NUMBER TWELVE NOTES FROM THE SHOP

Woodsmith™

PROJECTS:

SHAKER STYLE WRITING DESK

OCTAGONAL CLOCK

ROUND MIRROR FRAME

TECHNIQUES:

CUTTING TWIN TENONS BY HAND

ADJUSTABLE MITER JIG

SPECIAL

HORIZONTAL BORING JIG

Woodsmith

Number Twelve **November, 1980**

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Talking Shop

ABOUT THIS ISSUE

We finally managed to do it. We added four more pages to *Woodsmith*, taking it up to 16 pages. (And still no advertising.) With the additional four pages (and the addition of an Art Director) we were able to try some new things in this issue.

The Slant-Top Desk, for example, is a rather involved project. We had to use four pages to get in all of the art and text. In the past I always felt this was way too much space for one project. But with the added pages, we'll be able to offer larger projects like this in future issues (as many have requested).

We're also trying a new approach to presenting information: the step by step drawings. I always wanted to do things like this, but I lacked two things: skill and equipment. Ted (our new Art Director) has the skill, and we went ahead and got the equipment.

These step by step drawings should give a pretty clear picture of how we went about building the project. As we were in the building process, we took photographs of the steps along the way. Then Ted converted these photos to art (and I added the sparkling captions). We've tried to keep the art as clean and simple as possible, so you can see at a glance what is going on without a lot of unnecessary clutter.

A STORY

A couple of years ago I was trying to build a small octagonal window. It was, to say the least, a very trying experience. Here was the problem: The opening for the window was 14½" wide (the distance between two studs). I wanted to build the octagonal window to fit in that space. Now, the question is: How long should each of the eight sides be so the window fits?

It took me most of a day to figure that out. I finally settled on trial and error as the best solution. But, the problem has been haunting me ever since. When we decided to build the octagonal clock for this issue, I sat down determined to come up with a solution.

Three days, two calculators, and a box of pencils later I finally came up with a way to solve the problem. (Does anybody need a dozen pencils with no erasers?)

Anyway, I finally figured out all of the math involved and managed to condense it into three tables for easy reference in the future.

ANOTHER STORY

Let's say you have a problem (such as mine with the octagonal window). You take it to an engineer and a mathematician. The engineer looks through his books and charts and gives you the answer in an hour.

The mathematician, on the other hand, looks at the problem, looks at the engineer's books and charts, and gives you an answer in three days.

Why did it take so long, you ask the mathematician? Well, I could have given you the answer in an hour, but I was trying to come up with a way to solve the problem in 30 minutes.

That's the idea behind the various jigs and charts shown in this issue. Some projects (even relatively small ones like the octagonal clock and round mirror frame) require several specialized set-ups. Building these jigs, of course, takes time. But, the next time you're faced with a similar problem . . . .

NOTES AND THOUGHTS

TABLE VS. RADIAL. In the past few issues we've tried to include information for making cuts on both the table saw and radial arm saw. Sometimes the particular cut is not possible on both saws, or there's simply not enough room to show both methods.

The cove cutting article on page 16 is a good example. It's shown on a table saw. It is also possible on a radial arm saw, but the set up is a good deal more involved. I promise we'll include information on cove cutting on a radial saw in a future issue.

NEW PLANS. In the November issue of *Workbench* and *Popular Mechanics* we're running an ad for the plans to the roll-top bread box. Many of you ordered these plans when you originaly subscribed to *Woodsmith*. And, they also appeared in issue Number Four.

However, in all honesty I think I should mention that we have revised these plans. It's nothing major (the old plans are still good), but we wanted to redesign the bread box (making it slightly smaller). And, we used the step by step approach for the art. We've also included information on making the tambour (roll top) by cutting slats from solid wood.

At this point I was going to offer this new plan booklet to all current subscribers for $1.00. But it's getting close to Christmas and I'm in a generous mood. So if you want the new plans . . . they're free. Just write on a card or letter, "Please send *new* Bread Box Plans. I am a current subscriber." Send to: *Woodsmith*, Dept. S, Box 842, Des Moines, IA 50304. One catch: this offer expires Dec. 31, 1980.

Merry Christmas.

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Tools of the Trade

SPECIAL COLLET FOR ROUTING

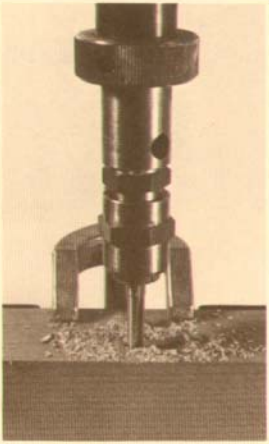
Recently I received a letter explaining the advantages of a router chuck (or collet chuck) for use on a drill press when doing routing operations. Until I received that letter I was unaware of this type of chuck, so I thought I'd check it out.

A regular drill chuck has three "jaws" designed to hold a drill bit and withstand the vertical pressure of drilling.

However, when a drill press is used for routing, much of the pressure on the bit is lateral (a sideways pressure as the wood is moved and routed). This can cause problems.

There are only three points of contact with a regular chuck (each of the three jaws). If it is used for routing, one of two things can happen: The lateral pressure on the bit can serve to loosen the holding power of the chuck. And, there's also the possibility that the bit could break because of insufficient support. Both of these occurences are undesireable.

On the other hand, a router chuck (or collet chuck) is designed to withstand lateral pressure. In fact it is very similar in design to a collet in a router — giving support around the entire circumference of the bit.



Shown in the photo is a *Sears* Collet Chuck, Holding Collar. If you want to order one you'll have to get it through the *Sears* Catalog: No. 9 GT 24672, $8.99. *Shopsmith* also has a Router Chuck No. 505597, $11.00 for use on their equipment.

As far as I know *Rockwell* doesn't have such a chuck. And, I'm not aware of other drill press manufacturers that offer this type of chuck.

As we were trying out this router coller on a *Sears* Drill Press, we decided to try a new method of making a slot mortise. The usual way to use a brad point drill bit to bore a series of holes along the length of the mortise. (Refer to *Woodsmith* No. Eight.) This method leaves a series of small triangles along the cheeks of the mortise that must be chiseled out.

We found that using a straight router bit to cut the slot mortise is much easier and faster. As shown in the photo, we simply used a ¼" straight router bit to "drill" a series of holes along the length of the mortise. Once the mortise is cut to depth, the workpiece is moved back and forth to clean up the cheeks.

SLOW-SPEED SHAPER BITS

About a year ago the folks at *Portalign* came out with a set of nine "Shaper Bits" specially designed for use with electric drills. (Actually these bits are made in West Germany and are sold in the U.S. by *Portalign*. In general Europeans have quite limited space for shops, and rely more heavily on portable electric tools than we do. So, the Germans made some bits that work in small drills.)

To use these bits, an electric drill must be mounted in some way. That's where the *Portalign* Drill Guide comes in. A drill is mounted to a Drill Guide, which in turn is mounted under a table (or just a board) with a hole drilled in it so the bit extends through the top. In use, it's very similar to a router table. (Note: These bits are *not* for use in a router, maximum speed is 4,000 RPM.)

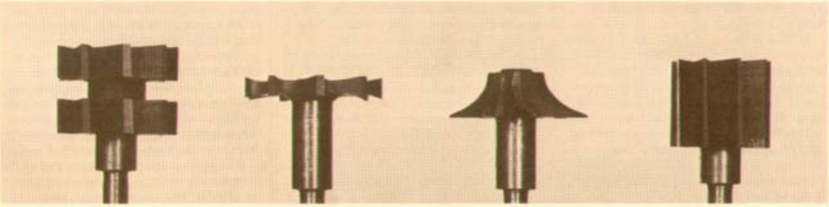
To be honest, when I first saw these bits I thought they would be great for cutting soft butter. But in oak . . . at slow speed . . . forget it.

But, I gave them a try. To my amazement they cut through oak at only 700 RPM, and made a nice clean cut at that.

This piqued my interest, so I tried them on a radial arm saw (3450 RPM). Once again they worked very well — without all the chattering and arguing you get with router bits. The only disadvantage (if it is one) is that these shaper bits are dimensioned in millimeters, not inches.

The secret, I suppose, is that each bit has nine flutes (cutting edges). If used in a ¼" drill (2500 RPM) this gives you about 22,000 cuts per minute, which is comparable to a router. There is, of course, much less horse power in a drill so the rate of feed must be slower. But they do get the job done.

The *Portalign* Shaper Bits are available at hardware and lumber yards carrying tools for woodworkers. The bits range in price from $3.79 to $7.99. If you have trouble finding them, write to: Portalign, P.O. Box 262040, San Diego, CA 92126.



Slant-Top Desk

A WRITING DESK WITH A SHAKER APPROACH

Just as I was finishing up on this desk a friend of mine dropped by the shop. All of the pieces were cut and I was doing the finish sanding before assembling the desk.

She saw all of the pieces neatly stacked on one of the assembly tables and asked what the desk was going to look like.

So, I went ahead and dry-assembled the desk to give her an idea. She was fascinated by the joinery (you don't often get to see the "insides" of the joints.)

As we talked about the desk, she asked how I went about designing it. An interesting question, I thought, because it was a matter of working around a whole set of limitations. Then I rattled off the following list:

1) I wanted to build a desk along Shaker lines, but the Shakers didn't build many writing desks (incoming and outgoing letters were strickly censored by the leaders of the church). Mostly it was a matter of using crisp, clean lines and adding the traditional round-tapered legs.

2) I wanted the desk top to slant slightly, so it would be comfortable for writing, but not so steep that paper and pens would slide off the top. I simply experimented with a piece of plywood until I got what I thought was a comfortable slant — it turned out to be about 10°.

3) Next I had to decide how high the desk was going to be. Past experience of writing on a 29"-high table convinced me that the desk should be a few inches higher for comfort. With a little more experimenting (and some guess-work) I decided on a median height of about 32".

4) I thought there should be some drawers below the top for storing all of the stuff that seems to accumulate around a desk. This meant that there had to be sufficient space below the top for the drawers, and at the same time enough clearance under the drawers for my legs to fit underneath. With a little more experimenting I decided that 24" would be a bare minimum. After working out a few dimensions I was able to add ½" to this measurement.

5) Then I made a scale drawing of a side view of the desk. Here's where I had to decide how deep (from front to back) the desk was going to be. Again, there were a few problems. I knew the top would slant up at 10°, but I wanted to size it so it would be built from standard dimension lumber. (Most hardwood sold by mail-order companies is sized to the standard widths of softwoods). Here, 16" seemed like a nice compromise (three pieces 5½" wide, with a little left for cleaning up the edges.)

6) Okay, the top slants up at 10°, it's 16" wide, and it will be attached with hinges to a top board. Now, how high are the back legs? I dusted off the old trigonometry tables . . . let's see, the tangent of 10° is ??? Whew, the back legs are less than 34". (I wanted to turn the legs on the *Shopsmith*, which allows only 34" between centers.)

7) While I'm at it I might as well add some pigeon holes on the top. If I do that though I'll increase the total depth of the desk. I'd like to use single (centered) drawers slides to mount the drawers. The longest available are 22¾". So, that's the maximum *inside* depth of the desk. Now how deep can the pigeon holes be?

8) I want some of the pigeon holes to be vertical, some horizontal. And, they should be arranged in a nice pattern. The horizontal openings should be wide enough to hold a No. 10 business-size envelope. Okay, that's 9½", so I allow for that.

9) What kind of joinery am I going to use? Mortise and tenon. What kind of wood should I use? Cherry, because I like to work with it. How will I finish it? With *Minwax* stain and *Deft* polyurethane.

10) This is getting too complicated. I think I'll just stack some bricks on the floor, put a piece of plywood on them, and call it quits.

THE LEGS

I started with the legs. Blanks for the legs are cut from 8/4 stock (1¾" actual). I cut these blanks about an inch long and then trimmed them to final length after turning.

The first step is to square up the blanks. Then I marked out the length to be turned (23½"), the length of the pommel (the square portion for the mortises at the top of the leg), and finally the position and length of the slot mortises.

The back legs have double mortises, each 3" long (Fig. 1). The width of the aprons as they meet the back legs is about 8" — too wide for a single tenon. Thus, two mortises (and two tenons) are cut. I made these mortises 5/16" wide, and cut them on a drill press as shown in *Woodsmith* No. 8.

A single 3"-long mortise is marked on the front leg where the side apron meets the leg (Fig. 2). Then twin mortises are cut to accept twin tenons on the drawer rails. The temptation here is to cut a single tenon at the end of the drawer rail and fit it into a mortise cut horizontally on the leg. This would not provide a glue surface since you will always have short grain against long grain. The best way is to cut twin mortises (and tenons) as shown.

Turning the legs is not as easy as it looks (at least it wasn't for me). After roughing down the blank, you can use a parting tool and calipers to mark the diameter at several points (see Fig. 3). But, in the end, it takes a keen eye and a gentle hand to get a nice even taper.

I started at the bottom (1" diameter) and gradually took off the wood with a gouge. I got it to where I thought it was about right and then refined the taper with a skew chisel, frequently stopping the lathe and checking the taper with a straight edge laid along the taper.

The final step is to cut off the top of the front legs at 10° (to match the slant of the side aprons). But this should be done *after* the aprons are made so a precise cut and fit can be made.

THE APRONS AND RAILS

For each of the three aprons I glued up two boards to get enough width. (These boards were simply edge-glued — without dowels or splines). Then I planed and sanded them smooth, and ripped them to their maximum width, 8½".

I cut all of the tenons before I cut the taper on the side aprons. In this case I think the method for cutting tenons shown in *Woodsmith* No. 8 is much easier than standing them on end in a tenon jig.

I used a *Sears* Satin Rim Dado Blade to make the cuts (the teeth on this blade are ground straight across to produce a flat-bottom cut, rather than a "V" bottom.)

Set the blade so it makes a 3/16"-deep cut. The first cut should be made 1" from the end of the apron to set the tenon's shoulder for the mortise in the back leg. Then make a series of overlapping cuts out to the end of the board. These cuts should be on the *outside face* of the apron.

When making the shoulder cut at the other end of the apron, be sure to mark off the shoulder to shoulder distance (see Fig. 4). Then make overlapping cuts out to the end of the board. These cuts are also made on the *outside face* side of the apron.

Now, flip the apron over to make cuts on the *inside face* of the apron. Since the first cut will establish the thickness of the tenon, it's best to make a narrow trial cut out at the end of the board. Then check the fit of this tip of the tenon in each mortise. Trial and error should produce a tenon width that matches each mortise.

At this point the side aprons can be taper cut. I used a taper jig (shown in *Woodsmith* No. 11) to make the 10° taper. (A 10° taper

FIGURE 1

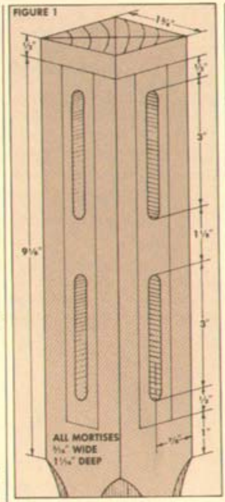


FIGURE 2

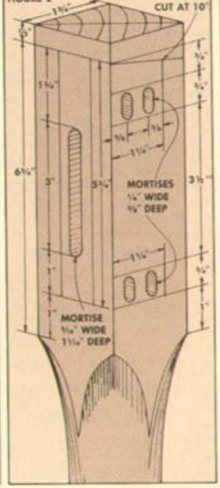


FIGURE 3

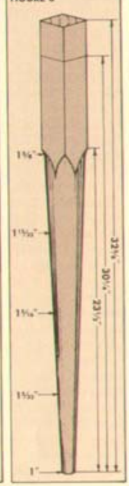
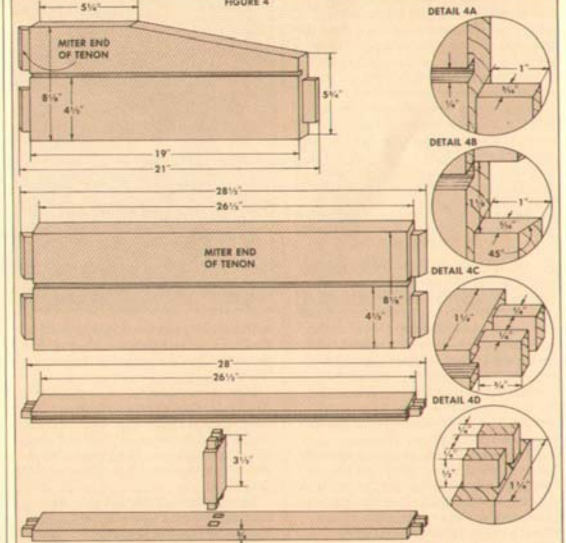


FIGURE 4



translates to 2⅛" per foot.) The taper should begin 7" from the back edge (the shoulder of the tenon) and take off 2⅛" by the time it reaches the front edge (see Fig. 4).

All of the final shoulder cuts must be made to fit the tenons into the mortises. I made these with a back saw, and then rounded over the top and bottom edges of the tenon to fit the slot mortises. The tenons that fit into the back legs must also be mitered as shown in Detail 4B.

Twin tenons must be cut in the drawer rails and divider (Details 4C and 4D). Rather than set up the table saw to do this, I think it's faster and more accurate to cut them by hand. (See page 12 for step by step on cutting twin tenons.)

At this point I dry-assembled the legs, aprons and rails. When everything is lined up as it will be during final assembly, you have to mark and cut the grooves for the plywood shelf.

First, I cut a ¼" x ¼" groove in the top front rail. Then I put it back in place with the other assembled pieces and marked the position of this groove on one of the front legs. These marks were then carried around the leg to one of the side aprons. I set the rip fence to cut a ¼" x ¼" groove and made the cut in both side aprons and the back apron at the same time. This way I was sure that the grooves in the three aprons matched up; and as long as I accurately transferred the marks from the front rail, all four grooves should line up perfectly. (Wishful thinking in my case.)

With the grooves cut, you can get the dimensions for the plywood shelf. (I used ½" birch veneer plywood for this shelf.) I cut ¼" x ¼" rabbets on the *top* edge of the plywood and notched out the corners to fit around the legs.

Finally, cut the top of the front legs at 10°. Also, bevel rip the shelf lip (F) at 10° to fit on top of the top drawer rail and in between the legs.

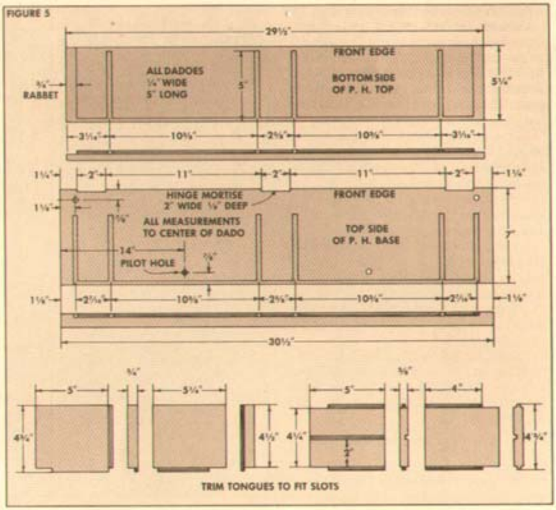
THE PIGEON HOLES

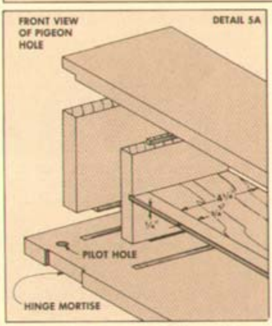
The two sides and the four dividers of the pigeon hole section are set into stopped dadoes. To avoid disaster when cutting these dadoes, cut the pigeon hole base and top to width first. Then lay the top on the base and mark its width on the base. As shown in Fig. 5, the dadoes stop about ¼" from the front edge of the top, but must stop about 1½" from the front edge of the base. (These dadoes can be cut on a radial arm saw or with a router — cutting them on a table saw is a bit awkward.)

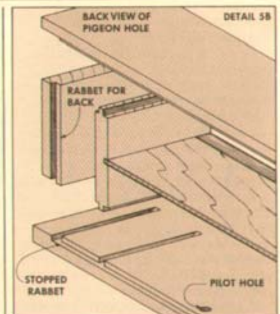
As shown in Details 5A and 5B, the *side pieces* fit into the base with a "bare-faced" tongue on the "in" side, and into the top with a rabbet joint. The four *dividers* fit into both the base and top with tongues. One note here. I planed the dividers to about ⅝" thick. I think they just look better at this slightly narrower thickness. Also, the back edge is trimmed ¼" shorter than the side pieces to allow for the plywood back.

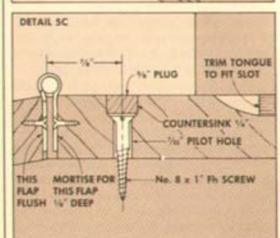
Dadoes are cut in each of the dividers for the two horizontal shelves. After cutting these dadoes, I ripped a ¼" x ¾" solid wood strip to fit at the front of the shelf. Behind this strip is a piece of ¼" plywood (I used cherry veneer plywood, but birch would be okay.)

Finally, the base, top and both sides must the rabbeted to accept the plywood back of the pigeon hole assembly. The rabbets on the top and sides go the full









length of each piece, but the rabbet on the bottom must be stopped at the dado for the side piece so it doesn't show, see Detail 5B.

GLUING UP

The gluing up can be done in stages. I started with the two front legs and the drawer rails. Then came the two back legs and the back apron.

I think the best bet is to dry-clamp the side aprons and the plywood shelf to these front and back assemblies. When you're sure everything is going to fit, go ahead and glue this up. However, I did *not* glue the plywood into the aprons, it simply rests in the grooves.

Now the pigeon hole assembly can be glued up. This requires quite a few clamps — one at the front and back of each divider. After gluing, fasten the pigeon hole section to the desk by drilling pilot holes through the pigeon hole base and into the side and back aprons. The pilot holes should be counterbored, then No. 8 x 1¼" Fh screws are driven, and the holes are filled with plugs.

THE WRITING SURFACE

Now the desk is starting to look like a desk. The next step is to make and attach the top (writing surface). Since this is a writing surface (as well as a prominent part of the desk), the top requires a great deal of care in its making.

I glued up three boards 5½" wide (again, edge gluing — no dowels or splines). Then it's just a matter of working until you get a perfectly flat surface. I started out with a *Wagner Safe-T-Planer* to take off the high spots. Then I used a belt sander with a fine (100-grit) belt, a *Rockwell* orbital sander, and finally a hand sanding block to get the surface to where I wanted it. All of this is quite a bit of work, but it's worth it.

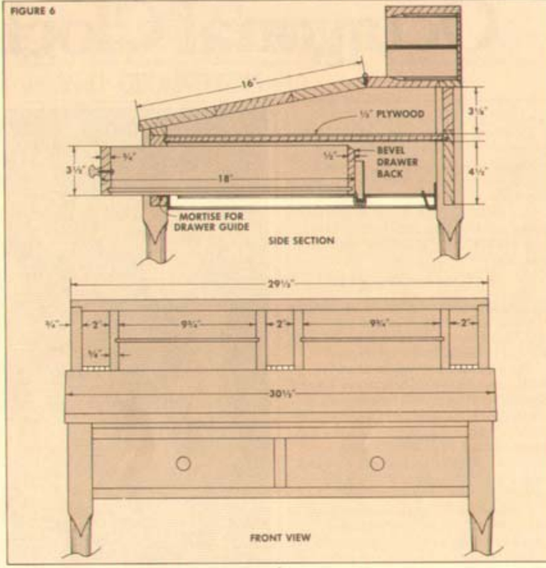
Before mounting the top to the base of the pigeon hole assembly, the front and back edges must be bevel ripped at 10°. I ripped the back edge first, and then cut the front edge so there is a ⅛" to ¼" overhang beyond the front legs.

I mortised in the hinges so the hinge flap on the desk's top was flush with the beveled edge. However, the mortise for the hinge flap on the base of the pigeon hole assembly must be cut deeper than flush. As shown in Detail 5C, this mortise must be about ⅛" deep. (If you go too deep and the lid binds, use a piece of thin cardboard to shim out the hinge.)

THE DRAWERS

I assembled the two flush fitting drawers with blind dovetails in the front and through dovetails in the back. The front of the drawer is ¾" solid cherry, the sides and back are ½" poplar (just because it's cheap), and the bottom is ¼" birch plywood.

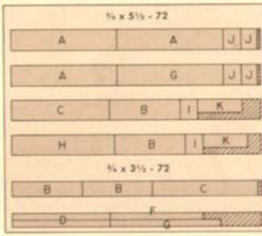
FIGURE 6



MATERIALS LIST

A	Top	¾ x 16 - 30½
B	Side Apron	¾ x 8⅛ - 21
C	Back Apron	¾ x 8⅛ - 28½
D	Drawer Rail	¾ x 1¼ - 28
E	Drawer Divider	¾ x 1¼ - 4½
F	Lip	¾ x 1¼ - 26½
G	Pigeon Hole Base	¾ x 7 - 30½
H	Pigeon Hole Top	¾ x 5¼ - 29½
I	P. H. Sides	¾ x 5¼ - 4¾
J	P. H. Dividers	⅝ x 5 - 4¾
K	Drawer Front	¾ x 3½ - 13
L	Legs (Front)	1¾ x 1¾ - 30¼
M	Legs (Back)	1¾ x 1¾ - 32⅝
N	Shelf	½ x 19½ - 27

CUTTING DIAGRAM



I decided to mount the drawers with metal drawer slides (*Knape & Vogt* KV 1175 single track drawer slides). The track hangs about ¼" below the bottom of the drawer rail, but it's not noticeable (unless you're sitting on the floor under the desk.)

I made two changes in the directions that come with the drawer slides. First I made the sides and back the full height of the opening, and simply beveled off the back edge of the drawer's back (see Fig. 6) so the drawer (and back roller) could be tilted into the opening. Also, I didn't use the side rollers, because they take up too much space.

THE FINISH

All of the pieces for the desk were final sanded before assembly. So, at this point it's just a matter of doing a little touching up and cleaning off the sawdust with a tack cloth.

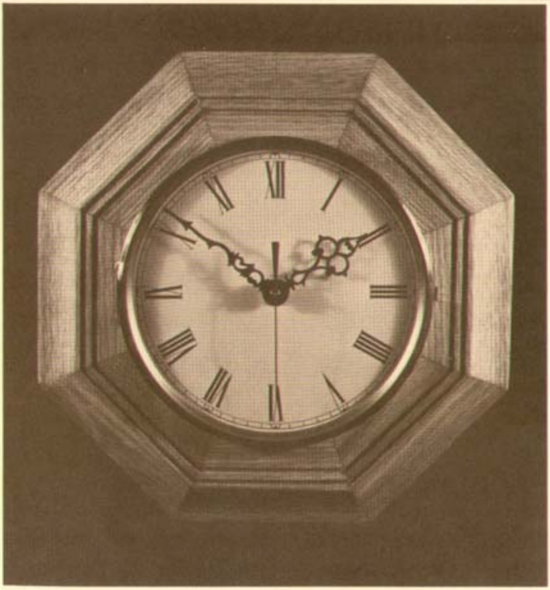
I applied two coats of *Minwax* Cherry stain to the desk, waiting a day in between coats. Then I applied three coats of *Deftlhane* Satin No. 2. Because of the difficulty of getting into the pigeon holes, I opted for the spray can of *Deft*.

Now it's just a matter of sitting back and watching an unbelievable amount of stuff accumulate around the desk.

Octagonal Clock Frame

AN EIGHT-SIDED TIME FRAME

You can't get there from here. That's the feeling I had as I was starting to build this octagonal clock. It doesn't look all that difficult. . . and it really isn't. It's just eight chunks of wood, each with a couple of grooves and a gentle cove on the outside. But to cut these eight pieces and get them joined together requires three different jigs and an Excedrin headache's worth of math.



THE COVE AND GROOVES

Cutting the cove and grooves is a matter of working backwards. What you want to end up with is two strips 2½" wide and 24" long, with a 1"-wide half-cove on one edge.

The trick is to start with a board 5⅛" wide, and cut a 2⅛"-wide *full* cove down the center. Then rip this board in half. To cut this cove, I used parallel bars to get the angle of cut and then clamped a fence 1½" from this line. You want to leave a 1½"-wide shoulder between the cove and edge for the grooves and rabbets. (Refer to page 16 for more on cove cutting.)

I used a 60-tooth carbide-tipped blade to make this cut. Be sure to start with a shallow, 1/32"-deep cut, and make repeated passes, raising the blade only 1/32" each time, until the cove leaves ½" of wood.

The next step is to cut the two grooves (these are only for decoration) and the rabbet (Fig. 2). Now, rip the board down the center. These two strips must be exactly the same width, or things will get messed up later. I moved the fence in just a smidgen, and ripped a clean edge on the half-cove edge.

CUTTING THE MITERS

The next step is to cut the eight mitered pieces to form the frame. Before you can do that you need to know the size of the frame, which is determined by the size of the bezel. (A bezel is a hinged brass rim with a domed glass "door" that fits over the clock's face and hands.)

For this clock I used a bezel with an outside diameter of 7⅛". If you want to use a bezel (or just a face) of another diameter, you must do a little math.

Figuring all of this out is discussed in detail on page 14. But basically you must use the Outside Circumference formula to find the minimum inside length of each side. In this case the inside diameter must be at least 7⅛", or radius 3 9/16".

But we need to allow for the ¼" rabbet and another ⅛" for safety. This means a radius of 3 15/16". So, using the formula, the inside length is 2.535" or 2 17/32". Then using the Inside/Outside Conversion Table, the outside length is 4 39/64", or 1/64" less than 4⅝". (You see, nothing could be easier.)

Now, the eight mitered pieces can be cut, as shown in Fig. 3. I cut off eight pieces at 22½°, 6" long. Each piece was then cut to final length.

ASSEMBLING THE FRAME

Dry-clamp the eight pieces to see if there's a gap. If there is, drill holes for dowels in only six pieces and glue up two halves. When drilling the dowel holes, match up the mitered ends of two pieces and draw a line across them. Use the line on one of these pieces to set up the horizontal boring jig, and drill a hole in the same end of each piece. Then use the line on the second piece to drill a hole on the other end of each piece.

I used *Franklin* Liquid Hide glue to glue up the frame. This glue allows enough open time (20 to 30 minutes) to get everything aligned. After the glue is set (24 hours), the miters on the two halves can be sanded or planed to a perfect fit, and then glued together.

MOUNTING THE BEZEL

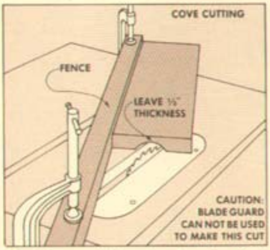
After the frame is assembled, I cut an octagonal piece of ¼" plywood to fit in the rabbets on the inside of the frame for mounting the clock movement.

At this point I finish sanded the frame and then applied two coats of *Watco* Danish Oil as a finish.

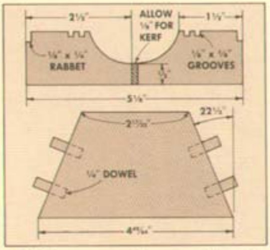
The last step is to mount the bezel and clock movement. I bought the works and hardware for this clock from *Mason & Sullivan*: No. 3403X bezel and face (dial), $13.50; No. 3609X-14 Quartz Movement, $6.50; No. 4826X Serpentine Hands, $.60; and No. 4896X Second Hand, $.50. For the catalog to order these parts write to: Mason and Sullivan, 586 Higgins Crowell Road, West Yarmouth, Cape Cod, MA 02673 or phone (617) 778-0475.

Octagonal Frame

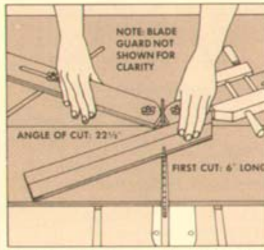
STEP BY STEP



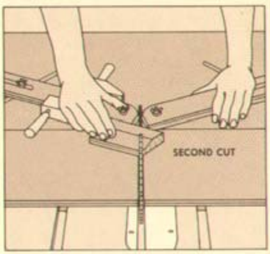
1 *Use parallel bars to set angle of cut, then clamp fence 1½" from blade. The cove is 9/16" deep (leaving ½"), 2½" wide. It's centered on a board 5¼ x 5¾".*



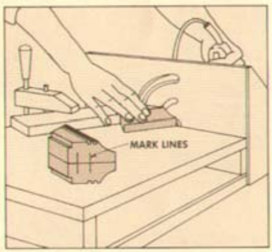
2 *Cut grooves next to cove with a dado blade. Then cut rabbets on outside edges. Rip board down the center. Dimensions of mitered piece shown at bottom.*



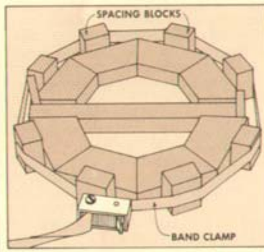
3 *Place strips in miter jig with a rabbet against arm. Cut four 6"-long pieces from each strip. This cut sets the angle (22½°) on one end of each piece.*



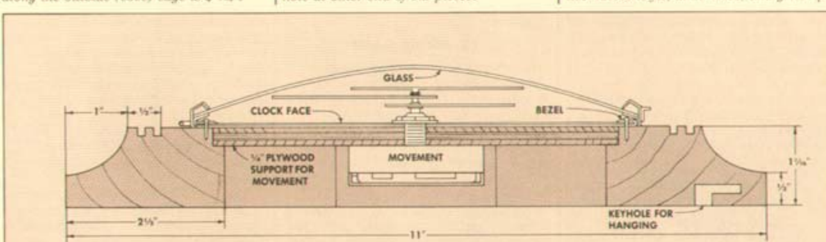
4 *Switch to other arm to cut eight pieces to length. With rabbeted edge against fence, cut off at 22½° so length along the outside (cove) edge is 4 49/64".*



5 *Mark a line across two pieces. Use this line to drill hole at one end of six pieces. Use line on second piece to drill hole at other end of six pieces.*



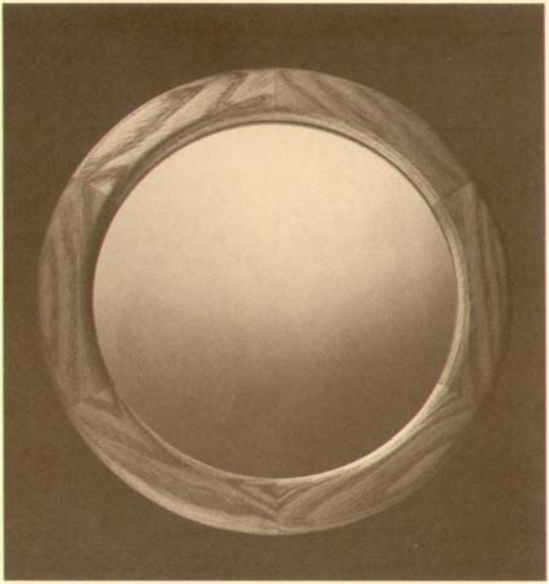
6 *Clamp octagon as two halves with scrap piece between the halves. Use shims to fill gaps (if there are gaps). Sand two halves to fit, drill holes, and glue up.*



The rabbets form an octagonal shoulder to accept a piece of ¼" plywood. This is used as a base to mount the clock movement. Before attaching the bezel, route a key-shaped hole with a picture frame router bit to hang the clock securely.

Round Mirror Frame

A CIRCLE WITH SIX SIDES



It's kind of like fitting a square peg in a round hole. Except, in this case you have to fit a round frame in a hexagon. That's how we went about building this round mirror frame.

I guess round frames are a bit mysterious. It doesn't seem right to make something round out of several things that are straight. It also seems extremely difficult. It's not.

At least it's not difficult to cut out the circle. It is a bit difficult to make it perfectly smooth. This is, once again, a matter of several jigs and a heaping tablespoon of mathematics.

THE ROUND MIRROR

It's best to start with the mirror, and then build the frame to suit. I used a 12" x 12" mirror tile (many hardwood stores carry them now) and cut it to an 11½" diameter circle. You can probably get the best results by taking the mirror to a store that does stained glass work. They have special (expensive) machines that can cut and smooth the edges of the mirror to any diameter you want.

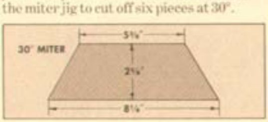
I decided to give it a try on my own with a glass cutter. First I cut out a cardboard template and marked the circle on the mirror with a crayon.

Scoring a complete circle with a glass cutter is nearly impossible. So I did it in sections and hoped for the best. To my amazement, it worked . . . a bit rough, but it was a circle.

THE HEXAGON

To build the round frame, first you build a multi-sided frame and then cut the outside and inside edges in a circle. Ted suggested that we make a dodecagon. To which I promptly replied, "Huh?" You know, twelve sides. Oh yea?! We finally settled on a hexagon (six sides) to reduce the number of joints.

We started with a piece of ¾" red oak 5½" wide and 36" long. This was ripped to yield two pieces 2⅝" wide. Then we used the miter jig to cut off six pieces at 30°.



These initial cuts are made intentionally long — about 8½". Then a second cut is made on the other end of each piece to set the final outside length. Finally, holes are drilled in each piece for ¼" dowel pins, and the frame is glued up. I used *Franklin* Liquid Hide Glue (open time: 20 to 30 minutes).

THE ROUND FRAME

After the glue is set (24 hours) I drew the circles using a large compass (see *Woodsmith* No. 7). Then I used a sabre saw to cut the outside and inside circumferences. (These cuts were rough.) The next step is to sand the outside and inside edges of the circle smooth.

To do this we used a sanding jig similar to the one shown in *Woodsmith* No. 11. The mounting plate is a piece of ¼" plywood cut ½" less in diameter than the oak circle. The four spacing blocks are needed to raise the inside edge so it can be sanded and rabbeted on the inside edge.

Figure 5 shows the sanding jig in use on a radial arm saw. This same thing can be done on a drill press. Once the inside and outside circumferences are sanded, you have a basic round frame.

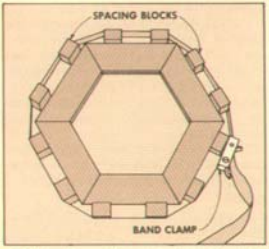
I made it a little fancy by rounding over the outside and inside edge. Though we tried using a standard router bit, a radial arm saw just goes too slow to get a smooth cut. So we tried some new bits from *Portalign*. They worked very well, even in oak. I also used a *Portalign* bit to cut the circular rabbet.

Before finishing, I cut a key-shaped hole in the back of the frame with a picture frame router bit (mentioned in *Woodsmith* No. 10).

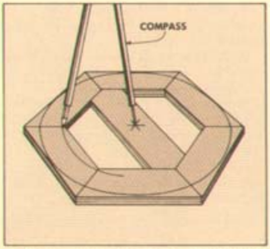
The mirror frame was finished with two coats of *Watco* Danish Oil. Then I mounted the mirror in the rabbet with glazing points (the kind used to mount glass in a window frame). Then I cut a cardboard back for the frame and simply stapled it to the back of the frame. This was done with an ordinary stapler, by swinging the base out of the way and pounding in the staples.

Round Frame

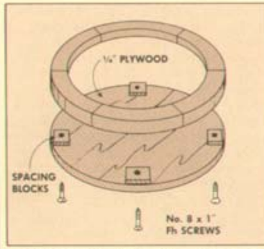
STEP BY STEP



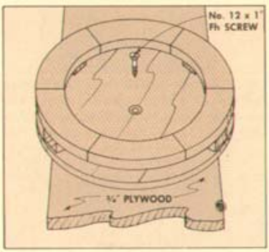
1 *Start by cutting six pieces to make a hexagonal frame. Each piece is mitered at 30°. Use a band clamp and spacing blocks to clamp the frame tight.*



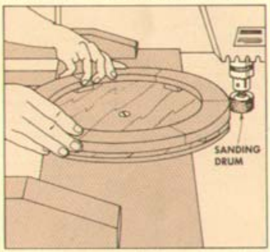
2 *Cut a piece of scrap to fit inside the hexagonal frame. Place a straight edge on pairs of opposite joints to mark the center. Then draw circles with compass.*



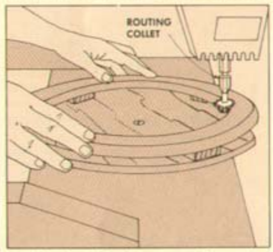
3 *Use a sabre saw to cut out circle. Cut out mounting plate 1/2" less in diameter than circle. Glue on spacing blocks and attach circle from below, centered on plate.*



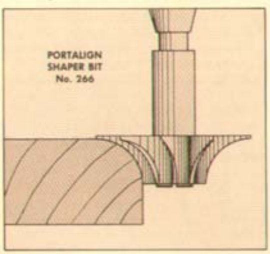
4 *Cut a base for sanding jig from scrap 3/4" plywood. Base should be nearly as wide as mounting plate for support. Mount plate to base with 1" screw.*



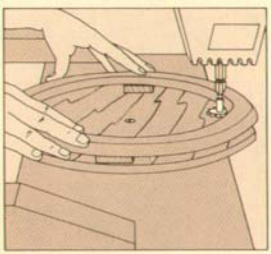
5 *Attach jig to radial arm saw table. Use sanding drum to sand outside and inside circumferences. Set drum to sand a little at a time to prevent burning.*



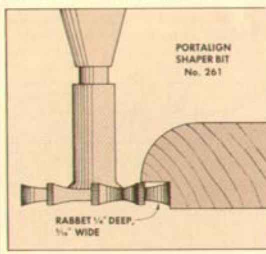
6 *Use* Portalign *bit mounted in routing collet to route half-round on inside and outside edges. Make several shallow passes, take only a little with each pass.*



7 *The* Portalign *Shaper Bit No. 266 was used to cut the round edge on the inside and outside of the frame. It works well in radial saw at slow speed.*



8 *Change bits to cut rabbet on back of the frame. The rabbet should be about 1/4" deep for the mirror and glazing points. Make several passes to cut rabbet.*



9 *The* Portalign *Shaper Bit No. 261 can not be raised or lowered while cutting. Set depth of cut to take 1/2" off bottom, then reset to take off a second 1/2".*

Twin Tenons

STEP BY STEP TO CUTTING THEM BY HAND

When cutting any mortise and tenon joint, the key thing to remember is that the mortise is always cut *with the grain*.

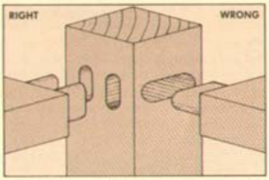
Let's say you want to join a rail (horizontal piece) to a leg. There might be a tendency to cut the joint as shown on the right in Fig. 1. Granted, this is a mortise and tenon joint. But it doesn't provide a gluing surface because the mortise is cut across the grain. Thus, the cheeks of the mortise are short (end) grain — not a gluing surface.

This is where the twin mortise and tenon comes into play. In this variation two mortises are cut with the grain, then the two tenons are cut to fit.

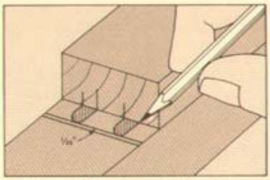
Cutting the mortises doesn't present too much of a problem. I cut slot mortises on a drill press as shown in *Woodsmith* No. 8. However, there is one little trick I like to use. When laying out the mortises, I mark lines for the thickness of the rail, and then I mark a set of second lines 1/32" inside the first ones. The mortises are cut to these inside lines so I don't have to worry about stopping *exactly* on the line. Thus, if I go a little over the line it won't show.

Cutting the twin tenons is a bit more of a problem. It is, at best, difficult on a table saw, and impossible (or too dangerous) on a radial arm saw. The problem is cutting the section between the tenons. If this section isn't exactly the thickness of the saw blade, two cuts must be made, increasing the chance of error.

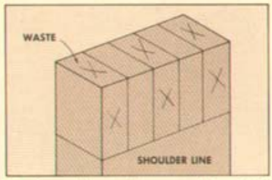
I prefer to cut twin tenons with a back saw and chisel. I think it's faster and more accurate this way. It just takes a little patience.



1 *Cutting a single mortise across the grain produces short (end) grain on the cheeks of the mortise. The correct way is to cut two mortises with the grain.*

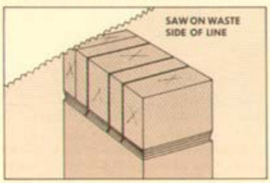


2 *The outside line marks the thickness of the rail. The mortise should stop 1/32" short, on the inside line. Position the rail over the mortise to mark tenons.*

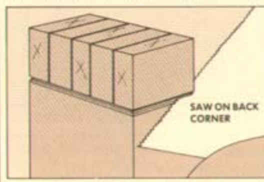


3 *Carry the marks across the end of the rail, and down the two sides. Then mark the shoulder lines of the tenon. The waste portions are marked with an "X."*

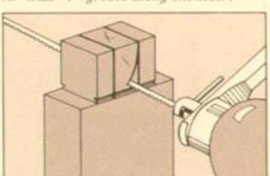
4 *Make vertical cuts by gently tapping chisel along shoulder line (bevel of chisel toward end of rail). Then slice out 1/16"-wide "V" groove along shoulder.*



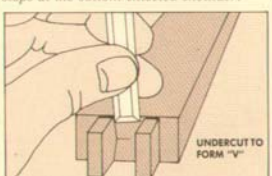
5 *Use a back saw to saw down the cheeks of the tenons. Make sure the saw kerf is on the waste side of the line and stops at the bottom chiseled shoulder.*



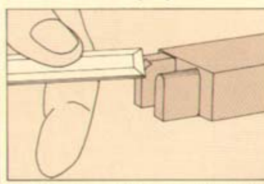
6 *Nestle a back saw in the chiseled shoulder. Start the cut at the back corner and saw around the side so you can see where the saw is going.*



7 *Use a coping saw to cut out the waste section between the two tenons. It's not necessary to remove all of the waste, just get most of it out of the way.*



8 *Remove the remaining waste with a chisel. Chop from both sides with the chisel at an angle so you undercut this shoulder to a slight "V" bottom.*



9 *Round-over the top and bottom edges of the tenons by slicing off the corners. Test the fit, and if necessary, pare down the sides of the tenons to fit mortises.*

Horizontal Boring Jig

DRILLING HOLES WAS NEVER SO EASY

For months I had been trying to come up with an easy (cheap) way to build a horizontal boring machine. But there seemed to be too many interrelated requirements . . . and no easy solution.

Then one day I was working with a *Portalign* Drill Guide on a drill when a picture of this jig jumped into my mind. Mounting a drill in a *Portalign*, I thought, would solve the problem of how to support the drill for the horizontal boring action.

The *Portalign* could then be fastened to a vertical mounting plate, which in turn would be fastened to a base. Vertical adjustments for various thicknesses of boards (the tricky part) could be made by simply pivoting the base of the *Portalign*. (Eureka!)

As shown in the Cutting Diagram, the jig is built from a 2' x 4' piece of ¾" plywood. You'll also need some ¼" plywood for the gussets and the bottom of the support shelf, see Fig. 1.

To make the vertical mounting plate, first drill a ¼" hole near the bottom of the plate (see Fig. 2), countersinking this hole on the back. This is the *pivot* hole. Then temporarily mount the *Portalign* using this hole, put a pencil in the other hole, and scribe a quarter arc. Drill a series of ⅜" holes along this arc and clean it up with a sabre saw and file. Then route a ¾"-wide countersink groove on the back. (I did this by simply hand-holding a router with a ¾" straight bit and following the arc.)

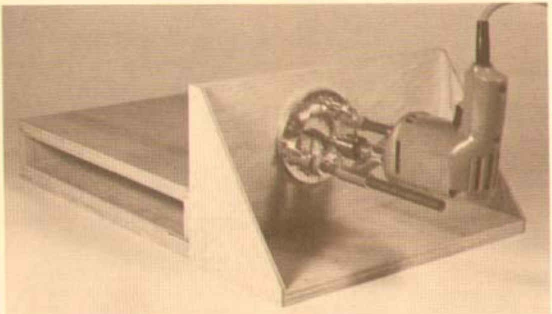
Once again, mount the *Portalign*, put a pencil in the chuck this time, and scribe another quarter arc where the drill bit will be. Drill a series of ½" holes along this arc and clean it up as the first one. Now, glue and nail all of the pieces of the jig together.

When using the jig to drill the ends of mitered pieces, use the angled support arms as shown in Fig. 3

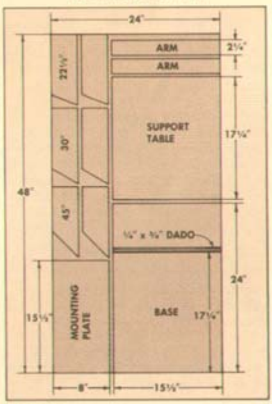
When using the jig for dowel joinery, simply mark a line across the two boards to be joined. Also mark an "X" on the face side of the boards and position the board in the jig with the "X" side *down*. Adjust the drill vertically to cut somewhere near the center of the board. Then drill a hole on the line of each board.

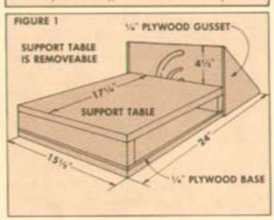
As for the drill and bits: I'd suggest using brad point bits. The *Leichtung* Catalog has a set of seven "wood bits" which will drill a much more accurate hole than ordinary twist bits.

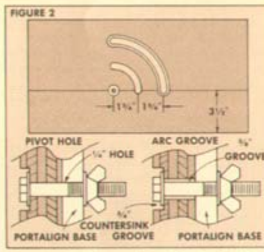
The best drill in this case is also the cheapest. An ordinary ¼" portable drill provides higher RPM's (around 2500 RPM) for a good drilling action.



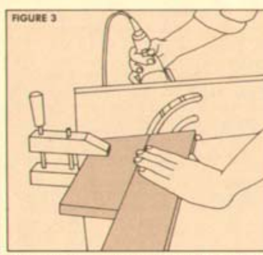
CUTTING DIAGRAM







The pivot hole is positioned at the height of the support table. The top arc is countersunk so the head of the hex nut and washer slide easily in the groove.

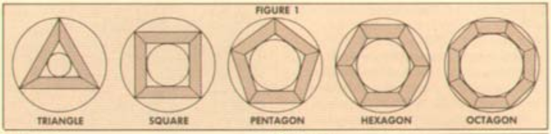


The mitered support arms shown in the Cutting Diagram are used for support when drilling the end of a mitered piece. A piece cut at 22½° for an octagon is shown.

Mathematics of Miters

CONFUSION IS A STATE OF MITER

FIGURE 1



A mitered frame presents two problems: 1) cutting the miter at the correct degree, and 2) cutting each side to the length and width you want. All of this is a matter of mathematics (trigonometry). We've tried to simplify things by coming up with the three tables, below. However, explaining these tables gets a bit confusing.

Refer to Figure 1. Here we've drawn the five most commonly used geometric shapes. We've also drawn an *inside circle* (that touches the center point of each side of the shape) and an *outside circle* (that touches the outer corners of each shape). These circles illustrate the use of Table I and Table II.

Okay, what do the tables tell you? Table I: Inside Circumference is used to determine the length of each side of a shape when you know the radius of a circle that's drawn on the *inside* of that shape.

Table II: Outside Circumference is used to determine the length of each side of a shape when you know the radius of a circle that's drawn on the *outside* of that shape.

That's simple enough, but this inside/outside stuff can get very confusing when it's applied to the real life situation of building a mitered frame. The problem is that each mitered piece has an outside length (long dimension) and an inside length (short dimension).

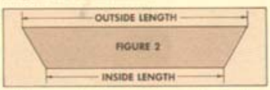


FIGURE 2

However, before you can use the Tables, you must first determine whether you want to find the inside length or the outside length of the mitered piece. (In other words, determine which ball park you're in, then you can find the right seat.)

Now, refer to Figs. 3 and 4. Here we've drawn a hexagon (six-sided) mitered frame. In both cases shown in Fig. 3 you're using Table I: Inside Circumference. The difference is that in Fig. 3a you're using the inside circle to find the *inside length* of the mitered side; whereas, in Fig. 3b you're using an inside circle to find the *outside length* of the mitered side.

FIGURE 3

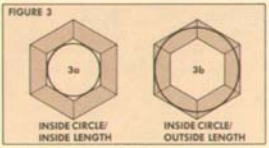


FIGURE 4

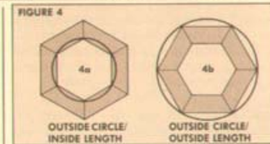


Figure 4 shows the use of Table II: Outside Circumference. In Fig. 4a you're using the outside circle to find the *inside length*, and in Fig. 4b you're using the outside circle to find the *outside length*.

Here are a few examples. In each of these examples we're using a hexagonal (six-sided) mitered frame, each side with equal length. To cut this frame you need to do two things: cut each side to the proper length, and cut the end of each side at the proper angle. So, first a word about the miter angle.

MITER ANGLE

The second column in Tables I and II is headed Miter Angle. The problem with giving a miter angle is that miter gauges on *Sears* and *Rockwell* equipment are different. The first figure in this column is for a *Sears Craftsman* miter gauge, the second figure (in parentheses) is for a *Rockwell* miter gauge.

TABLE I: INSIDE CIRCUMFERENCE

Table I is used to determine the length of each side of a shape when you know the radius of an *inside* circle. To use the formula given at the top of the table, simply plug in the radius and the I. C. Factor from the table. (For you math nuts, the I. C. Factor equals two times the *tangent* of the miter angle.)

Example 1: (Refer to Fig. 3a) Let's say you want to build a hexagonal frame for a clock face. You want the face to fit exactly inside the inside edges of the frame. The face has a diameter of 8" or a radius of 4".

In this case you're using an *inside circle* to find an *inside length*. Using the formula at the top of the table:

L.S. = 4" x 1.155
L.S. = 4.62" or 4⅝"

Example 2: (Refer to Fig. 3b) Let's say you want to build a hexagonal window frame to fit between two studs so two sides are parallel to the studs. The rough opening is 14". If you were to draw a circle between the studs it would have a diameter of 14", radius of 7".

In this case you're using an *inside circle* to find the *outside length* of the mitered

TABLE I
INSIDE CIRCUMFERENCE
Length of Side = Radius x I.C. Factor

No. of Sides	Miter Angle	I.C. Factor
3	60° (30°)*	3.464
4	45° (45°)	2.000
5	36° (54°)	1.453
6	30° (60°)	1.155
8	22½° (67½°)	0.828

*First figure, Sears; () for Rockwell.

TABLE II
OUTSIDE CIRCUMFERENCE
Length of Side = Radius x O.C. Factor

No. of Sides	Miter Angle	O.C. Factor
3	60° (30°)*	1.732
4	45° (45°)	1.414
5	36° (54°)	1.176
6	30° (60°)	1.000
8	22½° (67½°)	0.765

*First figure, Sears; () for Rockwell.

TABLE III
INSIDE/OUTSIDE CONVERSION
Inside = Outside - (Width x Factor)
Outside = Inside + (Width x Factor)

No. of Sides	Factor (one end)	Factor (both ends)
3	1.732	3.464
4	1.000	2.000
5	0.727	1.453
6	0.577	1.155
8	0.414	0.828

side. Using the formula:

L.S. = 7" x 1.155
L.S. = 8.085 or 8 3/32"

TABLE II: OUTSIDE CIRCUMFERENCE

Table II is used to determine the length of each side of a shape when you know the radius of an *outside circle*. (Again, for math nuts: O. C. Factor equals two times the *sine* of the miter angle.)

Example 3: (Refer to Fig. 4a) Once again you want to build a hexagonal frame for a clock face. But this time you want to mount the face on top of the frame so it just barely covers the inside corners. The face has a radius of 4".

In this case you're using the *outside circle* to find an *inside length*. Using the formula:

L.S. = 4" x 1.00
L.S. = 4"

Example 4: (Refer to Fig. 4b) You want to build a hexagonal window frame to fit between two studs, but this time you want two sides parallel to the floor (which means corners will be against the studs). The opening is still 14", radius 7".

In this case you're using the *outside circle* to find an *outside length*. Using the formula:

L.S. = 7" x 1.00
L.S. = 7"

INSIDE/OUTSIDE CONVERSION

In all of the examples given above, you're finding only one length: either the inside length or the outside length. Once you've found one, how can you find the other? That's where Table III comes in.

Table III has two columns. If you're working with a piece that's mitered on only one end, use the figure in the column headed: Factor (one end). If you're working with a piece that's mitered on both ends (as in the case of a frame), use the Factor (both ends). (Math nuts: Factor (both ends) equals two times *tangent* of (90° minus miter angle).)

If you know, for example, that the outside length of a mitered side is 7" (as in Example 4), what is the inside length? This depends on two things: the Miter Angle and the Width of the Side. So, let's say the mitered side is for a hexagon (30°) and the width of the side is 2". Thus,

I.L. = 7" - (2" x 1.155)
I.L. = 7" - (2.31")
I.L. = 4.69" or 4 11/16"

Basically, you multiply the width of the side times the Factor. This figure is then added to the Inside Length to obtain the Outside Length, or subtracted from the Outside Length to obtain the Inside Length.

There will be a pop quiz on all of this next Tuesday.

Miter Jig

A SIMPLE ANSWER TO PERFECT MITERS

The problem with cutting a miter is three-fold: 1) the angle of cut must be exactly the correct degree, 2) each piece must be cut to precise length, and 3) the cut must be true. The first two problems are basically measuring difficulties.

The third problem is (or can be) a result of the action of the saw blade as it spins and cuts the wood: it tends to pull the wood into the blade, or push it away (usually it pulls). This is called "creep." Part of the solution is to make sure the blade is sharp and, if the teeth have "set," that the set is even. Beyond that, all you can do is make sure the wood doesn't move as it's being cut. Enter the miter jig.

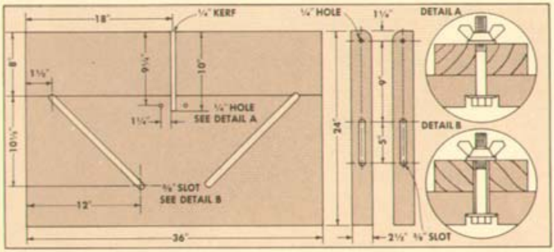
The purpose of this jig is to allow you to hold the wood firmly in place to prevent creep. This is accomplished by clamping a stop to the arm and pushing the workpiece *toward the stop* (away from the blade). We decided to make a miter jig with adjustable arms so you could cut any angle (miter) between 90° and 15°.

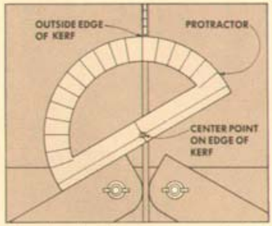
This miter jig is built from a 2' x 4' piece of 3/4" birch plywood (A-C fir can also be used). Briefly, cut off the two arms, see Fig. 1. At one end drill a 1/4" pivot hole and round off the inside corner. Drill pivot holes in the base, countersinking on the bottom. Cut a 5/16" x 5" slot in arms by drilling a series of holes and cleaning out with a sabre saw.

To cut the slot in the base, mark its position (as shown in Fig. 1), clamp a fence parallel to this line and use a router and 5/16" straight bit to route a through groove. Then route a 3/4"-wide countersink groove on the bottom, Detail B.

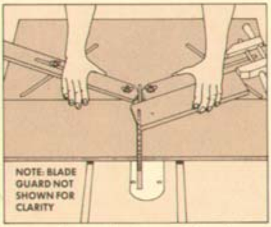
Cut two hardwood bars (maple is best) to fit the grooves of your table saw. Position the base on the saw's table so it aligns with the back edge of the saw. Fasten base to bars with No. 8 x 1" screws and glue. (Position the front edge of the base so the saw blade will cut a kerf line centered between the two arms.)

To set the angle of the arms, use the biggest protractor you can find (try an art supply store). Place the protractor along one arm and position it so the center point is on one edge of the kerf line. Then move the arm until the degree you want lines up with the blade.





To set angle of cut, use a protractor. Position center point on kerf and align edge of blade with degree wanted.



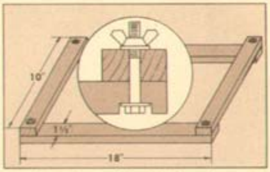
In use, clamp stop to arm (hand screw shown here), hold workpiece firmly against arm and push it toward stop.

Cove Cutting

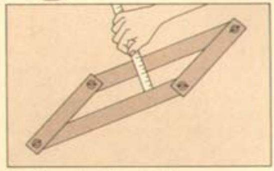
It's impossible. At least it sure looks like it's impossible to cut a cove on a table saw. But it's simply a matter of using an auxiliary fence and feeding the workpiece into the blade at an angle.

The shape of the cove is determined by three things: 1) the diameter of the blade, 2) the angle of feed, and 3) the depth of cut. The illustrations show how to set everything up.

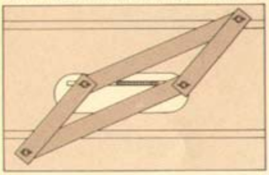
NOTE: The blade guard must be tilted out of the way to make room for the fence. This means you must exercise extra caution when making this type of cut.



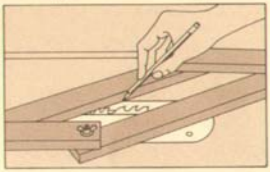
1 *To set the angle of feed, make a set of parallel bars. The bars pivot on hex nuts so opposite sides are always parallel.*



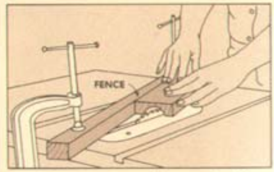
2 *Determine the width of cove you want to cut. Then set the distance between the two long bars to this width.*



3 *Raise blade to depth of cut, leaving at least ¼" on workpiece. Position bars so blade barely touches inside of both bars.*



4 *Hold bars firmly on table and mark a line along the inside of the bar that touches the "back" side of the blade.*



5 *Clamp fence parallel to marked line, allowing for width of shoulder. Make only 1/32" depth of cut with each pass.*

BACK ISSUES

Following is a list of the contents of back issues of *Woodsmith*. Back issues are available for $2 each.

Number One: Trestle Table, Contemporary Double-Duty Tables, Tie Rack, Cookie Cooling Rack, Cutting Board, Finger Clamps, Drill Press Guides, Taper Jig, Carpenter's Triangle.

Number Two: Contemporary Chairs, Table Saw Techniques: Box Joint and Stopped Dado, Hanging Lamp, Raised-Panel Door, Technique: Mitered Half-Lap, Shaker Peg Rack.

Number Three: Canvas and Redwood Deck Chair, Redwood Garden Bench, Deck Squares, Redwood Plant Tub, Cedar Plant Pillars, Hanging Planter, Tips For Outdoor Furniture, Nine Variations On Planter Boxes.

Number Four: Roll-Top Bread Box, Angle Drilling Jigs (Three), Shop Stool, Lazy Sam Tool Storage, Box Of Drawers, Box Building Basics, Router Case.

Number Five: Router Table, Make Your Own Tools: Wedge Clamps, Taper Jig, Bow Saw, Drawing An Ellipse, Oval Frame, Toy Train and Race Car.

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Number Eight: Joinery: Mortise & Tenon, Frame and Panel Construction, Wall-Hung Cabinet, Frame and Panel Cabinet, Panel Cutting Techniques.

Number Nine: Projects With Wooden Hinges: Adjustable Light Bracket, Jewelry Box, Lap Desk, Sweater Chest, Display Case; Joinery: Locked Miter, Joinery: End Boards, Joinery: Parallel Spline, Tips & Techniques.

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