back frame. Begin by ripping 4/4 stock (13⁄16" thick actual) for all the bottom rails (C and G) to 2½" wide, see Fig. 1. Then adjust the fence to rip the top rails (B and F) and all the stiles (A and E) 2" wide. Now cut the rails and stiles to final length, as shown in Fig. 1.

JOIN THE FRAMES.

After all the pieces are cut to size, they're ready for the tongue and groove joints that hold them together.

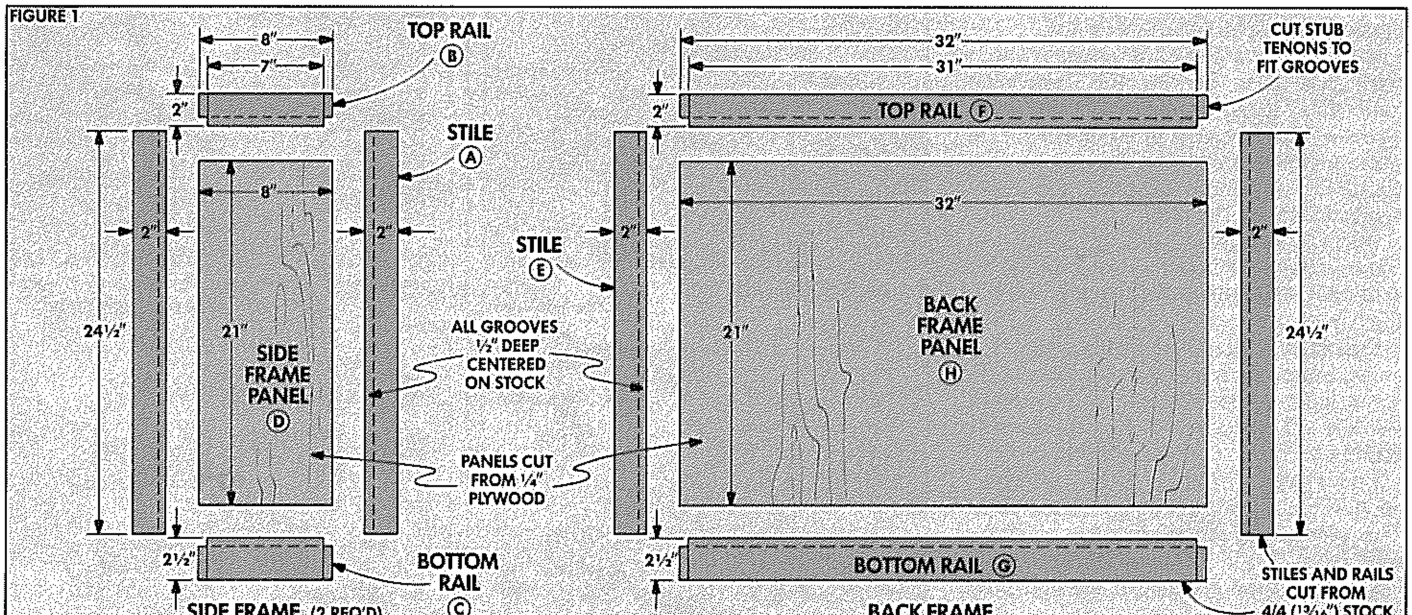
EDGE GROOVES. The grooves are cut so they're centered on the inside edge of all the frame pieces. (These grooves accept ¼" *hardwood* plywood which is usually thinner than ¼", so cut the grooves to fit the actual thickness of the plywood.)

POSITION FENCE. In order to cut the grooves centered on the edge of the workpiece, position the rip fence so the blade is slightly *off center*, see Fig. 2. Then cut a ½"-deep kerf the length of the workpiece. Now flip it end for end and make a second pass. This produces a centered groove.

SIDE 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 rear stiles (A) on the two side frames, see Fig. 4.

To position these grooves, begin by locating the fence 13⁄16" away from the *outside* of the blade. (This 13⁄16" measurement is equal to the thickness of the back frame's stile, refer to Detail in Fig. 4.) Now cut a ¼"-deep kerf on the face of the rear stile for the side frame. Next, move the fence slightly closer to the blade to widen the groove to ¼".

FIGURE 1



CUT THE TONGUES

After the grooves are complete, cut the tongues that tie the parts together.

STUB TENON. The tongues that connect the ends of the rails to the stiles are actually stub tenons that fit into the panel grooves, see Fig. 3.

These stub tenons are cut by making multiple passes over the saw blade to cut rabbets on both faces of the rail — leaving a tongue that fits the groove. (See *Woodsmith* No. 29 for a complete article on this technique.)

CUT 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, see Fig. 1. (I cut the panels 1/16" undersized so there's some space at the bottom of the groove for a glue relief.)

BACK FRAME TONGUES. Before gluing up the frames, I also rabbetted the back frame stiles to form the tongues that join the back frame to the side frames. Cut these rabbets on the edge of the stiles so the tongues will fit the grooves already cut on the side frames, see Detail in Fig. 4.

LAST STEPS

Now the frames and panels are almost ready for assembly. There are just two more steps to do now that make assembly easier.

DOVETAIL GROOVES. The first step is to rout a dovetail groove to accept the top apron (I). (This apron spans the front of the case between the side frames.) I routed a stopped dovetail groove on the inside face of each front stile, see Fig. 5.

To make this groove, adjust the ½" dovetail bit so it's 3/8" high, and set the fence 5/8" from the center of the bit, see Detail in Fig. 7. Then clamp a stop block 1½" to the left of the center of the bit, and cut the groove in the left frame, see Fig. 7.

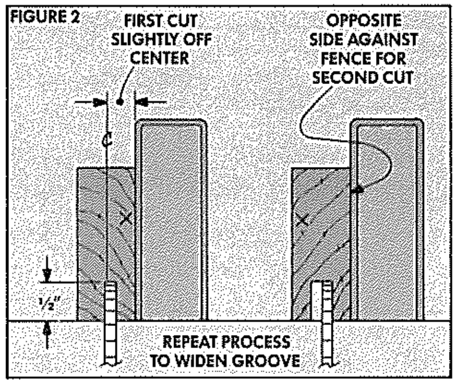
After cutting the groove on the left frame, move the block to the other side of the bit and repeat the cut from the opposite direction on the right frame.

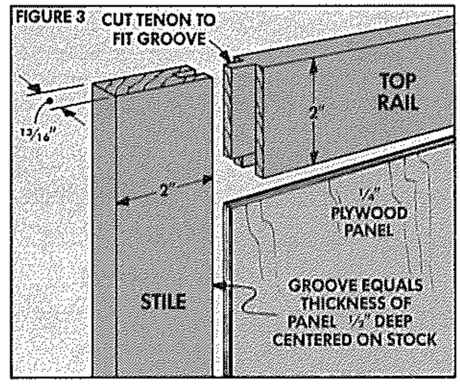
Shop Note: After making these cuts, don't change the setting on the bit. You need it to cut the dovetail tongues on the ends of the front apron later.

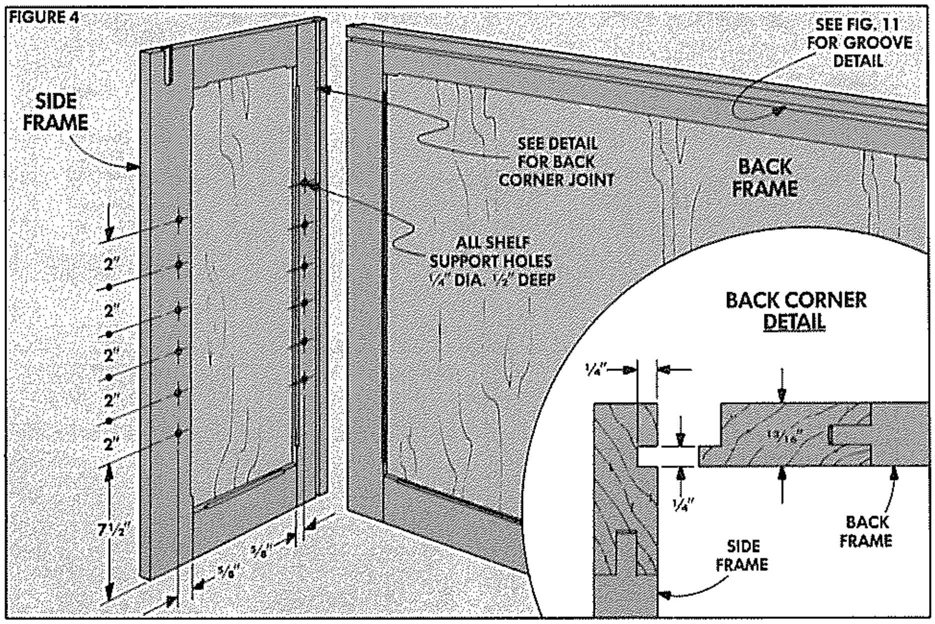
SHELF HOLES. To complete the frames before assembly, I drilled holes for the shelf pins that support the center shelf, see Fig. 6. (For more on shelf hardware and techniques, see page 18.)

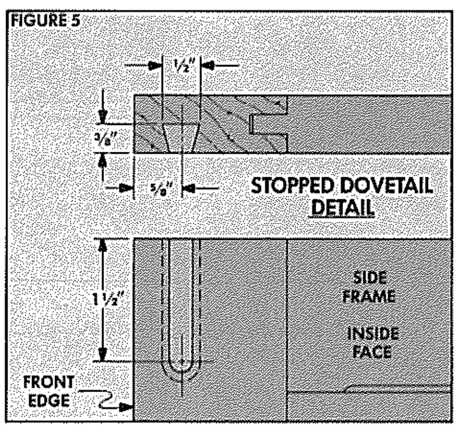
These holes are spaced every 2" starting 7½" up from the bottom of the frame, and are centered 5/8" from the *inside* edge of the stile, see Figs. 4 and 6.

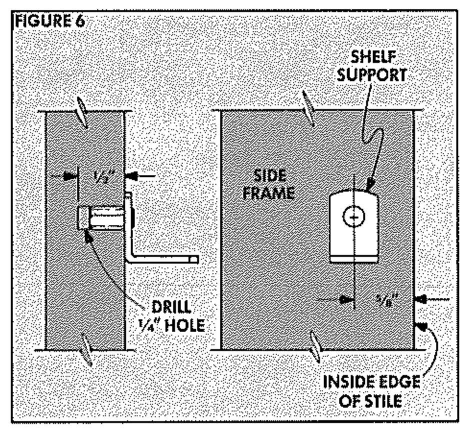
ASSEMBLE PANELS. Finally, the three frame and panel assemblies can be glued up. As I was gluing up the frames, I glued the plywood panels into the frame grooves for maximum stability.











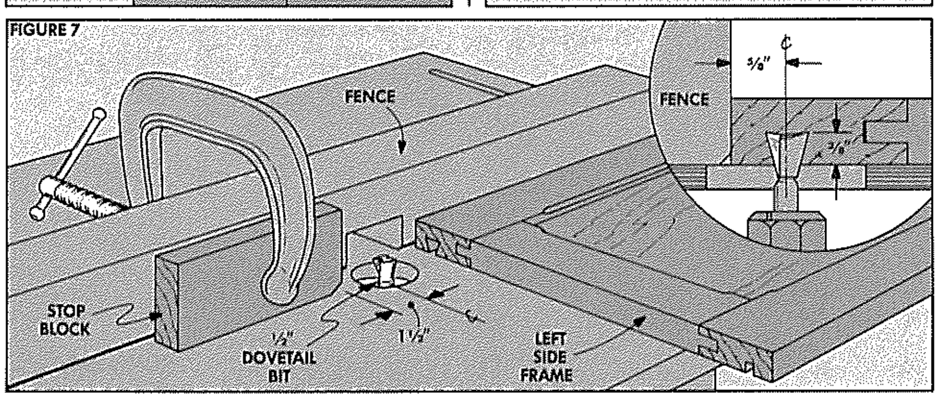


FIGURE 8

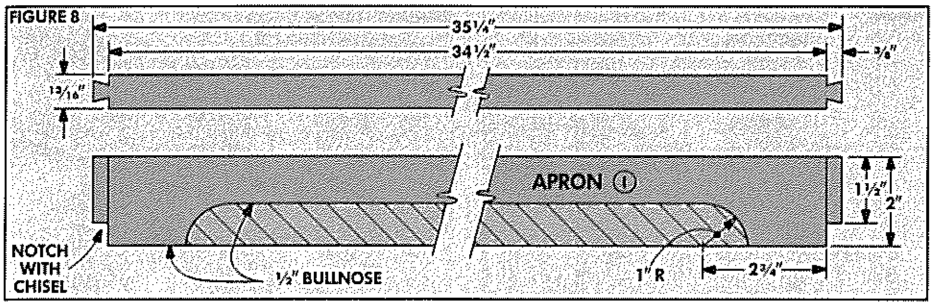


FIGURE 9

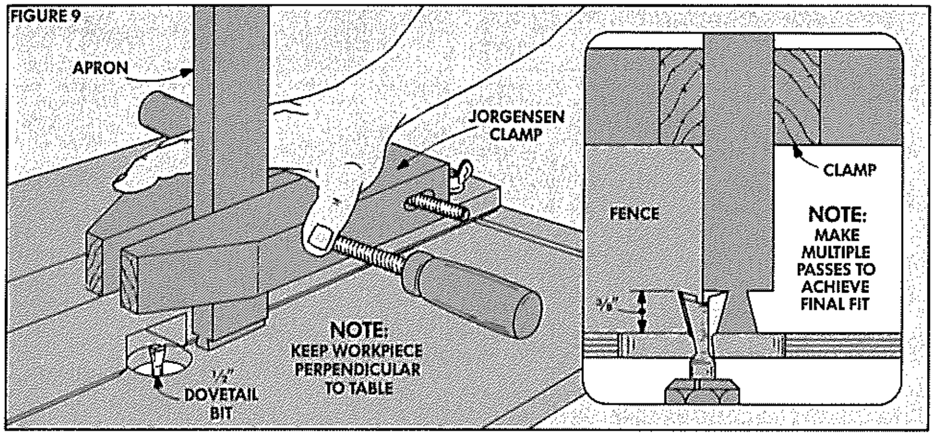


FIGURE 10

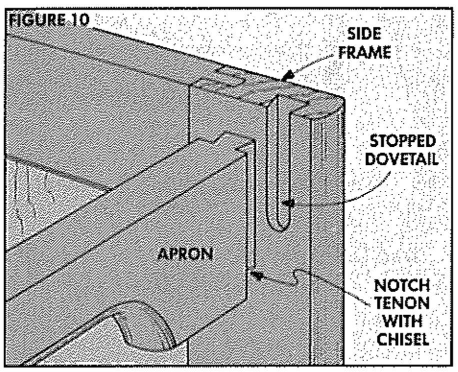


FIGURE 11

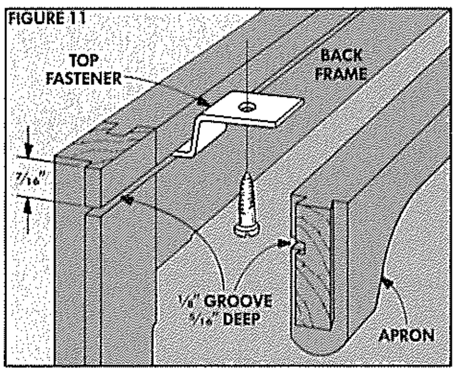
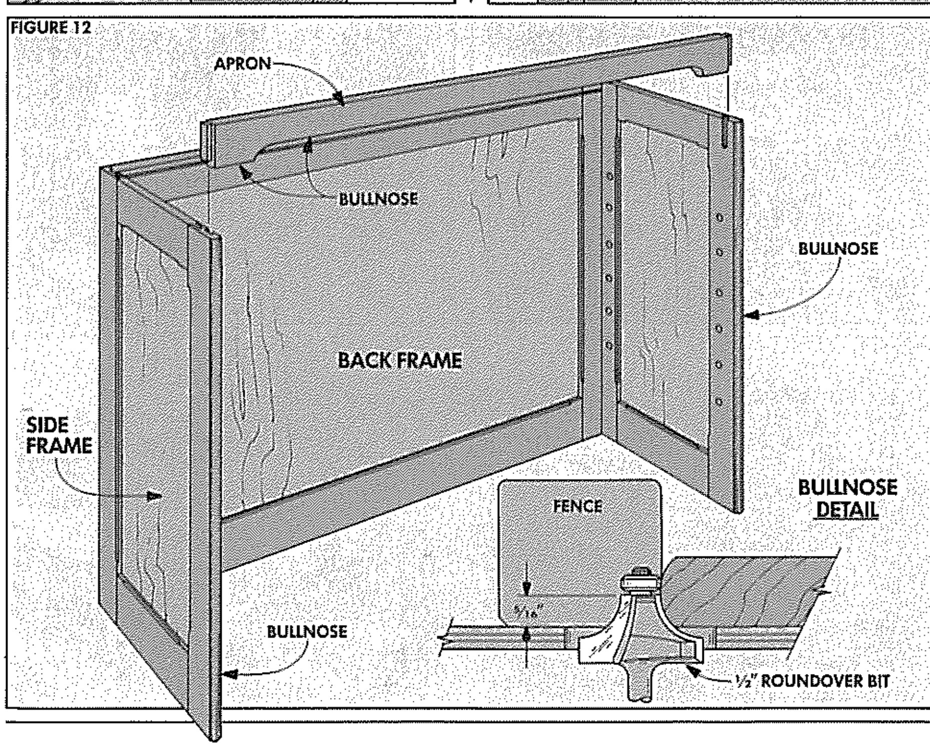


FIGURE 12



THE FRONT APRON

After the plywood panels were glued into the frames, I started work on the front apron (I) that runs across the top of the bookcase, refer to Fig. 12.

CUT TO SIZE. To make the apron, begin by cutting a piece of 4/4 stock 2" wide, see Fig. 8. The length of this piece equals the shoulder-to-shoulder length of the back frame (*not* including the tongues), plus ¾" (for the two ⅜"-deep dovetail grooves).

DOVETAIL TENONS. The apron is held to the side frames with dovetail tenons that fit into the dovetail grooves already routed on the side panels. To hold the apron securely while forming the dovetail, I clamped it in a Jorgensen hand screw, see Fig. 9. Then I adjusted the fence to take just a little off each face of the tenon at both ends of the apron.

To bring the tenon to final thickness, move the fence and repeat the process until the tenons fit the dovetail grooves.

TRIM TENONS. Next, trim about ¼" off the bottom of the tenon so when it slides into the groove, the top of the apron is flush with the top of the frame, see Fig. 10.

CUT PROFILE. When the dovetail joint fits, the curved profile on the bottom edge of the apron can be cut. To do this, draw a 1"-radius curve centered 2¾" from each shoulder of the apron, see Fig. 8. Then cut out the shape. Now straighten and smooth the finished edge on the router table. (For more on this technique, see Talking Shop, page 22.)

FASTENER GROOVES. Now it's time to plan ahead for fastening the top. The bookcase's top is secured to the front apron and the back frame with table top fasteners (see Sources, page 24). These stamped metal fasteners fit into grooves and are screwed to the underside of the top.

To make the grooves for the fasteners, cut a ⅛"-wide kerf 7/16" down from the top edges of the apron and the top rail of the back frame, see Fig. 11.

SOFTEN EDGES. The last step before assembling the case is softening the edges with a bullnose profile. To do this, use a ½" round-over bit set 5/16" high on the router table, see Detail in Fig. 12. Rout the front edges of the side frames and the bottom edge of the apron.

ASSEMBLE. After the edges have been bullnosed, the case can finally be assembled. First sand all the parts. Then glue the side frames to the back frame, and add the front apron, see Fig. 12.

TOP AND BOTTOM

Once the case is assembled, the top and bottom can be made. Both of these are ¾" plywood panels with a mitered frame on the front and sides, see Fig. 13. I started by cutting the two plywood panels (L and O) to size, see Fig. 13.

Shop Note: The *top* frame hangs over the case ¾" on the sides and front, so it should be built ¾" deeper and 1½" wider than the outside dimensions of the assembled case. The *bottom* frame hangs over 1", so it should be 1" deeper by 2" wider than the case.

EDGING STRIP. Before making the mitered frame, the grain on the back edge of the plywood is covered with a ¼"-thick trim strip. Rip this strip from 4/4 stock and fasten it to the back edge of the plywood with small brads and glue. When the glue is dry, carefully plane the strip flush with the surface of the plywood.

MITERED FRAMES. Next, the mitered frames can be made. Begin by ripping 4/4 stock 1¾" wide, see Fig. 13. These frame pieces are joined to the plywood with tongue and groove joints. So, cut a ¼" x ¼" 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, see Fig. 14.

Shop Note: To cut this tongue with minimum surface tearout, score the cut line first. See Talking Shop, page 22.

MITERS. When cutting the mitered corners on the frame, I concentrated on shaving the ends of the frame's front pieces (K and N) until the inside corners fit the corners of the panel, see Fig. 15. Then I mitered the ends of the frame sides (J and M), leaving the back end a little long.

TINY RABBET. There's one more step before the frames are glued to the plywood. Cut a tiny rabbet on the inside edge of the top frame pieces, see Fig. 14. (This adds an accent line and makes the joint more forgiving than a butt joint.)

ASSEMBLY. Now glue the mitered frames to the plywood panels. When the glue is dry, trim the back ends of the frame's side pieces flush with the back of the panels.

EDGE PROFILE

To dress up the edges of these frames, I wanted to make a fancy profile with a ½" round-over bit and a ¼" core box bit, see Fig. 14. However, I ran into problems when trying this on the router table because the shank of the bit had to be pulled too far out of the collet to get the depth of cut needed.

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

To solve this problem, I cut templates from ¼" Masonite and fastened them with carpet tape to the underside of the frame flush with the edges, see Fig. 16. When the bit reaches full depth, the pilot will ride along the Masonite, see Detail in Fig. 16.

FINAL TOUCH. To complete the profile, I routed a small cove on the shoulder of the round-over using a ¼" core box bit in the router table, see Fig. 17.

FIGURE 13

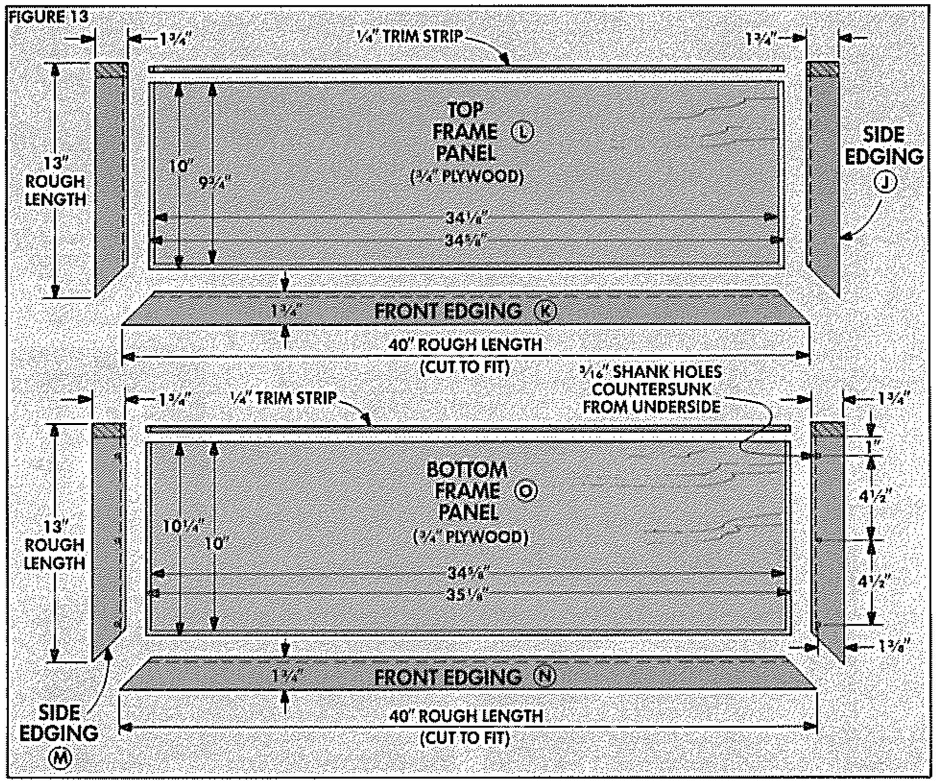


FIGURE 14

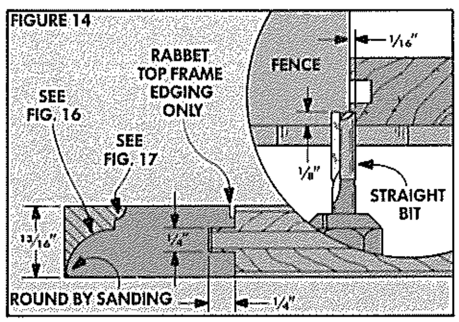


FIGURE 15

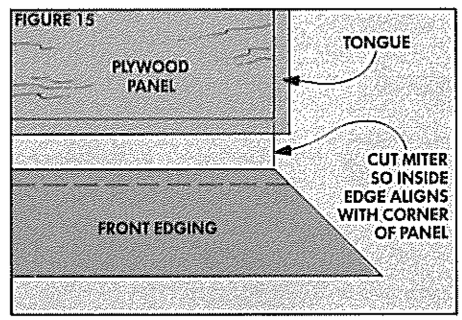


FIGURE 16

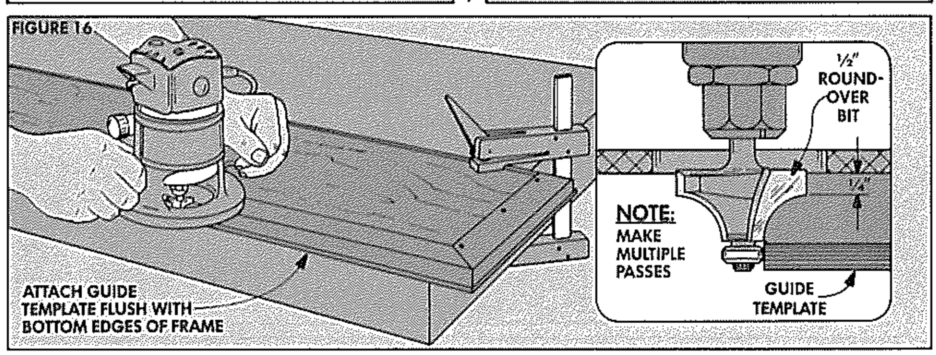


FIGURE 17

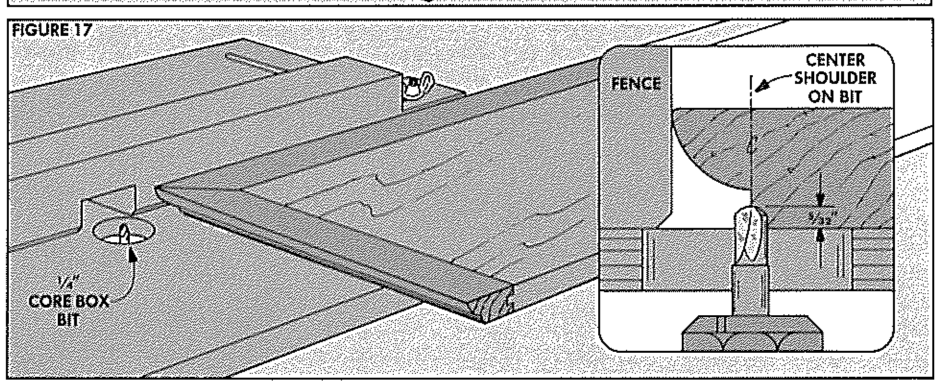


FIGURE 18

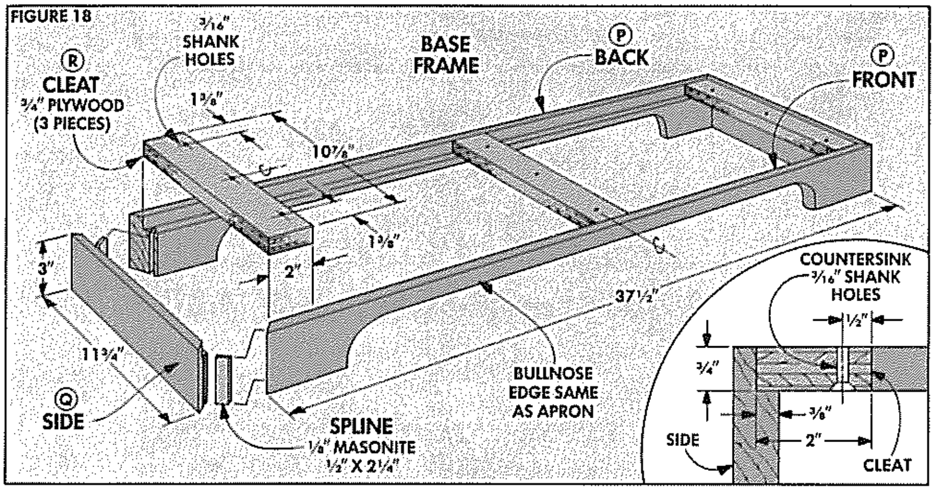


FIGURE 19

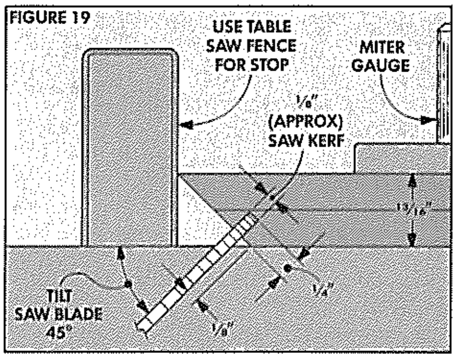


FIGURE 20

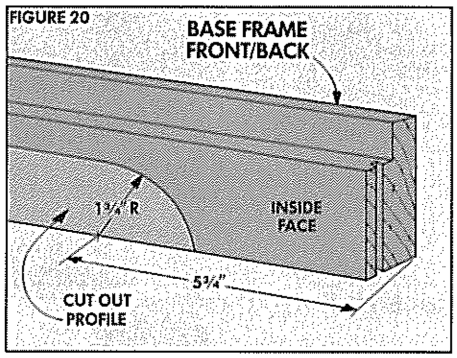


FIGURE 21

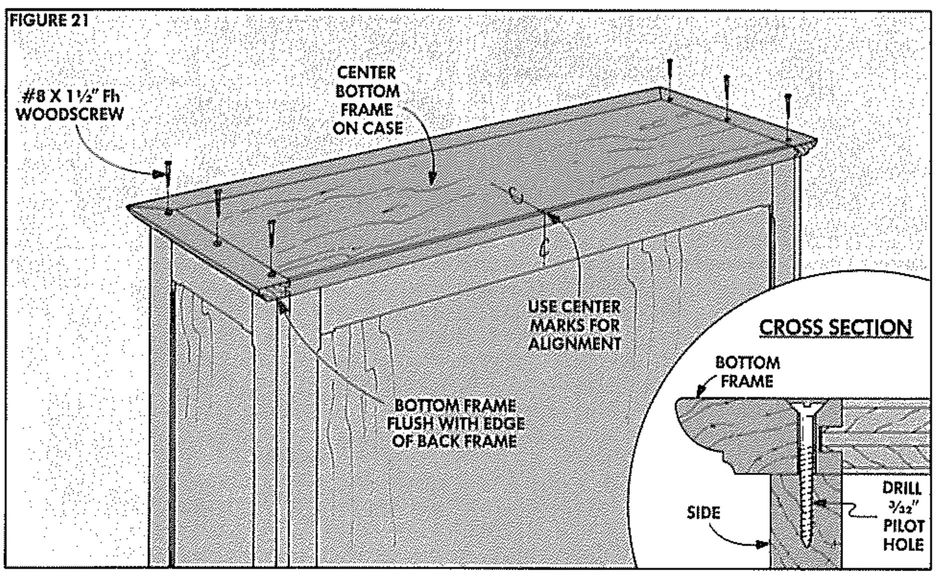
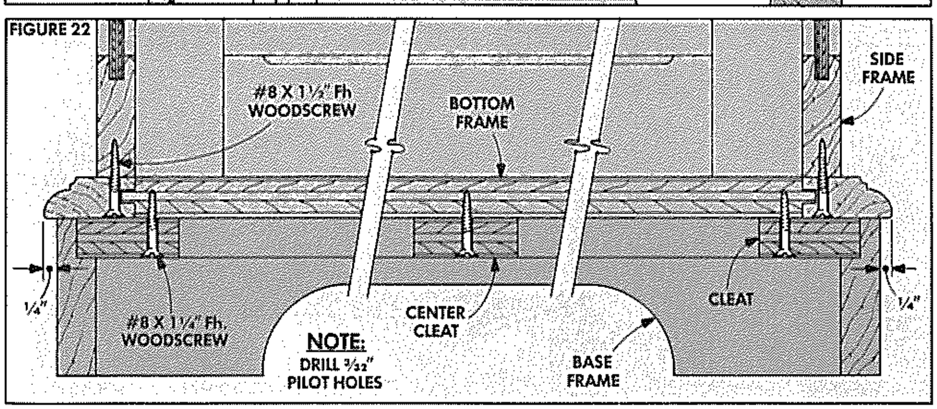


FIGURE 22



BASE

With the basic cabinet complete, I was ready to make the base. The base is a frame joined with splined miter joints.

CUT TO SIZE. To begin making the base, rip 4/4 stock to 3" wide for the front, back, and sides. Then cut the sides (Q) to a rough length of 12½" and the front and back pieces (P) to a rough length of 38½".

CLEATS. The base is attached to the case by three plywood cleats mounted in the base. I found the easiest way to mount these cleats was to cut a ¾" x ⅜" rabbet on the inside top edge of all the base pieces, see Detail in Fig. 18.

MITER ENDS. After the rabbets are complete, cut a 45° miter on each end of the workpieces so the finished measurement of the base is ¼" *less* than the bottom frame on the front and sides and is flush on the back, see Fig. 22.

SPLINES. To strengthen the corners and help keep them aligned while gluing, the mitered joints are splined with strips of ⅛" Masonite. I cut the kerfs for these splines on the table saw, see Fig. 19.

Use the rip fence as a stop and make adjustments in the blade height and distance between the blade and fence until the kerf is a little more than ¼" deep and located about ⅛" in from the inside corner of the miter, see Fig. 19. Then cut the kerfs on the ends of all the pieces.

BOTTOM PROFILE. After all the spline kerfs are cut, the curved profile can be made on the front and back pieces. To do this, strike a 1¾" radius centered 5¾" in from the long ends of the front and back, see Fig. 20. Then draw a straight line between the tops of the radii, remove the waste, and straighten the edge on the router table using the same technique as on the apron, see Talking Shop, page 22.

CLEATS. Now dry-clamp the base together and measure the distance between the rabbets to determine the length of the cleats (R). Then cut the cleats to size, see Fig. 18.

ASSEMBLE BASE. The base frame is assembled by gluing the corners together with the splines in place. Then clamp the base with a band clamp. While the glue is still wet, glue the cleats in place. (The cleats help pull the base frame square before the glue dries.)

MOUNT 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, see Fig. 21. Mark centerlines on the frame and on the case to align the two. (For more on this technique, see Talking Shop, page 22.)

Now drill pilot holes and counterbores through the bottom frame for six No. 8 x 1½" woodscrews, and glue and screw the bottom frame and case together.

MOUNT BASE FRAME. Now the base frame can be mounted. To do this, drill pilot holes and drive No. 8 x 1¼" woodscrews through the cleats into the plywood bottom, see Fig. 22.

MOUNT TOP. Next, the top frame can be fastened on. This is made easy by the metal table top fasteners. To use the fasteners, lay the top frame upside down, and place the case upside down on it.

Carefully center the case on the top frame. (Use centerlines to align the two, see Talking Shop, page 22.) Then slip the fasteners into the grooves and fasten the top with roundhead screws, see Fig. 25.

MAKE THE SHELF

With the bookcase essentially complete, all that's needed is a shelf. I wanted a trim-looking shelf that was ready to carry the heaviest library.

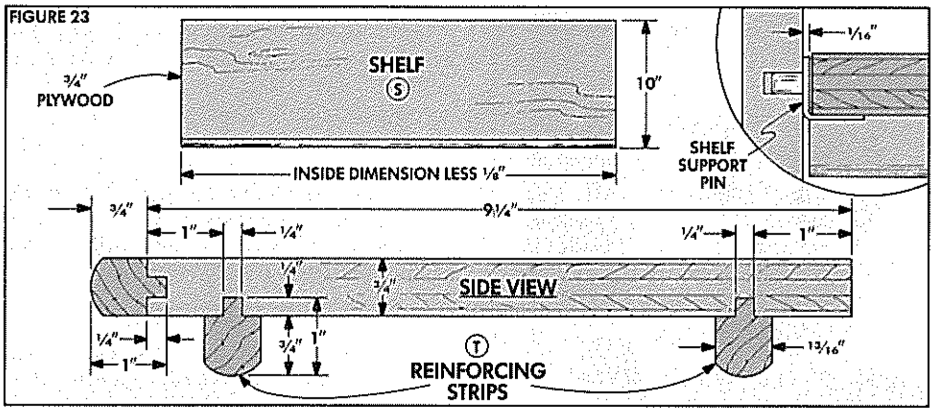
PLYWOOD SHELF. To make the shelf, I started with a piece of ¾" plywood and added reinforcement on the front edge and the bottom surface, see Fig. 23.

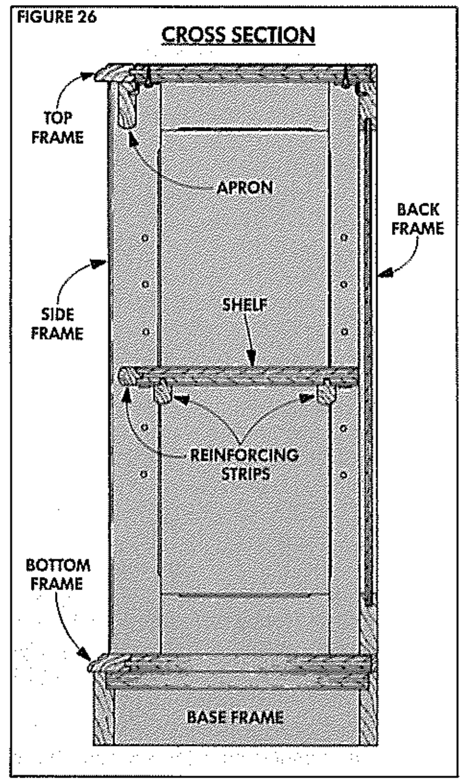
REINFORCEMENT. Generally, I would have just added a bullnose strip to the front of the shelf to make it stiffer. But this time, to really beef up the shelf, I made duplicate bullnose strips to serve as stiffeners on the bottom of the shelf.

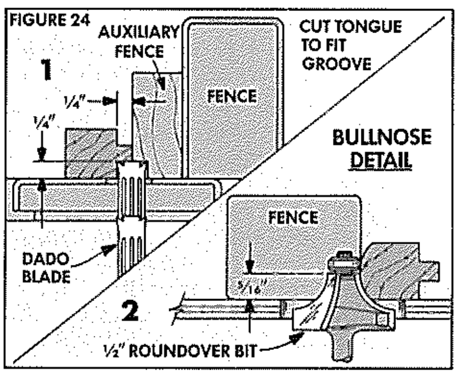
BULLNOSE PIECES. Before making these three pieces, cut ¼" x ¼" grooves on the front edge and bottom surface of the shelf, see Fig. 23. Then rip 1"-wide strips and cut rabbets to produce a tongue on one edge to match the width and depth of the grooves, see Step 1 in Fig. 24.

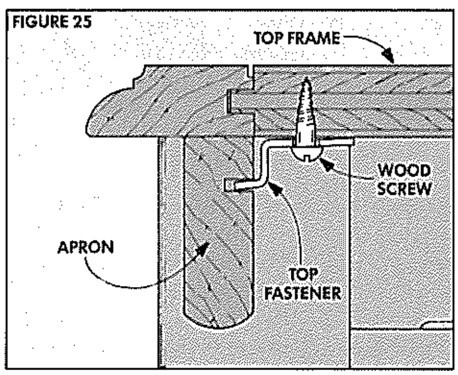
To complete these strips, rout a bullnose profile on the other edges (with a ½" round-over bit set 5/16" high), see Step 2. Finally, glue the strips into position.

FINISH. I stained this bookcase with two coats of Minwax Early American stain, and then applied two coats of tung oil.





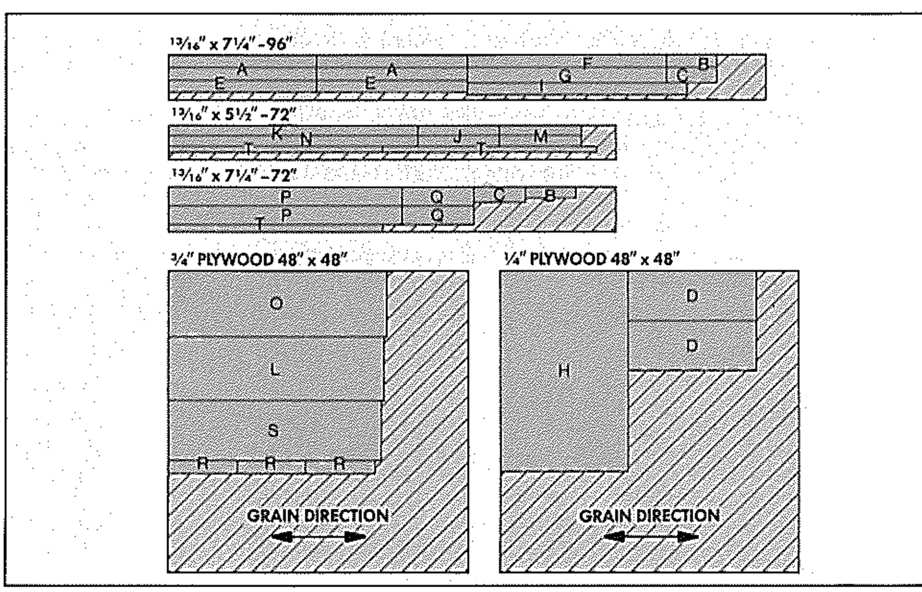




MATERIALS LIST

Overall Dimensions: 37½" w x 11¾" d x 27⅝" h	
A Side Frame Stile (4)	13/16" x 2" - 24½"
B Side Frame Top Rail (2)	13/16" x 2" - 8"
C Side Frame Bottom Rail (2)	13/16" x 2½" - 8"
D Side Frame Panel (2)	¼" x 8" - 21"
E Back Frame Stile (2)	13/16" x 2" - 24½"
F Back Frame Top Rail (1)	13/16" x 2" - 32"
G Back Frame Bottom Rail (1)	13/16" x 2½" - 32
H Back Frame Panel (1)	¼" x 32" - 21"
I Apron (1)	13/16" x 2" - 35¼"
J Top Frame Side Edging (2)	13/16" x 1¾" - 13"
K Top Frame Fr Edging (1)	13/16" x 1¾" - 40"
L Top Frame Panel (1)	¾" x 10" - 34⅝"
M Bot Frame Side Edging (2)	13/16" x 1¾" - 13"
N Bot Frame Front Edging (1)	13/16" x 1¾" - 40"
O Bot Frame Panel (1)	¾" x 10¼" - 35⅛"
P Base Frame Front/Back (2)	13/16" x 3" - 37½"
Q Base Frame Sides (2)	13/16" x 3" - 11¾"
R Cleats (3)	¾" x 2" - 10⅞"
S Shelf (1)	¾" x 9¼" - 34⅜"
T Reinforcing Strip (3)	13/16" x 1" - 34⅜"

CUTTING DIAGRAM



Hardware For Shelves

SHELF SUPPORTING STANDARDS

It seems like every time I go into the hardware store there's some new piece of hardware to fasten shelves to a wall or into a cabinet. Most of the hardware for holding shelves in a cabinet falls into two general categories: those with standards and those without standards (such as pin supports or dowels that fit into holes drilled into the sides of cabinets).

SHELF STANDARDS

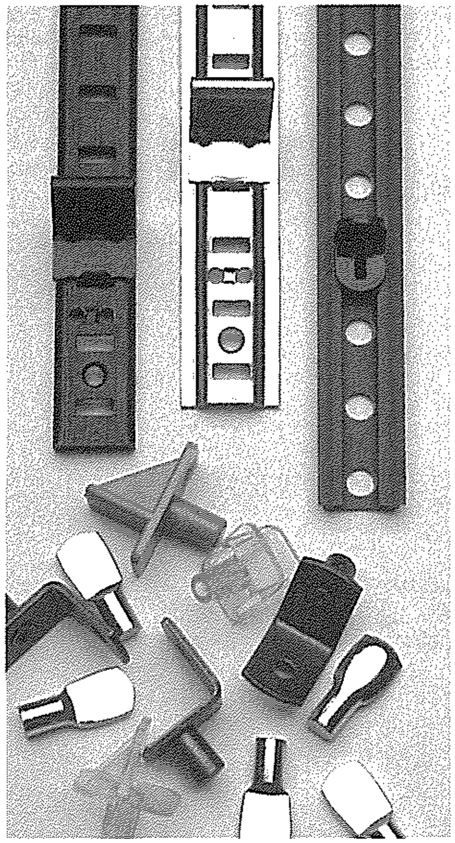
The most common standards are metal strips made of cold-rolled steel. These standards are $\frac{5}{8}$" to $\frac{15}{16}$" wide, and are commonly available from two to six feet long. They have a series of slots every ½" that accept metal clips to hold the shelves.

SURFACE MOUNT VS. FLUSH MOUNT. Some standards are designed for surface mounting, but most can be recessed (flush mounted) into a groove cut into the side of the cabinet, see Fig. 1. I think it's worth it to take the time to recess the standards. If you don't recess them, you have to cut the shelves short to allow for the thickness of the standards. (Note: One way to prevent the gap created when you cut a shelf short is to cut notches in the end of the shelf to fit around the standards.)

MOUNTING STANDARDS. Some people cut costs by cutting the standards shorter than the cabinet sides. I always assumed that it was important that the bottom end of the standard rested firmly on a solid support such as the bottom of the case.

"It's not really all that important," explained Bob Sorenson of Knape & Vogt, a major manufacturer of metal shelf standards. "It's true that all the weight is supported by the nails. But for most applications, the nails should hold. What is important is that most, if not all, of the nail holes are filled with nails."

In the metal standards there's also a series of very small holes (two side-by-side) every six inches that were always a mystery to me, see photo. Bob said that these holes are for a staple that's used in production situations. Knape and Vogt sells a staple gun to shoot these staples into the holes, see Sources, page 24.



MOUNTING TIP. The main problem with mounting the metal standards is getting all four standards in the cabinet aligned properly. If the holes don't line up on the same plane, the clips won't be level, and the shelf will rock or slant to one side. There's a simple little trick to be sure the holes are all aligned.

First, insert a clip *upside down* in a standard, see Fig. 2. Then, place a spacer block between the clip and the cabinet base and attach the standard to the cabinet side. Use the same spacer block and the same method to locate the other three standards. Using this method, all of the holes should be a uniform distance from the bottom.

EUROPEAN PLASTIC STANDARDS. Recently we discovered a relatively new shelf standard (at least new to the U.S.) that's made from a strip of plastic, see Sources, page 24. It's less expensive than a metal standard and considerably cleaner looking. (It's the one on the right in the photo.) This strip fits into a groove in the side of the cabinet, but doesn't need any nails or screws to hold it in place. Instead it has lateral teeth on the side of the strip to grip the sides of the groove, see Fig. 1.

To hold the shelves in place there are small plastic clips that twist into place. They're neat, clean, and not as obvious as the metal clips.

PIN SUPPORTS

The other main method for supporting shelves is with pin supports or dowels that are mounted into the holes drilled in the sides of the cabinet.

PIN SUPPORTS. Pin supports are available in both metal (nickel, brass, and walnut color) and plastic (tan and clear — great for glass shelves). They come in a straight spoon shape that fits under the shelf or an L-shaped bracket that hooks around the end and then under the shelf, see photo. The plastic supports are L-shaped, but have an additional support bracket under the foot of the "L."

There are two methods for mounting the L-shaped metal supports, see Fig. 3. If the open part of the "L" faces up in normal fashion, it supports the shelf while the end of the shelf keeps the pin pressed securely in the hole. But in this situation the shelf has to be cut short to allow for the thickness of the supports. This means there will be a slight ($\frac{1}{16}$") gap between the end of the shelf and the side of the cabinet.

The metal L-shaped brackets can also be used "upside down," see Fig. 3. In this position, the shelf will fit right up to the

FIGURE 1

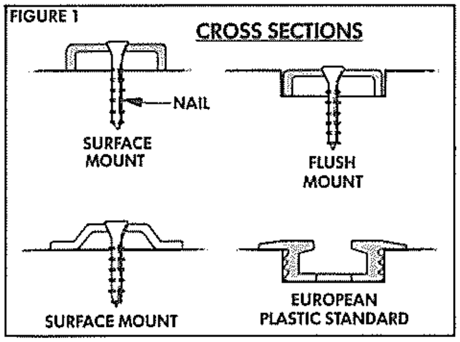


FIGURE 2

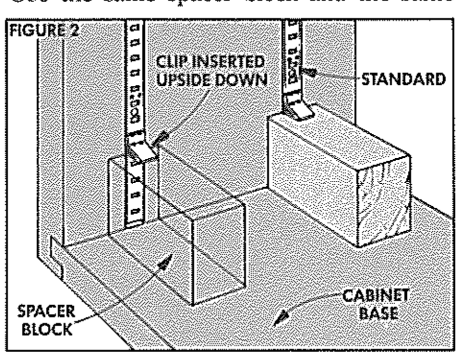
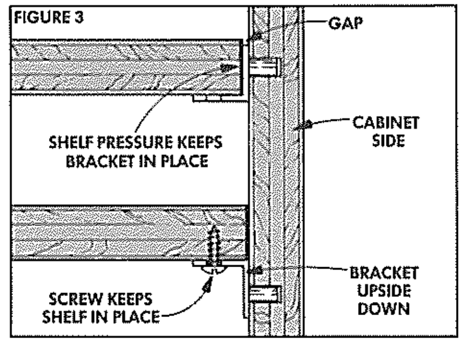


FIGURE 3



side of the cabinet. It's also a way of getting a little more space for tall books or records below the shelf. (The bottom of the shelf rests *above* the hole in the cabinet, not below it.) But this upside-down arrangement isn't as secure since there isn't pressure from the end of the shelf pushing the pin into the hole.

To help secure the shelf, most metal L-shaped brackets have a screw hole in them. Screwing the brackets to the shelf stabilizes it, but it's more difficult to change the shelf position.

DOWELS. An alternative to using pin supports is dowel pins. I usually use a ¼" dowel about 1" long (½" into the side of the cabinet and ½" under the shelf). I've also used bronze welding rod as pins.

DRILLING FOR PINS

One of the biggest advantages of using pins or dowels over the metal standards is their adjustability. You can control exactly how many holes you want and where you want them, and you can add more holes later.

LOCATING THE HOLES. No matter how many holes you use, it's important that the holes be lined up accurately so the shelves don't slant or rock.

One of the easiest ways to align the holes is to make a drilling guide from a piece of ¼" pegboard, see Fig. 4. The holes in most pegboard are located 1" apart.

To make a pegboard drill guide, cut a 5"-wide strip of ¼" pegboard to the length of the cabinet side. You don't have to use all of the holes in the pegboard. In a cabinet with one middle shelf only the middle three or four holes need to be used. The problem is locating these holes in relation to the bottom of the cabinet or the bottom shelf.

To do this, figure out the lowest position up from the bottom you might want the first adjustable shelf. (On our bookcase, we wanted the lowest hole 7½" from the bottom of the cabinet side, see page 13.) Now cut the pegboard so the distance from the bottom of the strip to the center of one of the holes equals this measurement. Then use a felt-tip marker to circle the holes that need to be drilled, and label the "bottom" end of the strip.

STORY STICK. If you want to space the holes closer or farther apart than the 1" spacing on pegboard, an alternative approach is to make a "story stick" from a piece of scrap. Just cut a strip to fit into the cabinet and drill the holes wherever they're needed.

The important thing is that you use the *same* drill guide for all the holes and that the drill guide always be located flush with the bottom of the cabinet side or bottom shelf.

DRILL SIZE. It's logical that if you're drilling holes to mount a ¼" pin support or ¼" dowel, you would use a ¼" drill bit. Logical, but not practical. I've found that the pin supports and ¼" dowels range in size from .240" to .255" thick (¼" is .250"). The thicker pins and dowels can be forced into a ¼" hole but getting them back out again can be difficult — and that's the whole (or hole) idea of adjustability.

What about drilling a little bigger hole? "The closer the tolerance match between the size of the pin and the size of the hole, the greater the strength," explained Bob Sorenson. "If you allow any slack, the pin shifts and and starts to literally pry or tear out the piece of wood."

But to make the pins a little easier to remove, I've started using an "F" letter machinist's twist drill bit, see Sources, page 24. An "F" bit is .007" larger in diameter than a ¼" bit.

The metal pin supports I've been using are a lot easier to get in and out of an "F" size hole. And I haven't noticed any problems with prying or tear-out.

WIRE SUPPORTS

There's one other piece of shelf hardware that's worth mentioning. They're usually called "Swedish style wire supports." (I guess the original idea came from Sweden.)

BENT WIRE. The system consists of a bent piece of wire that fits into pairs of holes (like the holes for the pin style supports) drilled into the side of the cabinet, see Fig. 5. The shelf sits on top of the wire or the end of the shelf can be slotted and the shelf slid in over the wire.

There's both an advantage and a disadvantage to this system. Since the shelf is flush against the inside face of the cabinet, there's no gap between the shelf and the cabinet side. But if the wires are slid over a slot in the shelf (as is usually done), the shelf won't hold as much weight because there's only the small lip above the slot supporting the shelf.

MAKE YOUR OWN. I decided to try making my own wire supports and bought a 3-foot length of 3⁄16" rod from the hardware store for 89 cents. After cutting the rod into 10" lengths, I bent ¾" at each end to 90°. Then I drilled two 3⁄16" holes in the side of the cabinet 8½" apart.

To mount the shelves, rout a ¼"-wide slot in the ends of the shelves with a slot cutter (or ¼" straight bit) to accept the rod. By stopping the slot short of the front of the shelf, it won't be seen. Another method to conceal the slot would be to rout all the way through and then cover the front edge with a face strip, see Fig. 5. (When using plywood, I do this anyway.)

A HYBRID SYSTEM

After using the wire support system and the dowel pin system, I began to think of a way to combine the two for an inexpensive and attractive system with the ends of the shelves tight (no gap) against the cabinet.

This system uses ¼" dowels and holes like the pin system, but the shelves are made a little different. The back edge of the shelf has a ¼" slot that slips over a pin (like the wire supports). This slot is stopped a couple inches from the back. On the bottom side near the front of the shelf there's a pocket that fits down on a ¼" dowel, see Fig. 6.

To get the shelf into place, fit the slot in the shelf ends over the back dowel pins and then slide the shelf toward the back until the pockets fall right over the front pins.

The nice thing about this system is that the front pins prevent the shelf from sliding front to back, while the back pins keep the shelf from tipping up if weight is applied to the front edge.

FINAL THOUGHTS

When you first see a shelf weighed down with books and supported by any of these *little* shelf supports, it would be easy to be concerned. But all of these shelf systems are based on "shear" strength. Knape & Vogt engineering studies show that their metal standards, for example, will hold 500 lbs. per square foot on a two foot shelf.

It's not very likely that any of these supports will break. It's much more likely that the shelf itself will sag. So choosing the correct support system is more a question of what looks best and is easiest to adjust.

FIGURE 4

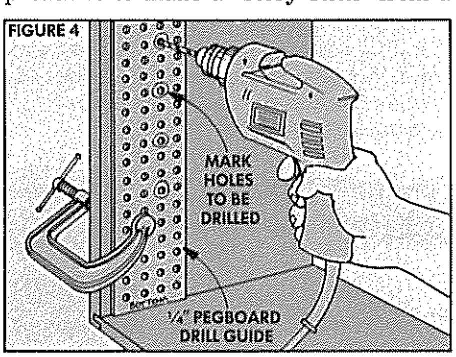


FIGURE 5

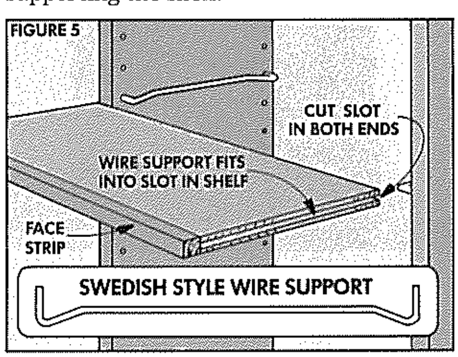
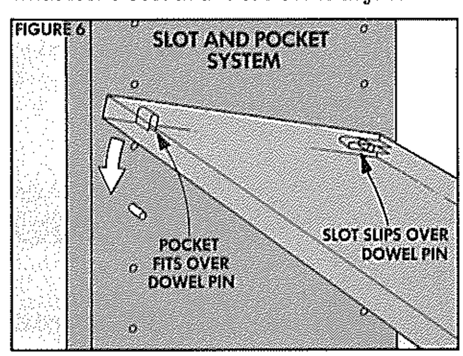


FIGURE 6



Making Shelves

MATERIALS AND DESIGN

When we started working on the bookcase (shown on page 12), the first question was whether the center shelf would be strong enough to hold a full set of books — without sagging.

Books are heavy — heavier than they look. A set of encyclopedias, for example, weighs in at about 100 lbs. When you're dealing with that much weight, the shelves in a bookcase have to be designed to hold up. The materials you use for the shelves and any method of reinforcing the shelves become important, or the shelves will sag.

SHELF MATERIAL

There are three materials commonly used for shelves: particle board, plywood, and solid wood. Each has advantages and disadvantages, and each sags differently.

PARTICLE BOARD. For most situations the worst material for shelves is particle board. The wood fibers in particle board run every which way. This helps keep particle board dimensionally stable, but does little to prevent sag.

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

The key thing here is that there's a number of different kinds of particle board available. Some sag more than others. For example, low density, class 1, particle board has a minimum average "E" factor of only .15. (The "E" factor refers to the "modulus of elasticity" or stiffness of the board. The higher the "E" factor, the less the board will sag.) Medium density, class 1, particle board has an "E" factor of .25. And high density, class 1, particle board has an "E" factor of .35. (That compares to 1.24 for Eastern white pine, one of the weakest pines.)

If you decide to use particle board for shelving, *high density* particle board (sometimes called "cabinetmaker's grade" rather than "underlayment") would be the best choice since it's slightly stiffer (but also considerably heavier).

PLYWOOD. What about making shelves out of plywood? Plywood doesn't usually warp like solid wood and it's dimensionally stable. These characteristics are important in a bookshelf where you want flat shelves that won't expand and contract with changes in humidity. But plywood will sag more than solid wood.

In solid wood the individual wood fibers run along the length of a board. These fibers resist stretching (sagging) along their length so a board of solid wood is stiffer along its length than its width. Plywood is constructed so that *some* of the fibers (every other layer) run along the length. This keeps a plywood shelf dimensionally stable but the shelf won't be as stiff as one of solid wood.

42 LBS. OF BRICKS CENTERED ON 10" x 36" SHELF	AMOUNT OF SAG
3/4" HIGH DENSITY PARTICLE BD.	7/32"
3/4" OAK PLYWOOD	6/32"
4/4 (13/16") WHITE OAK	2/32"*
6/4 (1 5/16") WHITE OAK	1/64"*
*VISIBLY ACCEPTABLE SAG 3/32" PER 36"	

Another factor contributing to the weakness in plywood is that it's 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 soft, light basswood. And there might be voids that weaken it further.

CREEP. There's something else I should mention about plywood and particle board. When you first load books on a bookshelf, the shelf may sag slightly. But over a period of time there's an additional sag called "creep."

Particle board and plywood are especially susceptible to creep because of the glue used to bond the material together. The glue stretches over time. The particle board shelves that you put up in the shop to hold paint cans might not sag at first, but may look like a sway-back horse ready for the glue factory after a couple years.

There's another thing about creep. In all wood materials creep increases if the temperature or humidity increases. Also green wood creeps much more than dried wood. (That's another reason to use kiln-dried lumber.)

SOLID WOOD. If your only goal in building shelves is to prevent sag, solid wood is the best choice. All the fibers in solid wood run along the length, and as long as the shelf is put into the cabinet lengthwise, sag will be kept to a minimum.

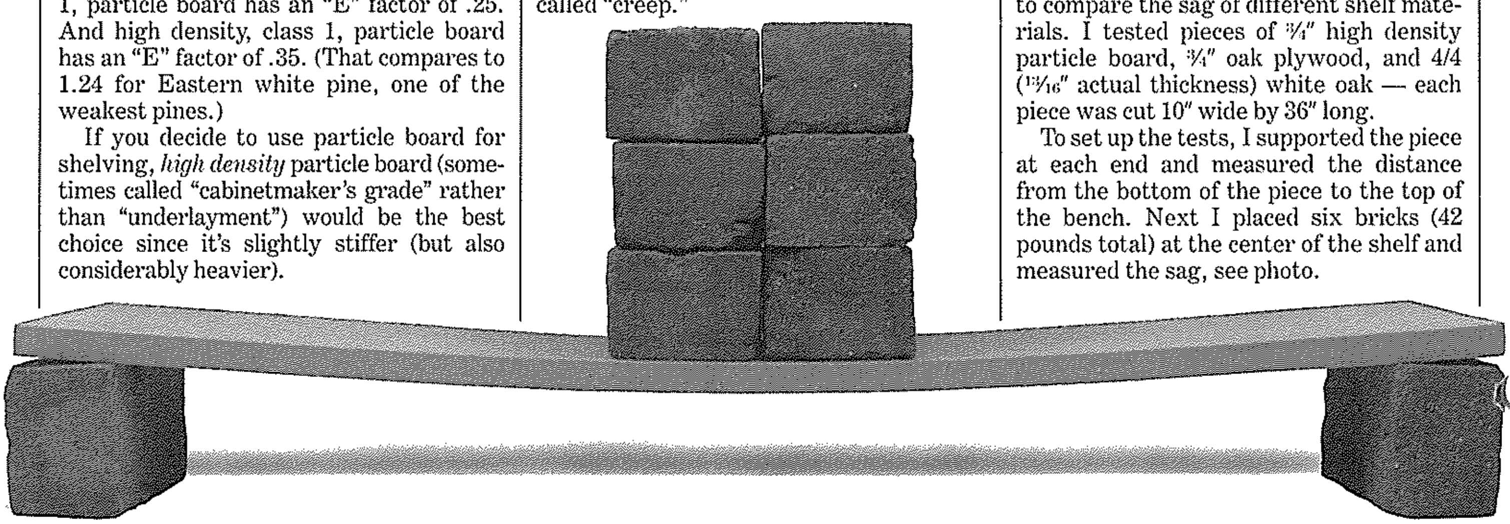
If the wood is particularly dense, such as oak or birch, the wood cell walls are thick, there are more of them, and they tend to resist the compression and tension forces that take place within a shelf under load. What this all means is that as a rough rule of thumb, it's usually better to make shelves out of a denser wood. As an example, yellow birch has an "E" factor of 2.01, northern red oak 1.82, black cherry 1.49, and ponderosa pine 1.26.

SAGGING

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.

SOME TESTS. Before building the bookcase for this issue, I did some simple tests to compare the sag of different shelf materials. I tested pieces of 3/4" high density particle board, 3/4" oak plywood, and 4/4 (13/16" actual thickness) white 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. The particle board sagged about 7/32", see the chart on the opposite page. The oak plywood sagged a little less than 6/32", and the solid oak only sagged 2/32". Using the 1/32" per foot rule (or 3/32" over three feet), only the solid wood is acceptable.

REDUCING SAG

Does this mean you shouldn't use plywood or particle board for shelving? No. As a matter of fact, they might be a better choice since they aren't as likely to warp or expand and contract with changes in humidity. But when using them (as well as solid wood), there are some steps you can take to reduce the sag.

DISTANCE. First, determine if there is some way to design the cabinet to decrease the span of the shelf. 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, for example, you can reduce the sag to one-eighth of the original.

To test this I cut a piece of 6/4 (1 5/16"-thick) white oak to the same dimensions as the other test shelves. When the bricks were piled on, the deflection was only a little over 1/64", which compares to a sag of 4/64" (1/16") for 4/4 stock.

REINFORCING METHODS

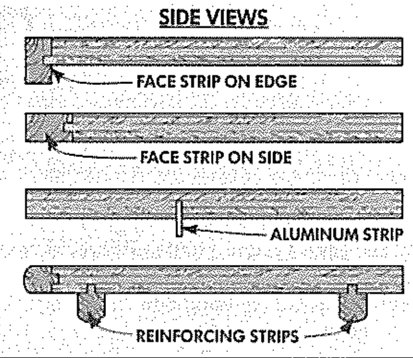
Supporting the center of a shelf, or doubling the thickness may not be realistic solutions. A better approach to reducing sag is to add support to the edges or under the shelf. It's common to see shelves with a face strip added to the front edge. This is not just decoration or a way to cover the edge of plywood or particle board. 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 would definitely sag. But if you tipped the same 2x4 up *on edge* and added the weight, there would be very little sag.

FACE STRIP ON EDGE. The same principle applies if you add a face strip on edge to the front of a shelf. To test how much this helps a plywood shelf, I added a 1¼"-wide vertical strip of 4/4 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", see chart above.

HORIZONTAL FACE STRIP. What about adding a horizontal solid face strip to the front of the plywood shelf? It covers the edge plies and doesn't decrease the shelf space. I tested this arrangement by adding a 1¼"-wide strip horizontally to the front of the plywood. The plywood sagged a little more than 4/32". That's an improvement over the plywood without a face strip but not as good as the strip on edge.

OAK PLYWOOD SHELVES (TYPICAL SAG OF 6/32")	AMOUNT OF SAG
WITH 1¼" WIDE FACE STRIP ON EDGE	2/32"*
WITH 1¼" WIDE FACE STRIP ON SIDE	4/32"
WITH ALUMINUM STRIP UNDERNEATH	2/32"*
WITH MOLDING STRIPS UNDERNEATH	3/32"*
*VISIBLY ACCEPTABLE SAG 3/32" PER 36"	



UNDERSHELF SUPPORT. Sometimes a vertical strip is needed for strength but doesn't fit the design of the project. One way to hide the support is to put it *under* the shelf. The support takes up shelf space, but it can be fit into a groove cut in the bottom of the shelf.

I tried epoxying a 1/16"-thick by 1"-wide reinforcing strip of aluminum into a groove routed in the bottom of the plywood. Adding this thin strip of aluminum under the shelf was comparable to adding the 4/4 wooden strip vertically to the face — sag was reduced to 2/32".

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" which was right at the 1/32" per foot rule.

BOOKCASE SHELF. This method of reinforcement was the way I decided to build the shelf on the bookcase. The shelf is plywood (so it won't be as likely to warp or expand or contract), and there's a bullnose molding strip on the front edge — mostly to conceal the plywood layers. For stiffness I added two bullnose reinforcing strips to the underside of the shelf.

RECOMMENDED SPANS

If you're designing a cabinet, what's the greatest length (span) a shelf can be without an objectionable sag? There are four factors to consider: 1) how the load is distributed, 2) the expected load, 3) the shelf material, and 4) the method of reinforcement.

LOAD DISTRIBUTION. For the tests described in this article, I wanted to determine the "worst possible situation" for the distribution of the load. 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. This is the assumption used to develop the chart at right.

EXPECTED LOAD. Another factor used to determine maximum span is the total expected load — the longer the shelf, the more books (and weight) it has to hold.

A running foot of average-sized books weighs about 20 pounds. So a three-foot shelf filled with average-sized books would have to support about 60 pounds. (Records and encyclopedias would weigh more, and paperback books less.)

SHELF MATERIAL. The third factor used to determine maximum span is the type of material used — particle board, plywood, or solid wood. Each has a different "E" factor, as discussed in the article above.

REINFORCEMENT. Finally, if you want to increase the span, you can add reinforcement to reduce the amount of sag.

GUIDELINES. Taking all four factors into consideration, the chart shows some general guidelines for the maximum span for shelves to avoid an objectionable sag.

The most practical approach is to use 4/4 stock, or plywood with reinforcement. This will produce shelves with minimum sag and the best visual appearance.

MAXIMUM SPAN RECOMMENDATION FOR 10" WIDE SHELF FULL OF BOOKS	
¾" PARTICLE BOARD	24"
¾" PLYWOOD	30"
4/4 (13/16") SOLID STOCK	36"
6/4 (1 5/16") SOLID STOCK	60"
¾" PLYWOOD REINFORCED WITH:	
1¼" WIDE FACE STRIP ON EDGE	36"
1¼" WIDE FACE STRIP ON SIDE	32"
ALUMINUM STRIP UNDERNEATH	36"
MOLDING STRIPS UNDERNEATH	36"

Talking Shop

SOME TIPS FROM OUR SHOP

CUPPING BOARDS

By the time I edge-glued and then planed a blank for the top cap on the table clock (see page 8), it was getting late in the day. So I just set the blank on the case top to see what it would look like and then left it that way overnight.

When I returned the next morning both the blank for the top cap and the case top had cupped in opposite directions. There was a 1/8" gap between the pieces at the front and back.

The cupping developed because I didn't allow the freshly-planed pieces to *uniformly* adjust to the dry environment in the shop. The air could easily dry the outside of the pieces, but not the insides where the two pieces laid together.

There are a couple solutions to this problem. First, always stand workpieces on edge as you work on a project. Don't lay pieces flat overnight on a bench, the table saw, or on each other.

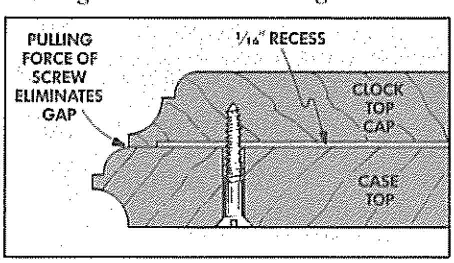
If a piece should warp (cup), try flipping it over and lay it flat on the *other* side. It may take flipping it back and forth a number of times to completely flatten the piece.

When planing a blank flat, plane both sides. If you just plane one side, you're opening up the wood cells so the blank dries faster on that side and also makes it likely to cup in that direction.

A HIDDEN RECESS

Okay, what do I do if I can't get a cup or bow out of a board or there's a slight crown in it from overeager sanding, and I want to fasten it flat down to another board?

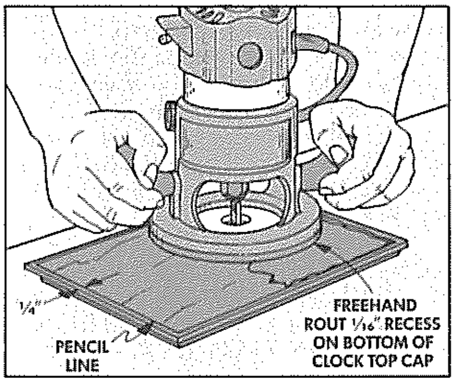
This is actually what happened with the case top and the top cap on our clock. The problem was getting the two pieces to fit together tight so there wouldn't be a gap showing around the outside edges.



To solve the problem, I routed out a 1/16"-deep recess on the bottom of the top cap. (This is sometimes called undercutting). The purpose of the recess was to accept most of the slight crowned surface of the case top. It also removed some of the cup on the bottom of the top cap.

The recess is routed to leave a 1/4" lip around the outside edge. The only resistance to pulling the two pieces flat together is this narrow lip. And it can be pulled down easily with screws to eliminate the gap and produce a tight joint.

To make a recess like this, start by laying it out with a pencil leaving a 1/4"-wide lip around the outside. Then fasten the board to the bench (I used double-sided carpet tape) and mount a 1/2" (or larger) straight (or mortising) bit in the router.



Now set the bit to take a 1/16"-deep cut and carefully freehand rout out the center of the recess — out to the pencil line.

TRIMMING OFF 1/16"

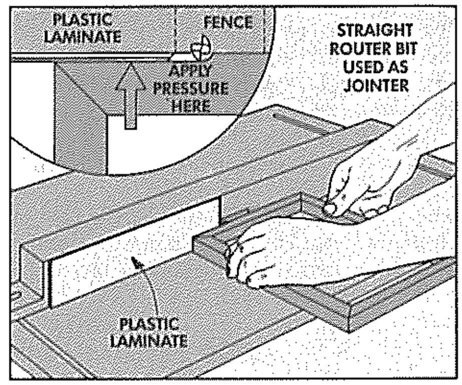
When I was building the clock, I needed to trim a *uniform* 1/16" off the sides, top, and bottom of each door frame so the frame would fit into the case. I first considered doing it on the table saw, but that involves a number of set-ups — and lots of possibilities for errors. And when you get done making the cuts you still have to remove any saw marks.

Then I remembered a tip that we printed in *Woodsmith* No. 45 for turning a router table into a "jointer" that will trim off a uniform 1/16" and leave a smooth surface. To make the router table "jointer," glue a piece of plastic laminate (Formica) to the left (outfeed) side of the fence so that one end lines up with the bit opening in the fence. Then file a slight bevel on the edge of the laminate near the opening so that it won't "catch" the leading corner of the workpiece.

Note: Most common plastic laminate (Formica) is a little under 1/16" thick (it's about 3/64"). But by the time you add the thickness of the glue to attach it to the fence, it's close enough to 1/16" for trimming the doors.

Now mount a straight bit in the router table and move the fence so the outside of the laminate aligns with the outermost edge of the bit.

To trim the four sides of a door frame, start by pushing one side of the frame through the bit keeping the frame tight against the fence just *after* it passes the bit.



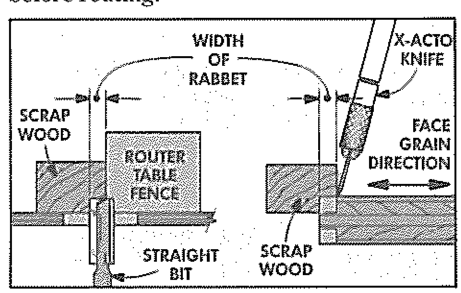
At the end of the first cut there may be a slight chipout at the miter on the next side. To clean up the chipout, move the frame counterclockwise and rout the next side. This works fine until you get to the last side — a final pass here would chip out the first side.

This minor chipout may not be objectionable — it depends on how tight the grain of the wood is. Take a look at the chipout as you rout the first three corners. If it's not objectionable, rout the remaining side moving the same direction.

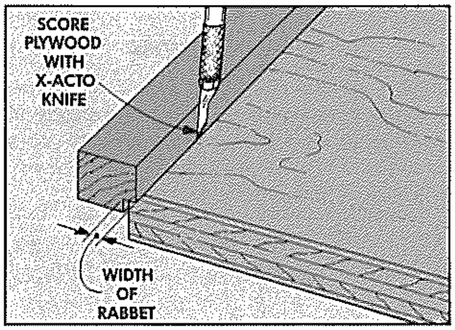
If there is a large chipout, there's a way to prevent it. Turn the frame upside down and rout about an inch into the fourth side — that's the final corner of the door frame. Then turn it back over and rout the rest of the last side.

SCORING FOR A SMOOTH RABBET

Cutting a rabbet *across* the grain on plywood (as when forming the tongues on the top and bottom of the bookcase on page 12) almost always results in tearout along the edge that forms the shoulder. The way to eliminate the tearout 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 for the knife when scoring the plywood.

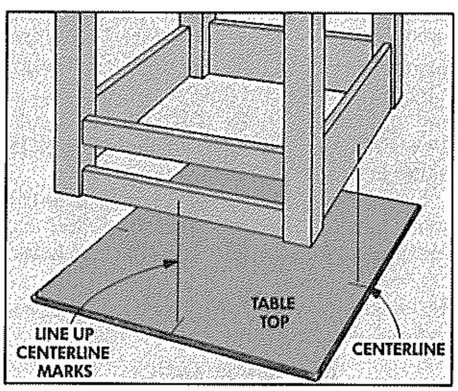


After the rabbet is routed in the strip, just fit the strip over the end of the plywood to guide an X-Acto knife while making a scoring cut. Then, flip the plywood over and rout the rabbet. The routed edge will be clean without any torn fibers.

CENTERING

Centering one part of a project (such as a top) onto another part (such as a case or frame) when they're different sizes always seems like a challenge. The problem is getting an even overhang on both sides. This is usually a matter of measure and adjust, measure and adjust. That is, measure the overhang on one side and then the other, then tap the top over a little, then back, and so forth, and so on, until they are equal — or "close enough."

Sometimes a plan will call for a specific measurement for an overhang on both sides. The only way to get that overhang is if both the top and case are made to the *exact* dimensions called for on the plan. But if these parts are a little off, you will never get the overhang specified. Usually it's more important that the pieces be centered on each other so there's *equal* overhang on opposite sides.



To center the top and bottom on the clock case and the bookcase, for example, I used an easier, and more accurate, method than trial-and-error. (I also use this method for most of the tables I build, see the drawing.) First, measure the length of the top and make a pencil mark right at the center. Then, measure the length of the case and make a pencil mark at the center.

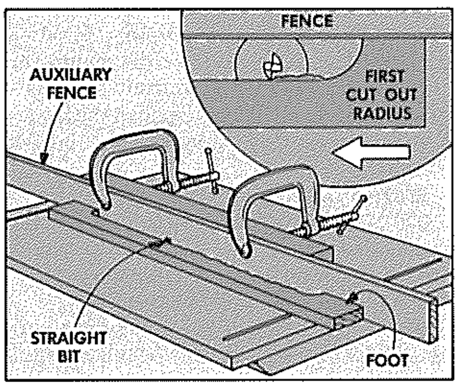
Now it's just a matter of lining up the centerline marks to get an even overhang on both sides.

STRAIGHTENING INSIDE EDGES

When cutting out an inside profile (like on the bottom edge of the bookcase apron and base on page 12), there's a problem with keeping the bottom edge straight. It's impossible to saw this profile on a table saw, difficult to straighten with a hand plane, and you get a ragged edge with a sabre saw or bandsaw.

One technique to get a smooth edge is to start by drilling out the radiused ends of the profile. Then draw a pencil line between the radii and clean out most of the waste between the ends with a sabre saw, cutting about 1/8" outside the pencil line.

To straighten the ragged edge made by the saw, I use the router table with a straight bit and a long auxiliary fence clamped to the router table fence. This auxiliary fence should be twice as long as the overall length of the workpiece.



The way this setup works is the "feet" on the ends of the workpiece slide along the auxiliary fence while the bit trims the inside profile in a straight, smooth line.

Position the fence so the distance to the outside edge of the bit is a little less than the finished dimension you want from the "feet" to the inside edge of the profile. Then, with the feet resting against the auxiliary fence, rout from right to left. Move the fence slightly and repeat until the edge is straight and smooth, and lines up with the radiused corners.

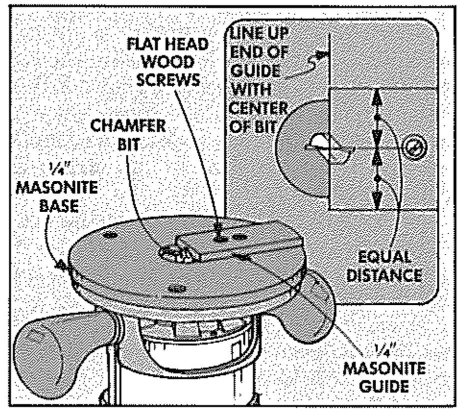
Use only as much pressure as needed to hold the legs against the fence. Too much pressure can cause the piece to spring inward, which will result in a finished profile that's concave.

One word of caution: There's a temptation to turn the workpiece around and rout with the workpiece between the fence and the bit. (So the long, straight top of the workpiece rides against the fence.) Don't do it. It's easy to lose control if it's set up this way since the bit will tend to grab the wood and pull it quickly through the cut.

INSIDE CHAMFERS

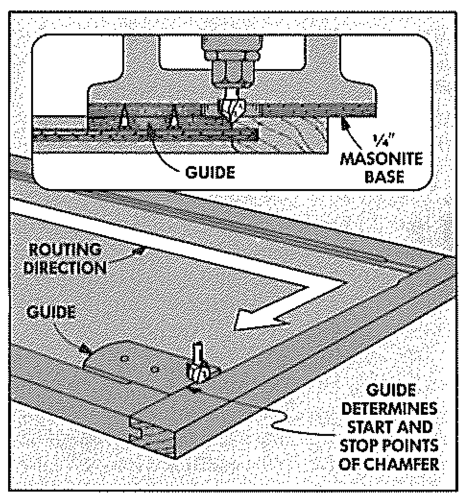
The inside edges of the frame around a panel (like on the bookcase sides on page 12) usually look nicer if they're lightly chamfered. But if the panel is already assembled this is difficult to do because the pilot on the chamfering bit runs into the panel and keeps it from cutting the edge.

To deal with this problem, I used a "V-groove" router bit instead. And to guide the bit, I made an auxiliary base for the router and attached a guide that does two jobs at the same time.



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. Then rather than trying to cut the chamfer all the way into the corners, the guide is also used to stop the chamfer a uniform distance (3/4" in this case) from the corners.

To make the guide, replace the original router base with one made from 1/4" Masonite. Then, for the guide itself, cut out another piece of 1/4" Masonite 1½"-wide by about 3" long. Align the edge of this guide with the center of the bit and screw it to the base.



To make the stopped chamfer, just adjust the depth of cut. The end of the guide will maintain a uniform chamfer and will stop it 3/4" from the corners.

Sources

CRYSTAL TABLE CLOCK

You can order the movement, hardware, and beveled glass for the table clock from:

MASON & SULLIVAN CO., Dept. 3929, 586 Higgins Crowell Road, West Yarmouth, Cape Cod, MA 02673; (617) 778-0475.

Mason & Sullivan has put together a special package that includes the half hour bell strike movement (No. 3306X) with dial, pendulum, key, serpentine hands, beveled glass, and all the hardware needed to build the Crystal Table Clock shown in this issue of *Woodsmith*. (Note: Since this is a special package put together for *Woodsmith* readers, it's not shown in the Mason & Sullivan catalog.)

For an information sheet about this special package and a free copy of the Mason & Sullivan catalog, send to Dept. 3929 at the address above.

To order the clock package, write or call Mason & Sullivan and order the *Woodsmith #49 Crystal Table Clock Package*, Order No. CO529X, $149.00.

SUEDE-TEX. As an added touch, we flocked the recess in the key drawer with Suede-Tex. For a description of this simple process, see *Woodsmith* No. 46. DonJer Products, the manufacturer of Suede-Tex, has moved since we printed that issue. For more information about Suede-Tex contact DonJer Products at their new address: Ilene Court, Building 8, Belle Mead, NJ 08502; (201) 359-7726.

BOOKCASE

You can order the hardware for the bookcase from:

THE WOODWORKERS' STORE, 21801 Industrial Boulevard, Rogers, MN 55374; (612) 428-2199 (Note: Minimum credit card order $15.00. Catalog: $2.00.) *Table Top Fasteners* (6), Order No. D9500, $1.60 per 10. *Pin Style Shelf Supports* (4), brass, Order No. D9156, $.15 each.

BOOKENDS, BRASS, AND BROWNELL'S

When I decided to make the brass base plates for the bookends on page 10, I knew there would be concern about cutting them to size. After all, *Woodsmith* is devoted to woodworking, not metalworking.

But even though brass is a metal, working with it is a lot more like working with wood than working with iron or steel. That's because it's very soft. So cutting brass on the table saw (with a carbide-tipped blade) really isn't any more difficult than cutting plastic laminate or Plexiglas. And, it won't hurt the blade.

When cutting the curved end of the plate with the sabre saw, I did use a fine-toothed metal-cutting blade to get a smooth edge. A wood-cutting blade will do the job, but it leaves a rough edge on the brass — just as it would on a thin piece of wood.

POLISHING BRASS. The secret to polishing brass is the same as getting a smooth finish on wood. It's a matter of scratching the surface with finer and finer abrasives. To do this, I sand the brass with three grades of silicon carbide paper — 220, 320, and 400 grit.

ABRASIVE CHARGE. To polish the brass to a mirror finish, I use a 6" soft buffing wheel on the bench grinder. The wheel itself is too soft to polish anything — it has to be "charged" with a polishing compound.

Charging a buffing wheel means imbedding the tiny abrasives in the compound onto the edge of the spinning wheel. This is easy to do, since most polishing compounds come as a "cake" made up of a waxy substance with the particles in the wax.

To charge the buffing wheel, press the cake against it while it's spinning. Friction will melt the compound and distribute the abrasive particles evenly around the outside of the wheel. Then, to polish the brass, press it against the spinning wheel until it shines like a mirror.

BROWNELL'S. We purchased the sheet brass and polishing compound for the bookends from Brownell's, Inc. Brownell's has been supplying the gunsmith trade with tools and equipment since 1939.

Since the gunsmith trade involves both woodworking and metalworking, Frank and Bob Brownell offer a range of specialty items that are almost impossible to find anywhere else. (How about surgical tubing to use as clamps, exotic wood blocks, rust preventative, or a bottoming rasp?)

Much of the catalog is aimed at the gunsmith trade, but we were surprised to find that there's quite an extensive selection of carving tools, files, rasps, measuring tools, abrasives, and finishing supplies. The quality of their products is first-rate, and it's one of those catalogs that I wished I'd known about long ago.

Most important, from our recent experience, the Brownells are great to deal with.

BROWNELL'S, INC., Route 2, Box 1, Montezuma, IA 50171 (515) 623-5401 (Catalog $3.50, refunded on first order). For the bookends we used *14 ga. (.0641" thick) Sheet Brass*, Order No. 084-041-14, $10.92 per 8" x 12" sheet. Other thicknesses available are: 24 ga. (.0201"), Order No. 084-041-24, $4.70; 20 ga. (.032"), Order No. 084-041-20, $6.32; 11 ga. (.0907"), $14.23.

The polishing compound we used is *No. 555 Polish*, gray, Order No. 080-555-1, $4.10 per 3 lb. cake.

SHELF HARDWARE

Most of the basic shelf hardware mentioned in the article on pages 18-19 is available at local hardware stores or through mail order catalogs. The special items mentioned are available from the following sources:

EUROPEAN PLASTIC STANDARDS. This system is available from The Woodworkers' Store (see address above). *Plastic Shelf Support Rails*, Brown, 24", Order No. D5800, $.55 each; 48", Order No. D5802, $1.15 each; 72", Order No. D5806, $2.10 each. *Plastic Shelf Support Clips*, brown, Order No. D5805, $.08 each.

SWEDISH STYLE WIRE SUPPORTS. These supports are available from Allen Specialty Hardware, 332 W. Bruceton Road, Pittsburgh, PA 15236; (For a copy of the Allen Specialty Catalog, send $1.00 to P.O. Box 10833, Pittsburgh, PA 15236). *Swedish Wire Shelf Supports*, 6¼" long, Order No. 30207, $.25 a pair; 8¾" long, Order No. 30208, $.30 a pair; 12½" long, Order No. 30209, $.40 a pair.

They are also available from The Woodworkers' Store (see address above). *Swedish Style Shelf Support*, 6½" long, Order No. D5711, $1.00 a pair; 8¼" long, Order No. D5712, $1.20 a pair.

STAPLE GUN. The heavy-duty staple gun used in production situations to mount Knape & Vogt's steel shelf supports is available from Knape & Vogt, Attn: Customer Service Dept., 2700 Oak Industrial Dr. N.E., Grand Rapids, MI 49505; (616) 459-3311. *Staple Gun*, for narrow crown staples ½" long, Order No. 1908, $121.

"F" LETTER DRILL BITS. In the article we mentioned that we use an "F" letter machinist's twist drill bit to drill the holes in the sides of cabinets for pin supports. An "F" letter bit measures .257" which is .007" larger than a ¼" bit. This is just enough bigger to allow the pins to slide easily in and out of the holes without being too loose. It's also great for ¼" dowel pins in joints or under shelves.

Letter size drill bits can be purchased at some hardware stores or from industrial equipment and supply houses (check the "Yellow Pages"). "F" bits can also be ordered from Brownell's (address above). Order No. 891-306-257, $1.80 each.

DEFT INFORMATION

Oops! We goofed. In *Woodsmith* No. 48 we printed the wrong area code for Deft, Inc. If you have any questions about using Deft products, the correct phone number to call is (714) 474-0400 during business hours (Pacific time). Ask for the Technical Service Department for Consumer Products.