# Joint Making

29

## Objectives

After studying this chapter, you will be able to:

- Select appropriate joints based on the product and material.
- Select hand tools, power equipment, and special jigs or accessories for joinery.
- Create and assemble nonpositioned, positioned, and reinforced joints.

## Important Terms

box joint
butt joint
butterfly joint
dado joint
dovetail joint
groove
half-blind multiple dovetail
lap joint
miter joint
nonpositioned joint
plate joinery
pocket joint
positioned joint
rabbet joint
reinforced joint
scarf joint
spline
structural finger joint

One of the most important elements affecting the durability of a product is joinery. This chapter covers typical joints for assembling furniture and cabinets. Looking at a finished joint reveals little about its structure. The components you see are combined. See **Figure 29-1.** It is the internal structure of the joint, either simple or complex, that affects the strength and stability of the product.

## Joints and Grain Direction

The direction of grain in a solid wood joint affects the joint's strength. The parts that meet will have end grain, radial (edge) grain, or tangential (face) grain. The holding power, or strength, of radial and tangential grain is equal since the joint meets "along the grain." The abbreviation "AG" is used to describe a joint that involves radial or tangential grain. A joint where mating components meet along the grain (abbreviated as AG/AG) is the

**Figure 29-1.** It is difficult to determine what types of joints were used to assemble these products. *(Thomasville)*

strongest. When end grain (EG) is involved, such as an AG/EG or EG/EG joint, the strength is only 10% to 25% that of an AG/AG joint. **Figure 29-2** clarifies AG/AG, AG/EG, and EG/EG joinery.

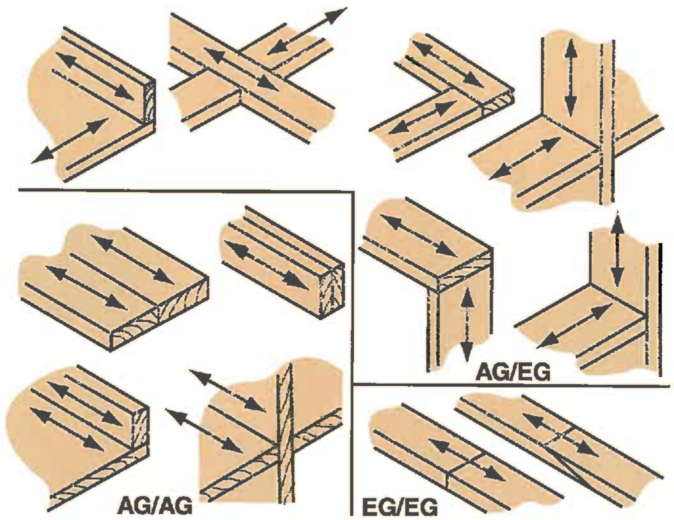



**Figure 29-2.** Grain direction of the joining components can affect the joint's strength.

Although radial and tangential grain have the same holding power. However, they shrink at different rates.

Radial grain bonded to radial grain offers maximum strength. Tangential grain surfaces glued together are just as strong. This is because they have consistent shrinkage rates. However, a joint where radial grain meets tangential grain is not quite as strong. These joints may crack and separate as each component shrinks a different amount. You can reduce shrinkage by using wood that has a low moisture content. In addition, adhesives that remain flexible when cured are recommended.

## Joints in Manufactured Panel Products

A majority of cabinets made today consist of particleboard, fiberboard, or other manufactured panel products. These materials present an entirely new set of considerations. Solid wood joints rely on the grain direction and strength of the wood for structure. Products made of fiberboard, plywood, or particleboard cannot. There are only a few joints that are suitable for panel products. These include butt, rabbet, dado, and miter joints. Even then, a method of reinforcement is added. Plate joinery is a popular method of reinforcing a joint. Staples and nails driven with a pneumatic gun are often used in production. Panels are first glued so the joint does not rely entirely on the fastener. Particleboard screws, one-piece connectors, and ready-to-assemble fasteners are also used. Still, the cabinetmaker must be careful. Both threaded and nonthreaded fasteners driven into the edge of a panel product tend to split the material.

## Joinery Decisions

While designing a product, the cabinetmaker decides which joints will be used to hold a cabinet, piece of furniture, or other wood product together. It is best to choose the simplest joint that meets the strength requirements of the product. In the furniture industry, two parts in a hidden area typically are joined with a butt joint reinforced with dowels, glue blocks, or mechanical fasteners. This is nearly as strong as a mortise and tenon or other positioned joint, but costs much less to produce.

Joinery begins once material has been surfaced and cut to size. Some parts must be cut oversize to allow for machined features of the joint. Remember, the internal structure of a joint may be much different from what you see in the finished product. Consult the working drawings before you cut material to size. Usually, a cutting list is provided. These measurements should allow for joinery.

The machines covered in *Chapter 21* through *Chapter 28* will produce most of the joints discussed in this chapter. However, special jigs, machinery, or attachments may be more effective for making some positioned joints with intricate contours. These are discussed in this chapter.

During layout, make all measurements from a common starting point. Use the appropriate layout tools. Lay out joints so that the components fit together freely. Leave room for the adhesive and expansion or contraction due to moisture changes.

Plan your sequence of operations carefully. Decide which processes should be done first, second, and so on. For example, when making a mortise and tenon joint, cut the mortise (recess) first. Then cut the tenon to fit. Sometimes the order is not important. On a shaper, either the tongue or groove of a tongue and groove joint can be made first. The accuracy of your machine setup ensures a snug fit.

Regardless of the joint being made, an accurate setup is essential. Make practice passes on scrap material to position the blade, bit, or cutting tool. Jigs, fixtures, or other setup steps may be helpful or even required.

## Joint Types

When designing a product, choose joints according to the estimated stress that the product will receive. Although there are hundreds of joints, all fall into one of these three categories:

- Nonpositioned.
- Positioned.
- Reinforced.

A ***nonpositioned joint*** is one where two components simply meet without any position or locking effect. Only the adhesive or fasteners holds the joint permanently. A nonpositioned joint has little surface area for the adhesive to contact. Some examples are butt and plain miter joints.

In a ***positioned joint,*** one or both components have a machined contour that holds the assembly in place. Adhesives solidify the joint. The mortise and tenon, dovetail, and locked miter joints are examples. Although more time consuming to create, positioned joints are stronger than nonpositioned joints. There is more surface area between the mating parts for the adhesive bond.

***Reinforced joints*** have some element besides adhesive that helps hold the joint. For extra support, butt and miter joints are often reinforced with dowels, splines, and plates. Glue blocks are bonded into hidden corners to help strengthen the joint. Mechanical fasteners also reinforce joints. Clamp nails, corrugated fasteners, nails, and staples may provide permanent or temporary position to the joint while the adhesive dries. Fasteners for ready-to-assemble furniture, such as the bolt and cam connector, do not require adhesive.

### Butt joint

A ***butt joint*** is a nonpositioned joint where the square surface of one piece meets the face, edge, or end of another. See **Figure 29-3.** The edge-to-edge butt joint is used without reinforcement to form wider material. (This process is discussed in *Chapter 33.)* Butt joints, other than edge-to-edge or edge-to-face, are very weak. They must be reinforced with glue and mechanical fasteners, such as plates, corrugated fasteners, screws, staples, brads, or insert nuts and bolts. See **Figure 29-4.** Doweled butt joints, discussed later in the chapter, are very strong.

Glue blocks add even more strength to a butt joint. Glue and nail them to one piece of material. Then drill clearance and pilot holes for screws to attach the block to the other piece of material. See **Figure 29-5.** Clamps are not necessary while the glue dries.

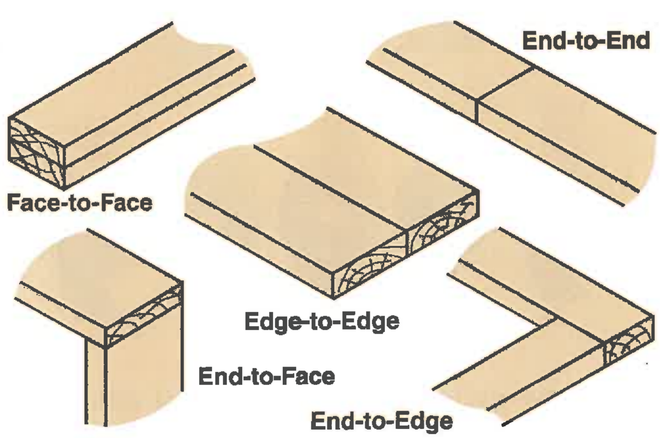



**Figure 29-3.** Butt joints.

**Figure 29-4.** One-piece connectors are used to reinforce the butt joints used to assemble this computer desk. *(O'Sullivan)*

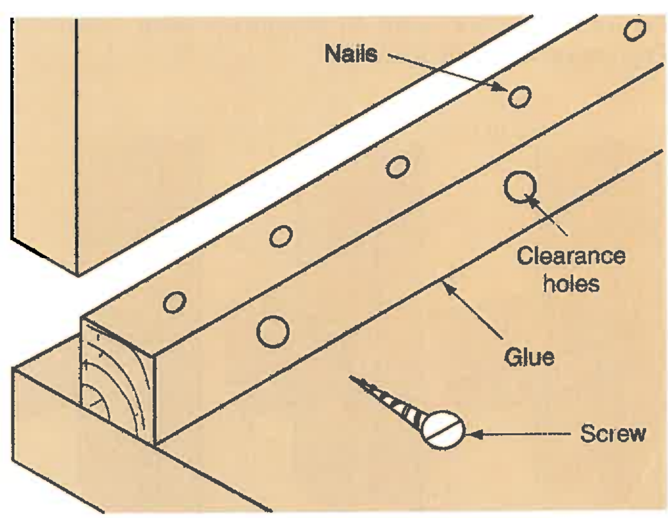



**Figure 29-5.** The glue block is bonded and nailed to one component. The second part is attached with screws through the glue block.

## Dado and groove joints

A *dado joint* is a slot cut across the grain. A *groove* is a slot cut with the grain. Dadoes typically are positioned EG/AG assemblies. You often find them used to mount shelves for cabinets and bookcases. See **Figure 29-6.** There are several types of dadoes. See **Figure 29-7.** In a *through dado,* the joint is exposed. If you choose not to see the joint, make it blind. This dado is cut partway and the joining component is notched to fit. A half dado is a combination dado and rabbet joint. It is used to eliminate unsightly gaps when the material is not equal to the thickness of either the dado blade or the router bit. It helps keep components square, and is often found as a back corner (back-to-side) drawer joint. A dado and rabbet, discussed later, are also used in drawer construction.

Dadoes and grooves are most often cut on the table saw or radial arm saw using a dado cutterhead. Two types of dado heads are available. See **Figure 29-8.** The *adjustable dado cutter* (sometimes called a wobble dado) rotates with a controlled side-to-side motion. The dado width is set by rotating the blade within its guide according to the scale. Another dado head consists of two blades and assorted chippers. Each blade makes a 1/8" (3 mm) kerf. The width of the dado is set by adding chippers between the blades. See **Figure 29-9.** Chippers may add 1/16", 3/32", 1/8", or 1/4" (2 mm, 2.5 mm, 3 mm, 6 mm) to the width of the dado. Shims can be added between the chippers and blades for minor adjustment in width. Shims are available in several increments from .004" to .031" (0.1 mm to 0.8 mm). Stack additional thin shims for even greater precision.

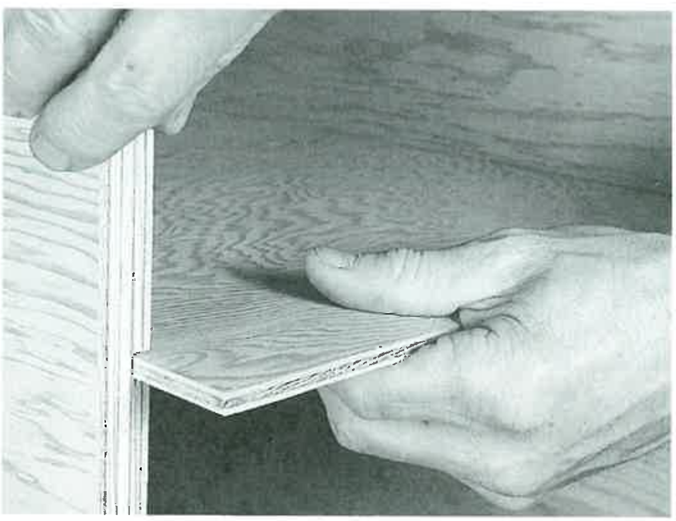


**Figure 29-6.** Dado joint to support a shelf. *(APA–The Engineered Wood Association)*

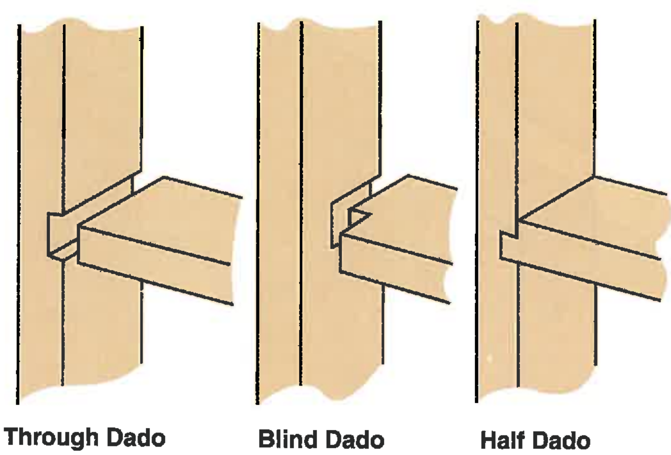




**Figure 29-7.** Dado joint variations.

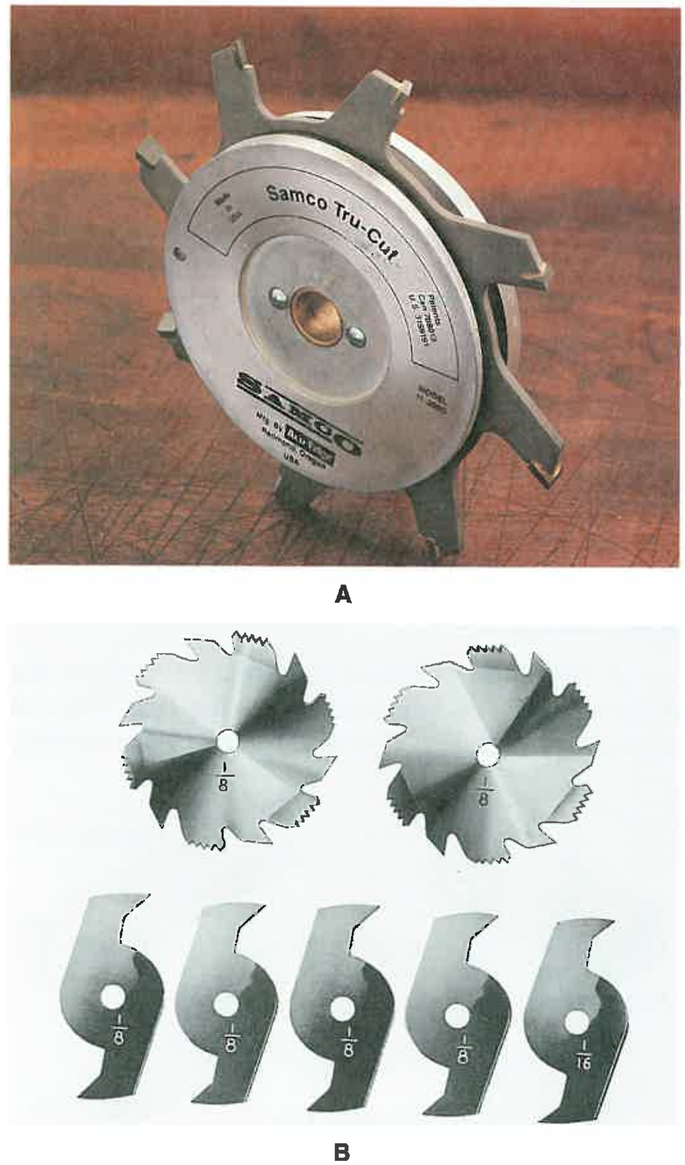




**Figure 29-8.** Dado cutters. A—Adjustable dado cutter. *(The Fine Tool Shops)* B—Dado blades and chippers. *(Delta International Machinery Corp.)*

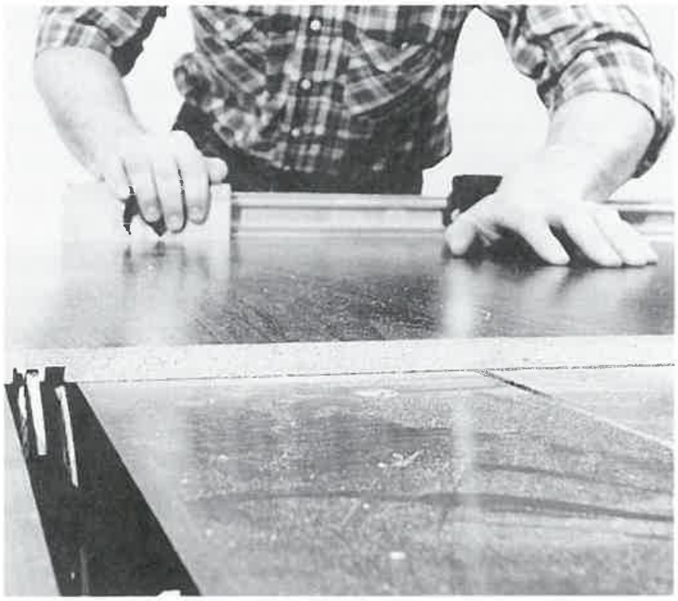
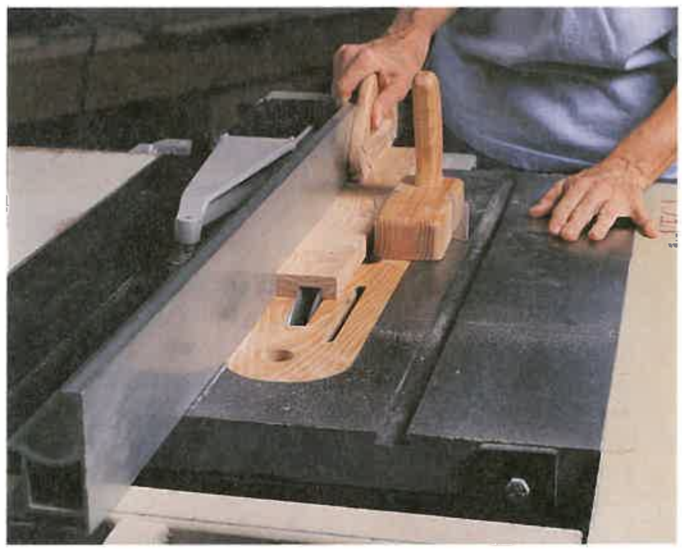


Figure 29-9. Chippers between the blades make this dado a one-pass operation. Guard was removed to allow the material to pass over the dado. *(Delta International Machinery Corp.)*

A



B

**Figure 29-10.** A—Crosscutting a dado. B—Ripping a groove. Guard was removed to show operation. *(Chuck Davis Cabinets)*

Most dadoes require only one pass of the cutter blade. See **Figure 29-10.** If the joint must be wider than the maximum width of the cutter, make more passes. Since the cut does not pass through the workpiece, you can use a fence and miter gauge together for the setup. However, there is always a hazard of kickback. Clamp a featherboard to the fence to hold the material against the saw table. When within 4" (102 mm) of the blade, feed stock with pushsticks.

Dadoes and grooves can also be cut with the router and straight bit. Usually, two passes are necessary to rout the full width because router bit diameters are limited and panel thicknesses vary. To rout accurate dadoes, use a fence or guide. Without the support provided by large table extensions on your saw, it may be more accurate, easier, and safer to rout the dado. Because of the smaller base on the router, the depth of the dado may be more consistent if the panel is cupped. See *Chapter 26* for further discussion of the router.

Another difference between sawing and routing operations can be seen in the blind dado. Plan a method to stop the blade or bit. Clamp a stop block to the table saw or to the workpiece when routing. After the dado is cut on the table saw, use a chisel to square the curved inside corner left by the blade. The router will square this corner, but leave a radius at the corners of the dado. Square those with a chisel. The corner of the joining component must be removed to fit the blind dado. Use the table saw with the workpiece on edge. Leave the blade height unchanged from cutting the dado. This assures an exact fit.

## Rabbet joint

***Rabbet joints,*** often used for simple case construction, are similar to dadoes, except for the joint's location. Rabbets are cut on the end or edge of the workpiece. A typical full rabbet joint has one part on edge at a width equal to the thickness of the adjoining part. The depth should be one-half to two-thirds the thickness. See **Figure 29-11.**

The rabbet joint is commonly used to attach back panels to cabinets, bookcases, and other casework. The joint conceals end grain of the back panel so that it is not visible from the side of the product. See **Figure 29-12.**

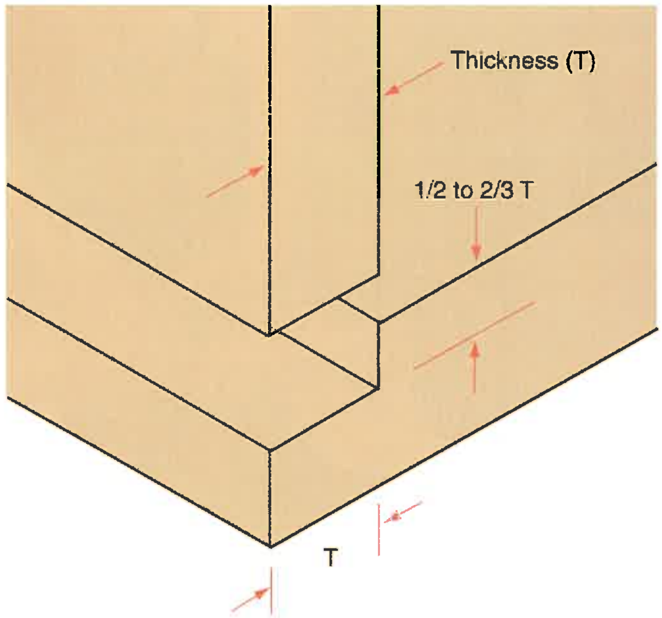



**Figure 29-11.** Critical dimensions of a full rabbet joint.

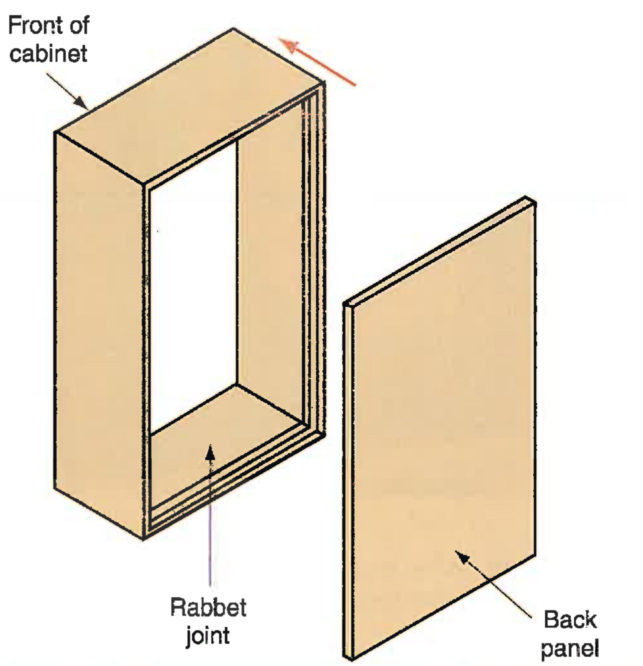



**Figure 29-12.** Rabbet joints are often used to hide the back panel edge and end grain.

There are several variations of the rabbet joint. With the ***half rabbet***, both components are cut the same way. Sometimes, a rabbet and dado are combined, which makes positioning easier. These include the ***dado and rabbet***, and ***dado tongue and rabbet***. See **Figure 29-13.** The dado tongue and rabbet is often used for drawer fronts.

Rabbet joints can be made using the dado head or a router bit. See **Figure 29-14.** Place an auxiliary fence against the rip fence to allow for adjustment of the width of cut. Slowly raise the dado head into

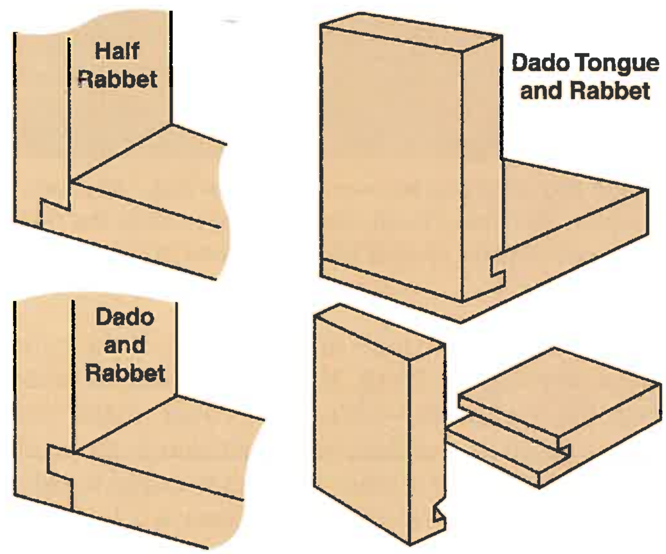



**Figure 29-13.** Types of rabbet joints other than the full rabbet.

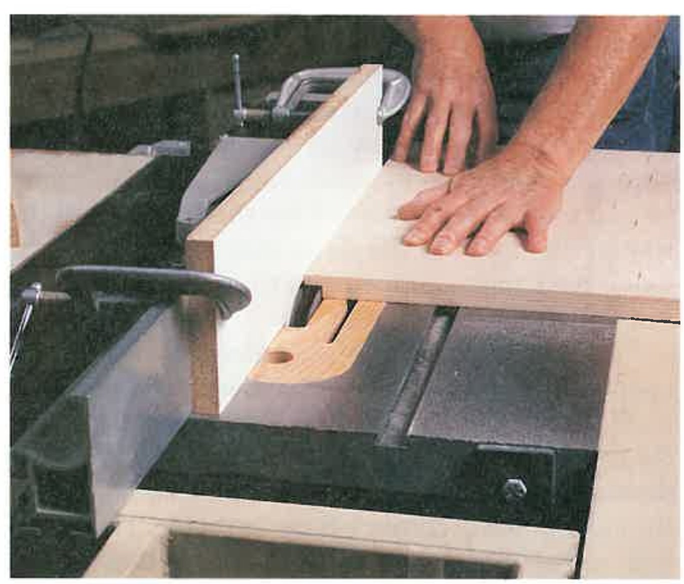


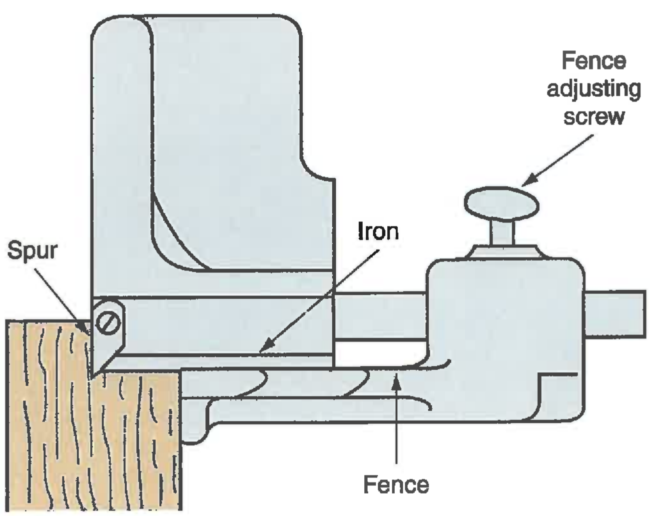
**Figure 29-14.** Cutting a rabbet with a dado blade. Clamp a temporary piece to the fence, set the fence to ¼" (6mm), turn on the saw, and raise the dado blade into the piece. Turn off the saw, and set the fence and the dado height desired. *(Chuck Davis Cabinets)*

the auxiliary fence. You may use the router with a rabbet bit. Without these tools, take multiple passes on the saw to create the full width of the rabbet. Two passes with a standard blade on the table saw will produce the joint. Make one pass with the workpiece surface on the table. Make a second pass with the same surface against the fence.

Rabbet joints can also be made in wood workpieces with two specialized hand planes; the rabbet and bull-nose planes. The ***rabbet plane*** cuts accurate, long rabbets. A fence helps guide the tool. See **Figure 29-15.** In a ***bull-nose plane,*** the plane iron is up front. This allows you to plane into corners. See **Figure 29-16.** The irons in both rabbet and bull-nose planes are set like a block plane. Several passes are necessary to attain the depth of cut needed.

Some rabbet planes are fitted with a spur. This is an attachment that scores the wood at the edge of the cut. This prevents the wood fibers from tearing as the plane iron cuts. If your plane has no spur, it is a good idea to score the surface of the wood with a knife. See **Figure 29-17.**


A

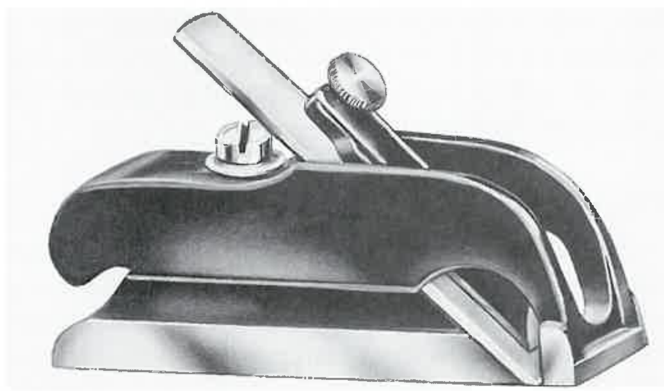



B

**Figure 29-15.** A—Rabbet plane. *(Stanley Tools)* B—Position of the plane when cutting a rabbet joint.

## Lap joint

***Lap joints*** are positioned joints in which one component laps over the other. The parts, which can meet at any angle, join with rabbets or dadoes cut



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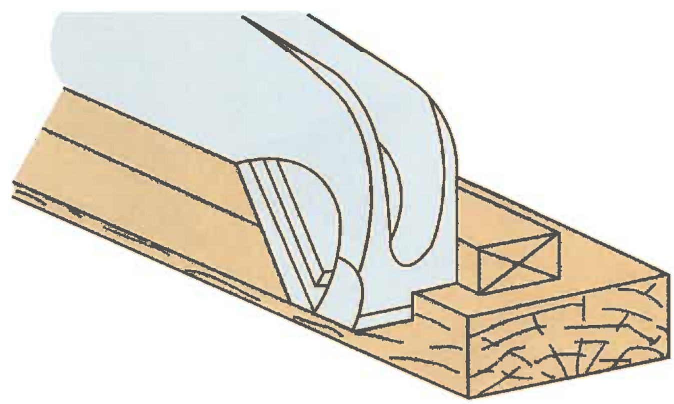


B

**Figure 29-16.** A—Bull-nose plane. *(Stanley Tools)* B—This plane rabbets into a corner.

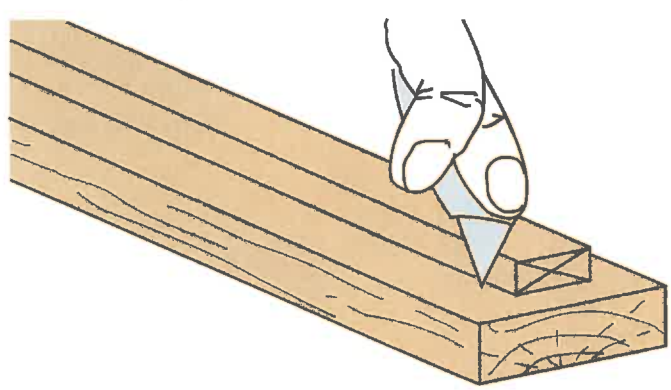


**Figure 29-17.** Score the wood along the layout line to prevent tearing the grain when cutting the rabbet with hand tools.

equal to the workpiece width. Lap joints are given different names according to where the components meet. See **Figure 29-18.** Lap joints are often called half laps because equal parts of each component are removed at the lap. Lap joints that meet at an angle other than 90° are called the ***oblique lap*** and ***three-way lap*** joints. Oblique laps are often found where diagonal stretchers meet, such as in the table shown in **Figure 29-19.**

Lap joints may be sawn or routed. Sawing is done with a dado head or multiple-passes with a standard blade. Both the radial arm saw and table saw are appropriate. Routing makes use of the square end bit and guide.

## Miter joint

***Miter joints*** are much like butt joints, but conceal all or part of the end grain because they are cut at a 45° angle. This makes the joint much more attractive. The two most common joints are the flat and plain miters. All that is visible is a 45° line. See **Figure 29-20.** The ***flat miter*** is also called a ***frame miter*** since it is widely used for frame and panel construction. The ***plain miter*** is also called the ***carcase miter*** because it joins the edges of panels in case construction.

In its simplest form, the miter joint is a weak, nonpositioned, end grain-to-end grain assembly. However, it can be made stronger when positioned.

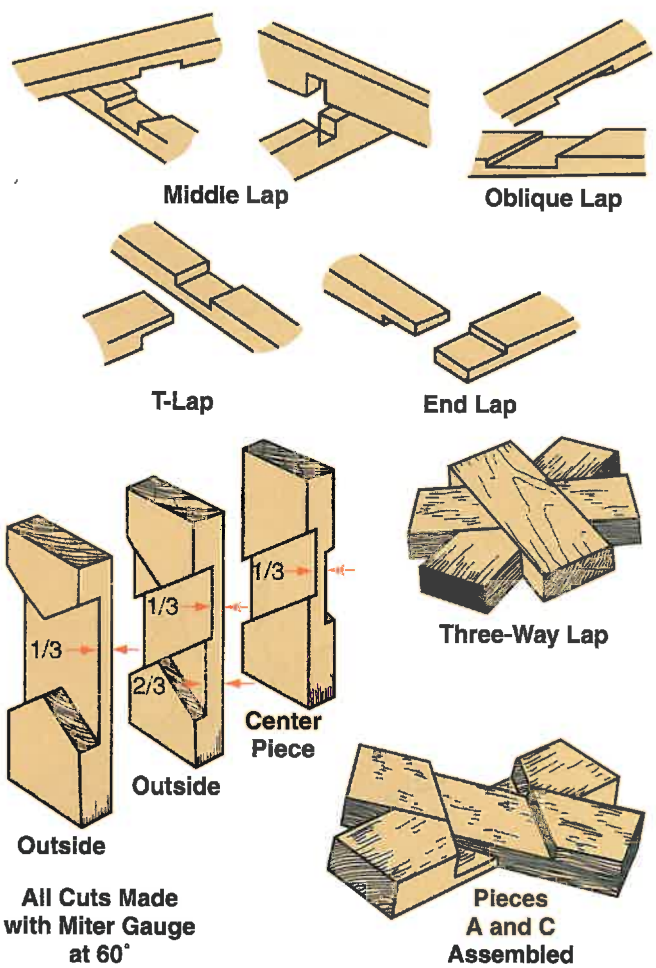



**Figure 29-18.** Lap joints. *(Delta International Machinery Corp)*


**Figure 29-19.** The oblique lap connects stretchers at their intersection. *(Thomasville)*

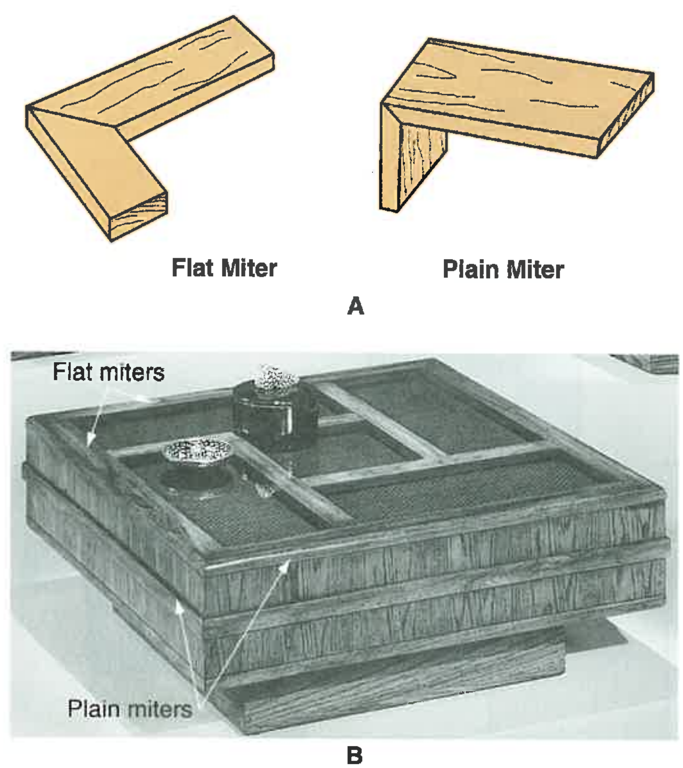



**Figure 29-20.** A—Simple miter joints. *(Delta International Machinery Corp.)* B—Flat and plain miters on a square cocktail table. *(Bassett)*

Most miters can be reinforced with dowels, splines, or plate joinery. Positioned miters include the rabbet miter, lock miter, half-lap miter, or lap and tenon miter joints.

Miter joints typically are sawn using a power miter box. On a table saw, tilt the blade to bevel a plain miter. To cut a flat miter, place the blade at 90° and rotate the miter gauge 45°. For some positioned miters, such as the ***rabbeted miter,*** a sequence of cuts is necessary. See **Figure 29-21.**

The ***lock miter*** is an even more intricate joint. It could be described as a rabbeted miter with an extra locking tab. See **Figure 29-22.** There are two methods to cut the components. If made by sawing, a sequence of six passes is needed. You could also make a lock with a shaper and a special cutter. Place the first component flat on the machine table as you feed it past the cutter. Stand the second up against the fence.

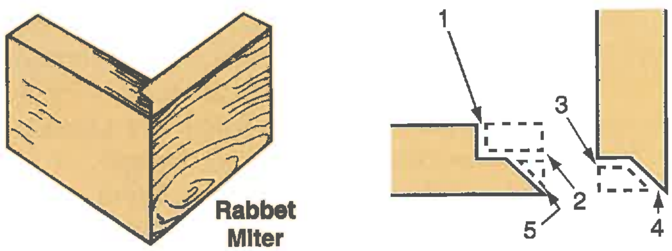



**Figure 29-21.** Making a rabbet miter. *(Delta International Machinery Corp.)*

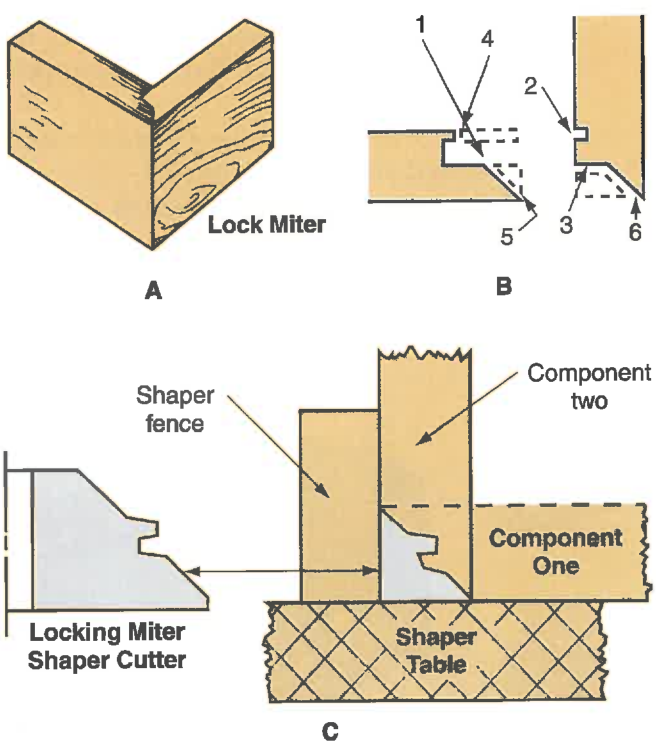



**Figure 29-22.** A—Lock miter. *(Delta International Machinery Corp.)* B—Series of cuts taken on the table saw to create the joint. C—The lock miter can also be cut on the shaper with a single cutter.

A ***half-lap miter*** combines a miter and lap joint. See **Figure 29-23.** Cut the half lap in the first component; then cut the miter. On the second component, cut a miter half the workpiece thickness.

A ***lap and tenon miter*** has different features at each one-third of the workpiece thickness. See **Figure 29-24.** First cut an open mortise in the end of part one. This can be done with a dado blade and tenoning jig, or several rip cuts. Then cut the lap one-third the thickness of part two. Finally, make the miter cuts.

***Clamp-nails*** reinforce plain miter joints. Refer to *Figure 16-20.* A thin saw kerf is cut on the mitered surface. Drive the clamp-nail to draw the two pieces together. No adhesive is required.

## Tongue and groove joint

The ***tongue and groove*** joint is a positioned version of the butt joint. The tongue is made on one component and the groove on the other, each cut one-third the workpiece thickness. See **Figure 29-25.** As an edge-to-edge joint, it can replace the butt joint when gluing stock to make a wider workpiece, such as a tabletop. With more surface contact than a butt joint, the tongue and groove increases the bonding surface.

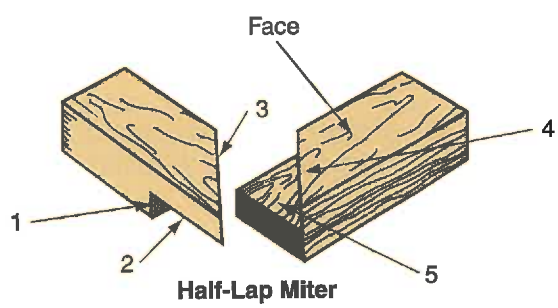



**Figure 29-23.** Cuts taken to make a half-lap miter. *(Delta International Machinery Corp.)*

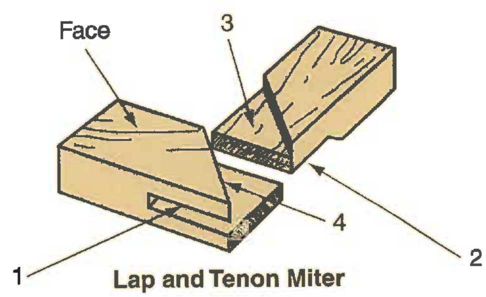



**Figure 29-24.** Cuts taken to make a lap and tenon miter. *(Delta International Machinery Corp.)*

A tongue and groove joint can be cut with a dado head on the table saw or radial arm saw. See **Figure 29-26.** With a standard blade, make two passes on each side to create the tongue. Make several passes through the joining component to create the groove.

In a production milling setting, the tongues and grooves are shaped by a matched pair of shaper cutters. One cutter shapes the tongue while the other shapes the grooves. Install the first cutter, set the height and depth, and machine the first half of the joint. Then exchange the cutter and machine the other components. Do not alter the spindle height or fence setting when installing the matching cutter.

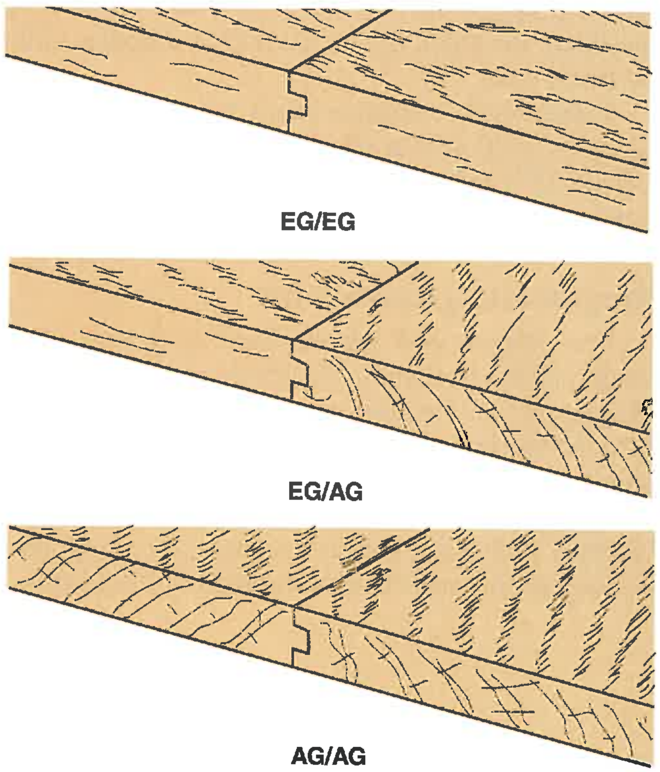



**Figure 29-25.** The tongue and groove position the joint and strengthen it by increasing the glue surface.

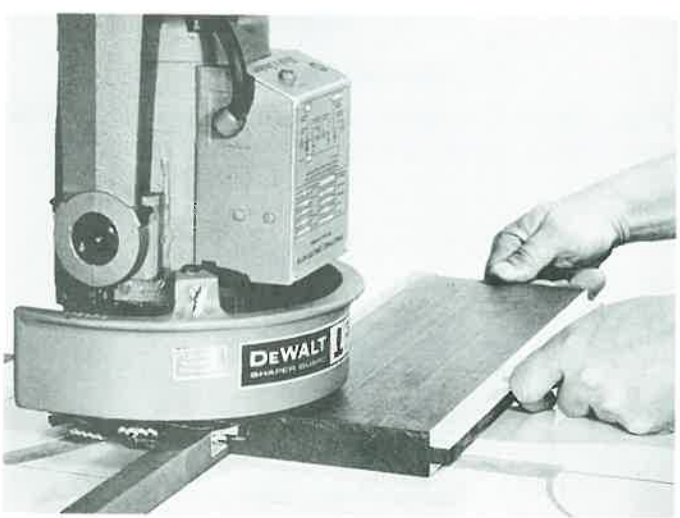



**Figure 29-26.** Cutting the groove with a radial arm saw and dado blade. *(DeWalt Industrial Tool Co.)*

## Mortise and Tenon Joint

The ***mortise and tenon joint*** has long been a sign of quality furniture construction. It is typically found connecting rails and aprons to table and chair legs. The joint consists of a ***tenon***, or projecting tab on one member, and a ***mortise***, or cavity, into which the tenon fits. In looking at a mortise and tenon joint, the joining components appear to butt together. Yet, the fit of the tenon and mortise is actually an extremely strong AG/AG assembly. See **Figure 29-27.**

There are many variations of the mortise and tenon. Some shown in **Figure 29-28** include:

- ***Through mortise and tenon.*** End grain is visible.
- ***Blind mortise and tenon.*** Most common mortise and tenon joint. End grain is not visible.
- ***Open mortise and through tenon.*** Eye appealing joint at the expense of reduced strength.
- ***Blind mortise and bare-face tenon.*** Often used when the tenoned piece is thinner than the one that is mortised.
- ***Blind mortise and haunched tenon.*** Used in frame construction for added strength.
- ***Blind mortise and blind haunched tenon.*** Similar to haunched tenon, except that the groove is cut at an angle so it does not appear in the final joint.
- ***Through mortise and wedged tenon.*** Useful where added strength is required.
- ***Blind mortise and wedged tenon.*** Added strength where a through tenon cannot be used.
- ***Open or blind mortise and mitered tenon.***
- ***Open or blind mortise and bare-face tenon.***

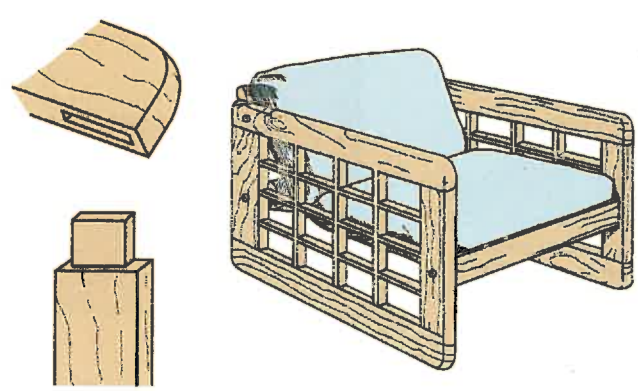


**Figure 29-27.** Components of the most common mortise and tenon joint, the blind mortise and tenon. *(Unfinished Furniture Store)*

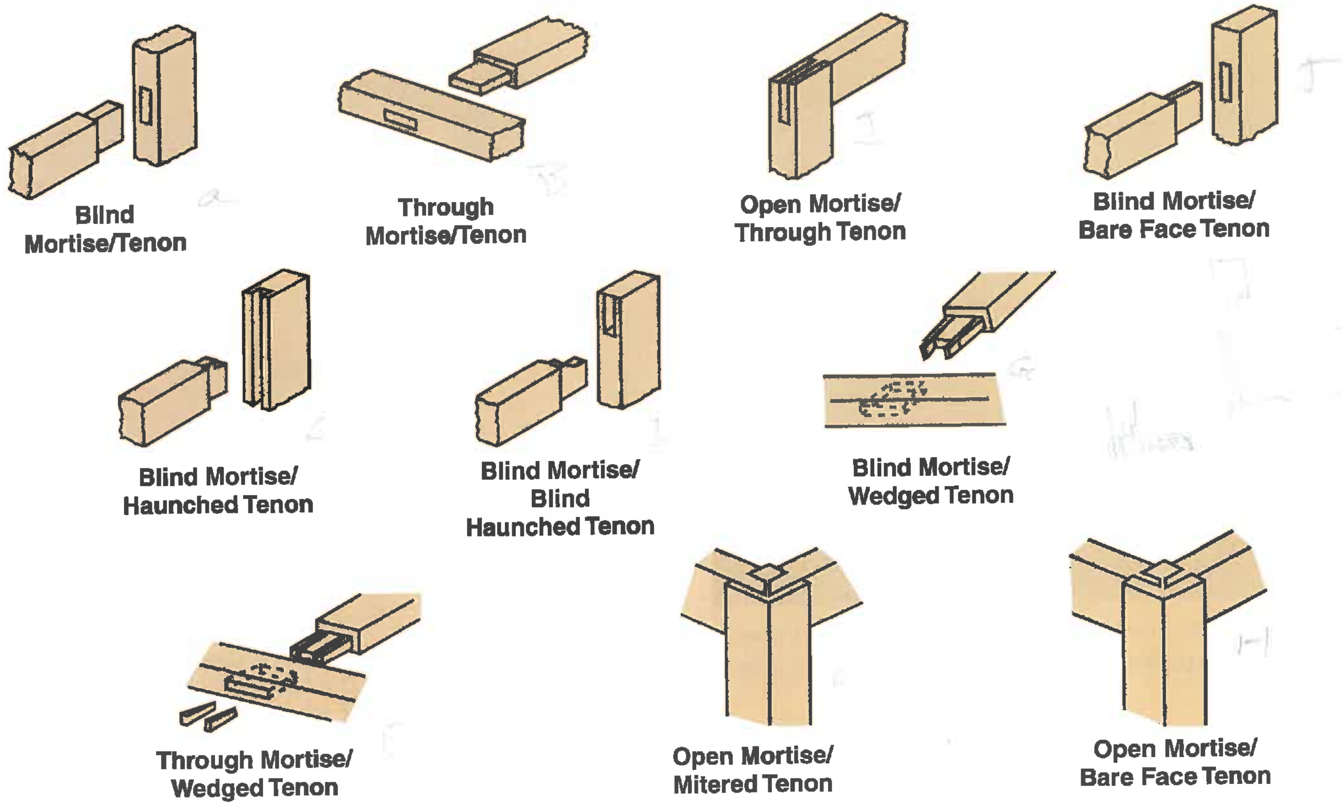



**Figure 29-28.** Mortise and tenon variations. *(Delta International Machinery Corp., Stanley Tools)*

## Mortising and tenoning equipment

Special equipment is available for making mortise and tenon joints. A drill press equipped with the mortising attachment makes square holes to create the mortise. See **Figure 29-29.** A ***mortising chisel*** fits into the attachment. The chisel, which does not rotate, lowers into the workpiece to square the hole as the drill bit turns inside it. The workpiece is held against the fence and table with guides. A drill press having foot feed works best for this operation. It leaves your hands free to position the workpiece.

The mortise can be made with a plunge router. Insert a square-end bit having a diameter the width of the mortise. Set the depth of cut for the mortise. Align the bit with one end of the mortise. Turn on the router, plunge the bit into the wood, and feed it the mortise length. A router guide or fence accessory helps keep the mortise straight.

A horizontal boring machine makes an accurate mortise quickly. The table is adjusted to the proper height, and stops are set for lateral movement and depth. Leave the mortise with rounded ends and round over the tenon to fit. See **Figure 29-30.**

The tenoning jig slides in table slots like a miter gauge and supports the component at 90° to the table. See **Figure 29-31.** It usually is manufactured for a specific saw model. To protect yourself since the tenoner cannot be used with a guard, place the

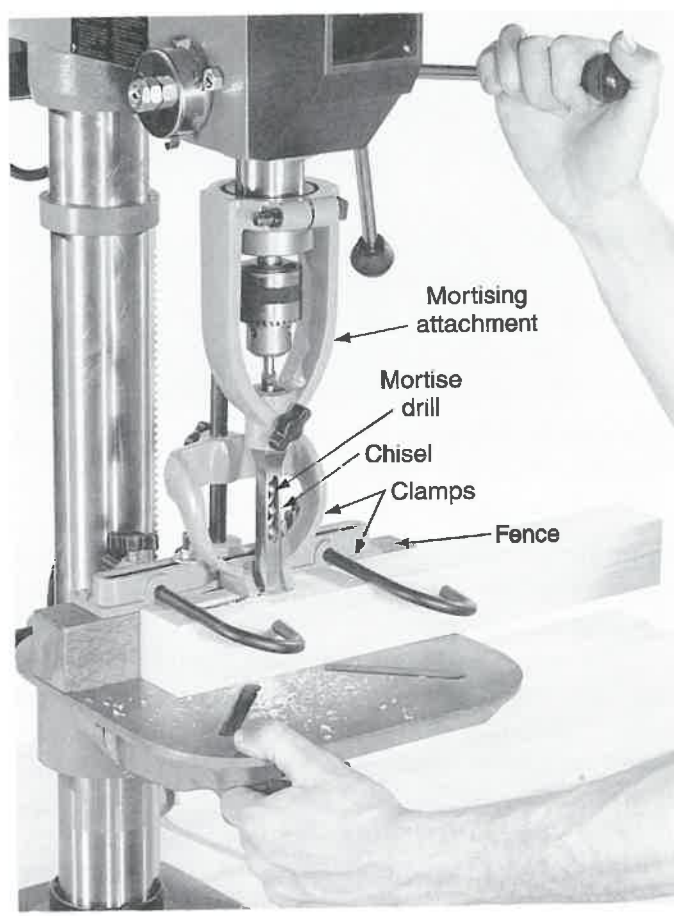



**Figure 29-29.** Mortising attachment on the **drill** press. *(Delta International Machinery Corp.)*

**Figure 29-30.** The horizontal boring machine provides a movable platform for creating the mortise. *(Chuck Davis Cabinets)*

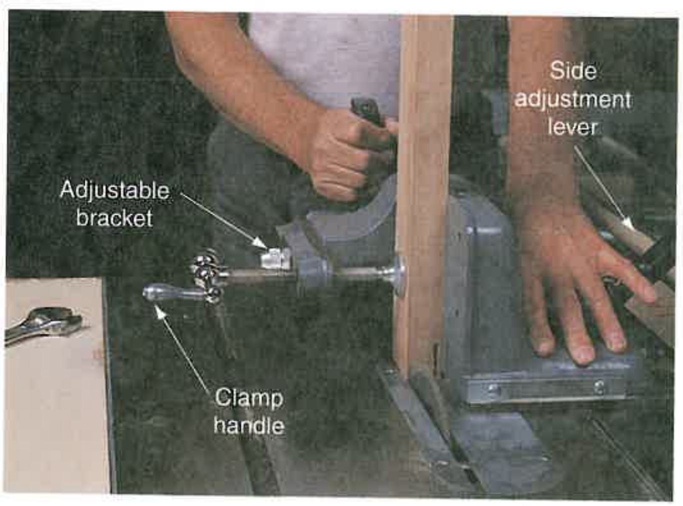



**Figure 29-31.** Tenoning accessory for cutting tenons on the table saw. (*Chuck Davis Cabinets*)

jig in the left table slot. Then stand to the left of the machine setup. This keeps the accessory between you and the blade.

You can also make tenoning jigs for the table saw. See **Figure 29-32.** They straddle the fence instead of sliding in the table slots. A guide or quick clamp holds the workpiece vertical. Hold onto the jig well above the blade.

In a mass production setting, there are two machines for producing this joint, the mortising machine and tenoner. The mortising machine appears much like a drill press retrofitted for mortising. See **Figure 29-33.** However, there are

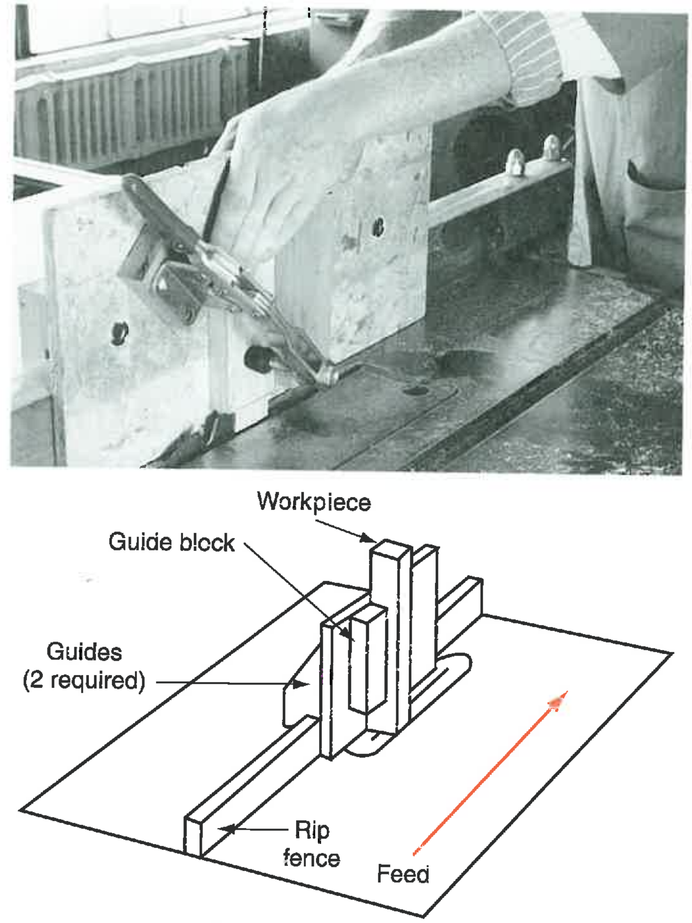



**Figure 29-32.** User-made jigs for cutting tenons on the table saw.

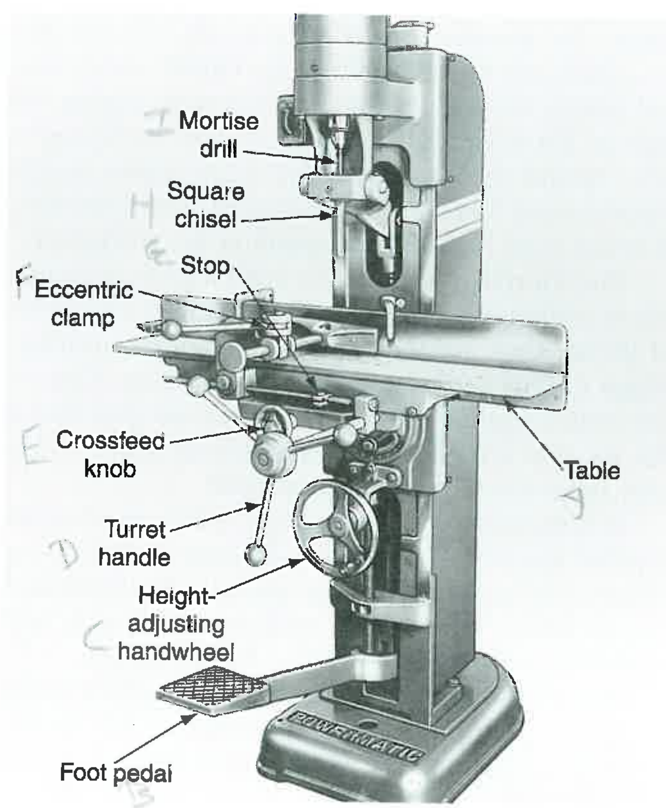



**Figure 29-33.** Mortising machine. *(Powermatic)*

some additional features that make it more efficient. First, an automatic feed moves the table the width of the mortising chisel after each plunge. Stops limit the table travel for a given mortise length. A cross feed handwheel controls table movement to position the workpiece under the chisel. The height adjusting handwheel raises or lowers the table. A foot pedal feeds the tool into the work.

There are two types of production tenoners; single-end and double-end. The machine shown in **Figure 29-34** is a single-end tenoner. The workpiece is placed on the table that moves it toward two sets of cutterheads. One cycle of the machine makes all necessary cuts to produce the tenon. A double-end tenoner produces tenons on both ends of a workpiece with each cycle.

## Making a blind mortise and tenon joint

The blind mortise and tenon is the most common of the mortise and tenon joints. It is found connecting rails to legs in chairs and apron to legs in tables. See **Figure 29-35.** Create this joint by cutting the mortise first. Then cut the tenon. This sequence allows you to trim and fit the tenon to fit the mortise.

There are several factors to consider before making the joint. First, the tenon thickness should be about one-half the stock thickness. The tenon width should be 3/8″ to ¾″ (about 10 mm to 19 mm) narrower than the stock width. This allows for a 3/16″ to 3/8″ (5 mm to 10 mm) shoulder. See **Figure 29-36.** The tenon length should be no longer than two-thirds the width of the thicker piece. The mortise should be 1/8″ (3 mm) deeper than the tenon. If the mortise is routed, round the tenon corners or chisel square the mortise so the mating parts match.

Follow this procedure to make a 3/8″ (10 mm) blind mortise using a tenoning jig on the table saw and mortising attachment on the drill press.

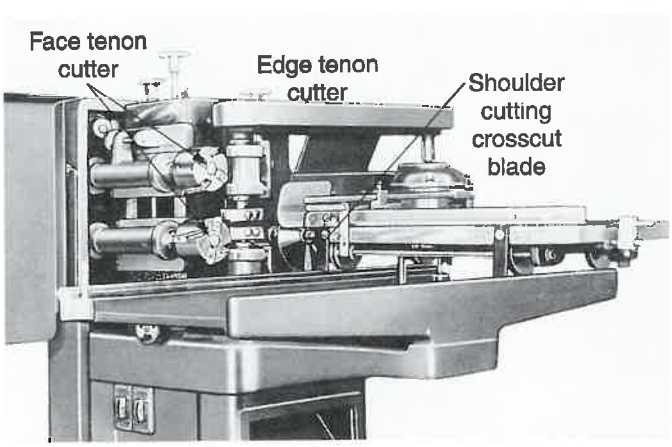



**Figure 29-34.** Single-end tenoner. *(Powermatic)*

1. Lay out the mortise width one-half the thickness of the tenon. The mortise length should be 3/8″ (10 mm) less than the tenon width to create a 3/16″ (5 mm) shoulder on each end.
2. Secure a 3/8″ (10 mm) mortising chisel in the mortising adapter of the drill press. Insert and tighten the drill in the chuck. Start and stop the machine quickly. A high pitch squealing noise indicates the bit is touching the inside of the chisel. If this occurs, loosen the drill only and lower it about 1/32″ (1 mm). Sometimes the chisel and drill bit are a combined assembly. See **Figure 29-37.** Make sure the chisel is square to the fence. See **Figure 29-38A.**

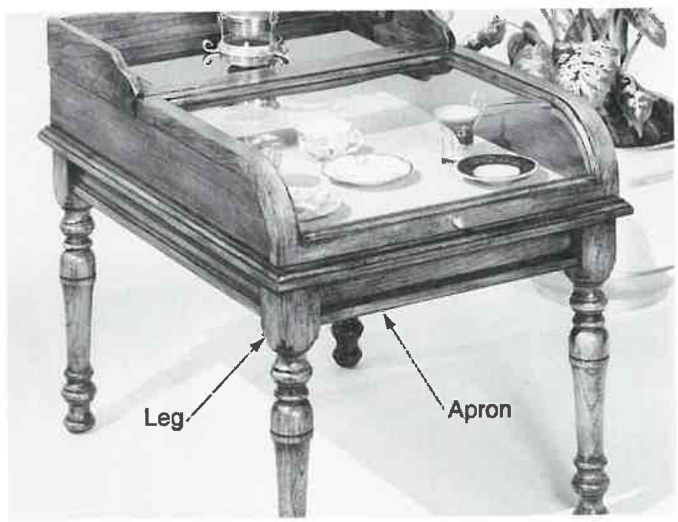
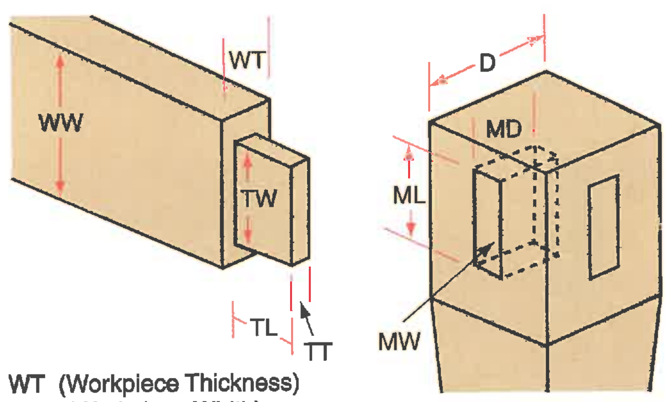



**Figure 29-35.** The apron under the tabletop of this curio table is connected to the legs with mortise and tenon joints. *(Butler Specialty Co.)*




WT (Workpiece Thickness)
WW (Workpiece Width)
TW (Tenon Width) = WW (Workpiece Width)-3/8″ to 3/4″
TL (Tenon Length) = < 2/3 D (Depth of Mortised Component)
TT (Tenon Thickness) = 1/2 WT (Workpiece Thickness)
MD (Mortise Depth) = TL + 1/8″
MW (Mortise Width) = TT (Tenon Thickness)
ML (Mortise Length) = TW (Tenon Width)

**Figure 29-36.** Standard dimensions of a blind mortise and tenon.

3. Clamp the workpiece to the table. It should already have been cut to size.
4. Align one end of the laid-out mortise with the chisel.
5. Adjust the depth stop so that the mortise is 1/8″ (3 mm) deeper than the tenon length. See **Figure 29-38B.**
6. Drill the first square hole. Then move the workpiece about three-fourths the width of the chisel and drill another square hole. See **Figure 29-39.** Repeat this process until the mortise is complete.
7. Lay out and mark the measurements on the tenon.
8. Set the blade height at 3/16″ (5 mm) (one-fourth the workpiece thickness). See **Figure 29-40.**
9. Cut shoulders on all four sides of the workpiece. Use the miter gauge.
10. Set the blade height 1/16″ (2 mm) less than the tenon length so that you do not cut beyond the shoulder into the part. See **Figure 29-41.**
11. Make cheek cuts on all four sides with the workpiece positioned in the tenoning jig.

**Figure 29-37.** One-piece drill bit and mortising chisel assembly. *(American Machine & Tool Co.)*

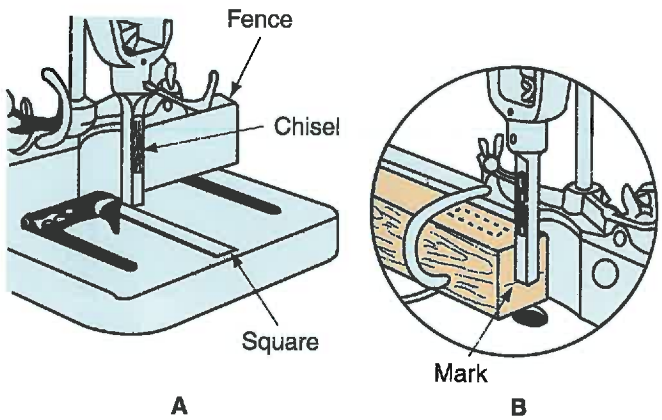



**Figure 29-38.** A—Square the chisel to the fence. B—A mortise depth mark on the end of the stock helps set the chisel height. *(Delta International Machinery Corp.)*

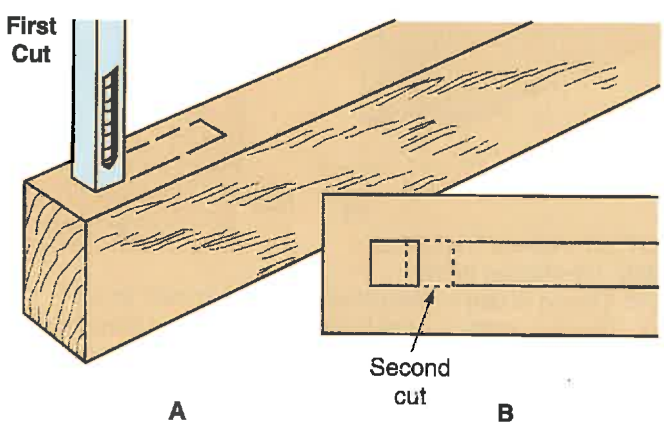



**Figure 29-39.** Successive mortising cuts. A—First cut. B—Lap slightly over the previous cut. *(Delta International Machinery Corp.)*

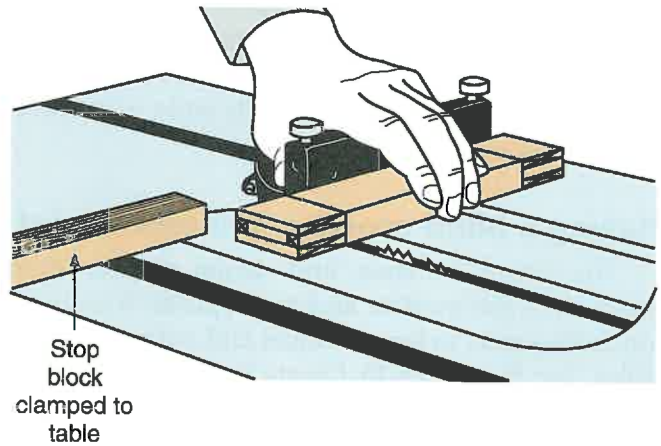



**Figure 29-40.** Making shoulder cuts.

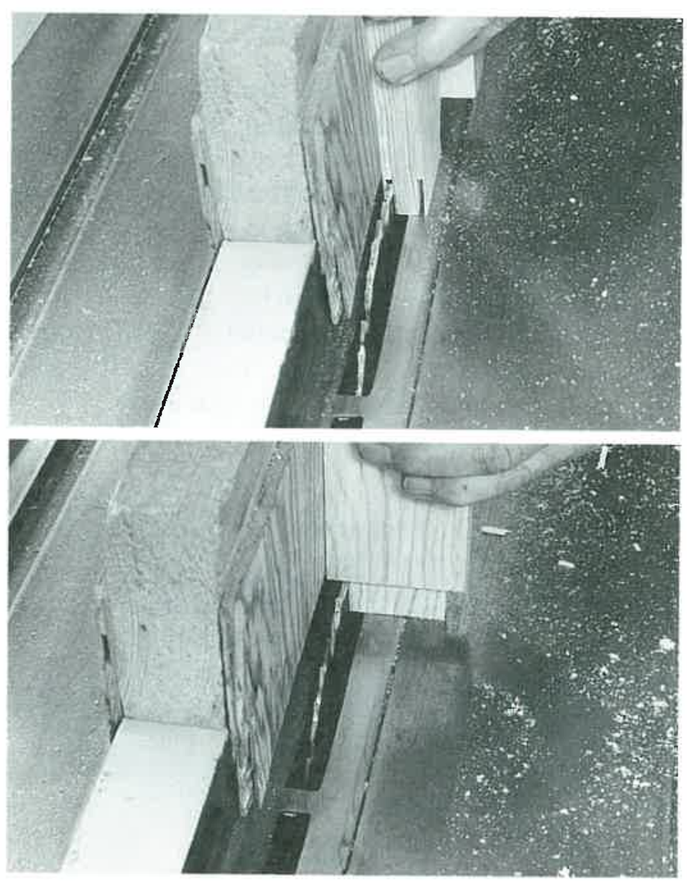


**Figure 29-41.** Making cheek cuts with the stock positioned vertical by a user-made tenoning jig.

## Mortise and tenon variations

The layout and procedure for making the blind mortise and tenon apply to many other variations of the mortise and tenon joint. However, some of the methods may differ according to the joint.

An open mortise and tenon joint can be made on the table saw with a tenoner jig. Use several passes to cut the open slot mortise. Then make two shoulder cuts on the tenon. Finally clamp the tenon part in the tenoner for the cheek cuts. Then turn the workpiece around to complete the second cheek cut. See **Figure 29-42.**

The router is also suited for making open or blind mortises. First lay out the mortise. Then install a square-end bit in the router. Set the depth according to the layout. Lower the bit into a blind mortise. (A plunge router works best for this operation.) For the open slot mortise, simply enter the end of the workpiece. Square the corners of the mortise or round the corners of the tenon so that the two match.

Tenons can also be cut in a horizontal position with a dado head or several passes on the table saw. See **Figure 29-43.** Raise the blade to the width of the shoulder. Position a stop to the length of the tenon. Use the miter gauge and make the necessary passes to cut on two or four sides, depending on the type of mortise and tenon.

Tenons that enter the same workpiece could hit each other in the mortises. To prevent this, miter the tenons. See **Figure 29-44.**

Wedges can be added for strength in mortise and tenon joints. When this is specified, mortise ends are drilled at a 5° to 8° angle. The blind wedged tenon joint presents special problems. Check the length and spreading capacity of the wedges. You might not be able to fit the tenon into the mortise. This occurs if the wedges are too long or too wide.

## Making mortise and tenon joints with hand tools

If you desire a challenge, make the mortise and tenon joint with hand tools. See **Figure 29-45.** Lay out the mortise and drill a series of holes to the proper depth. Then clean out the mortise with a chisel. Cut the shoulders of the tenon with a

**Figure 29-43.** Sawing tenons by making a series of crosscut passes. Guard was removed to show process *(Chuck Davis Cabinets)*

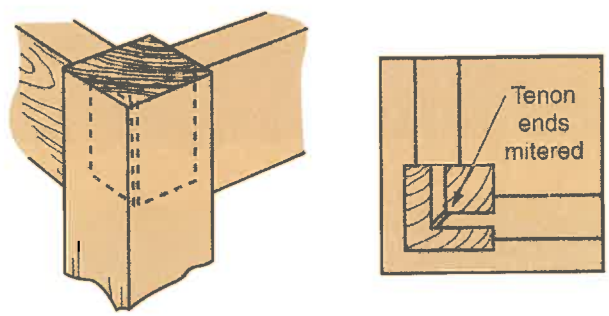



**Figure 29-44.** Miter tenons if they meet in the component. *(Delta International Machinery Corp.)*

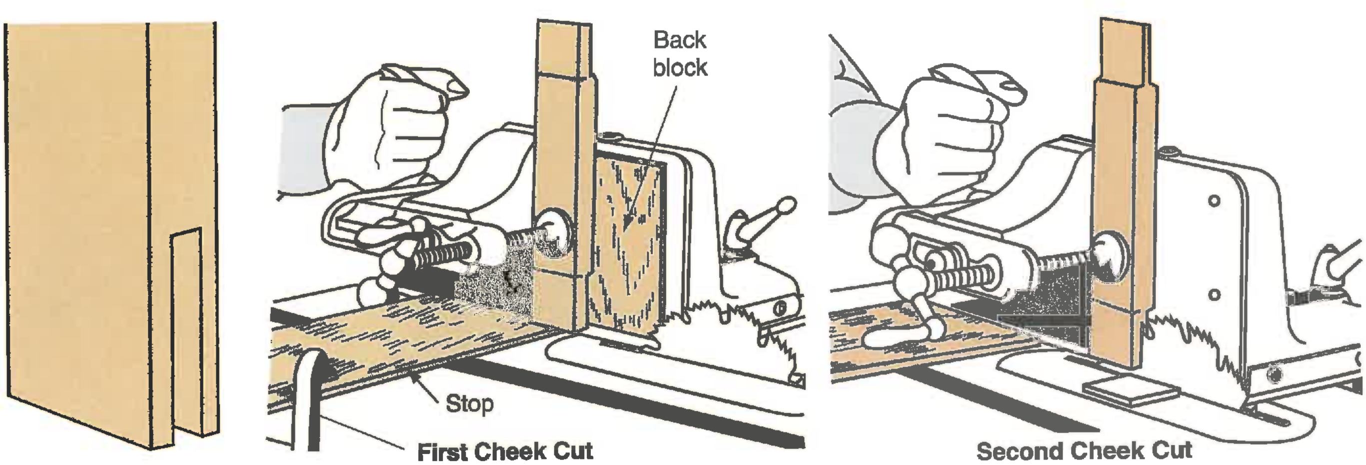
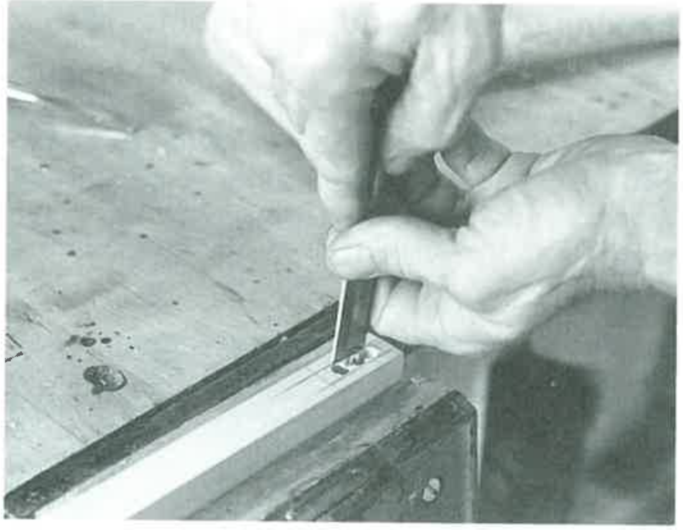



**Figure 29-42.** Making cheek cuts with the tenoning jig.



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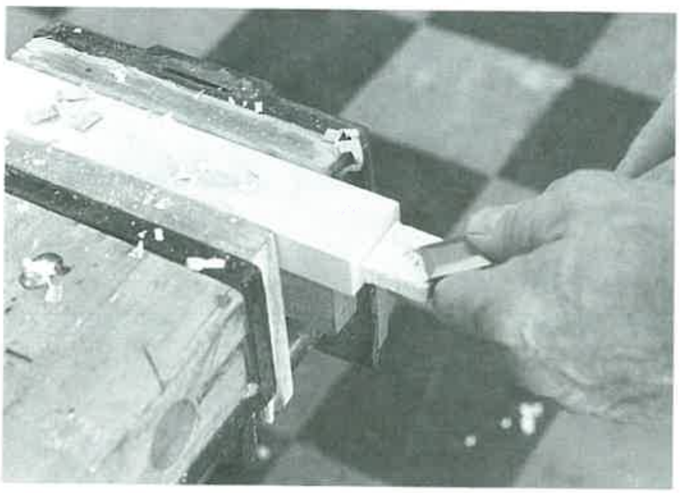


B

C

**Figure 29-45.** Hand mortising. A—After drilling several holes, chisel out the mortise. B—After making shoulder and cheek cuts with a backsaw or dovetail saw, chisel the tenon square. C—Assembling the joint. (*Chuck Davis Cabinets*)

backsaw. Have a square piece of stock clamped next to the layout line to keep the saw square. When sawing the cheeks, create a jig or guide to keep the saw straight. After making all the cuts, fit and trim the tenon with a chisel. Each joint must be individually fit, then marked for assembly.

## Decorative mortise and tenon joints

Several of the standard mortise and tenon joints can be modified to be more decorative. See **Figure 29-46.** An example of the tusk tenon on Early American furniture is shown in **Figure 29-47.**

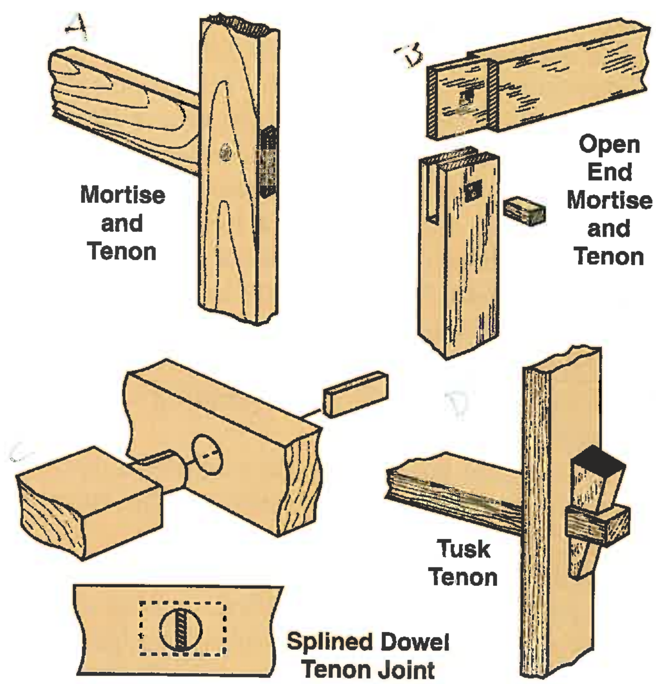



**Figure 29-46.** Decorative mortise and tenon joints. *(Delta International Machinery Corp.)*

**Figure 29-47.** Tusk tenon on an Early American coffee table. *(Craft Products)*

## Box Joint

The ***box joint,*** sometimes called a finger-lap joint, consists of alternating squares of end and surface grain. It is both a strong and decorative joint, often used to assemble drawers. Box joints generally are made using a dado head on the table saw. You must have an adjustable jig attached to the miter gauge. The jig's stop positions each cut for the joint.

**Figure 29-48** and the steps that follow show how to process a box joint having 3/8" (10 mm) fingers. It is very important that you set up the jig and saw accurately. Also, mark the pieces so that you process them in the same direction.

1. Create an adjustable jig for the miter gauge. The dimensions for one to make 3/8" (10 mm) box joints is shown in **Figure 29-48A.**
2. Install a dado cutter adjusted to 3/8" (10 mm) wide.
3. Adjust the blade height to the thickness of the stock.
4. Attach the box joint jig to the miter gauge and adjust it so that the guide stop is 3/8" (10 mm) from the blade.
5. Place board one (side component of box or drawer) against the stop. The edge to face up should rest against the guide stop. Make the first pass. See **Figure 29-48B.**
6. Reposition the board with the kerr over the stop and make pass two. See **Figure 29-48C.** Continue to do this until all cuts have been made.
7. Rip a 3/8" (10 mm) square by 6" (152 mm) long guide block. This is needed to offset the fingers of the joining component.
8. Place the guide block against the stop. Place board number two (box or drawer front) against the guide block. Then make the first pass. See **Figure 29-48D.**
9. Reposition the board so that the kerf made rests against the stop. Make pass two. See **Figure 29-48E.**
10. Continue relocating board two against the stop until all the cuts have been made.

Carefully choose which parts to process with and without initially using the guide block. The fingers of mating parts must mesh. See **Figure 29-48F.**

## Dovetail Joint

A ***dovetail joint*** is much like a box joint, except that the fingers are replaced by tails. Each tail and socket is cut at an angle to provide a locking effect that strengthens the joint. The angle of the individual fingers also makes the joint quite attractive. See **Figure 29-49.** Several different dovetail styles, shown in **Figure 29-50,** include:

- Multiple dovetail (through multiple dovetail).
- Half-blind multiple dovetail.

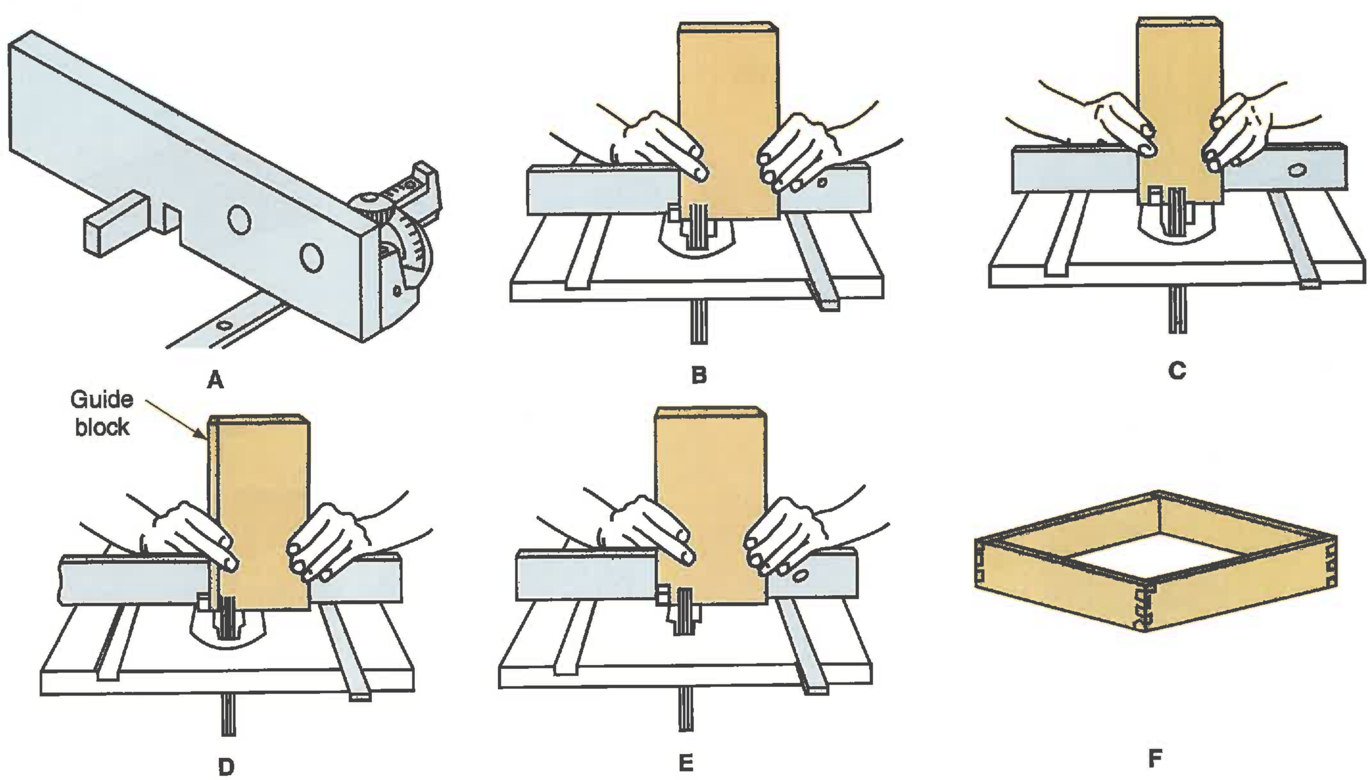



**Figure 29-48.** Cutting a box joint. A—Jig. B—First pass of first component. C—Second and successive cuts. D—First pass on second component. E—Second and successive cuts. F—An assembled product.

**Figure 29-49.** Dovetails are an intricate, but attractive joints. Through dovetails are similar to half blind dovetails. The end grain of both the pin and the tail are visible and may be decorative. *(Chuck Davis Cabinets)*

- Blind multiple dovetail.
- Blind miter dovetail.
- Through and blind single dovetail.
- Lap dovetail.
- Half-lap dovetail.
- Half-dovetail and half-lap dovetail.
- Dovetail dado and half-dovetail dado.

Dovetail joints have two parts; the ***tail,*** which fits into the ***socket.*** These parts may be produced by hand or machine. Through and lap dovetails can be cut by hand. Blind dovetails should be done by machine. The procedures for cutting popular dovetails are discussed in this section.

## Routing a half-blind dovetail joint

The ***half-blind dovetail*** is the most popular dovetail, widely used in quality drawer construction. This joint is cut with a router, template guide, dovetail bit, and dovetail jig. **Figure 29-51** and the procedure to follow, show how to cut the half-blind dovetail.

1. Clamp the dovetail jig to the woodworking bench or place in the vise.

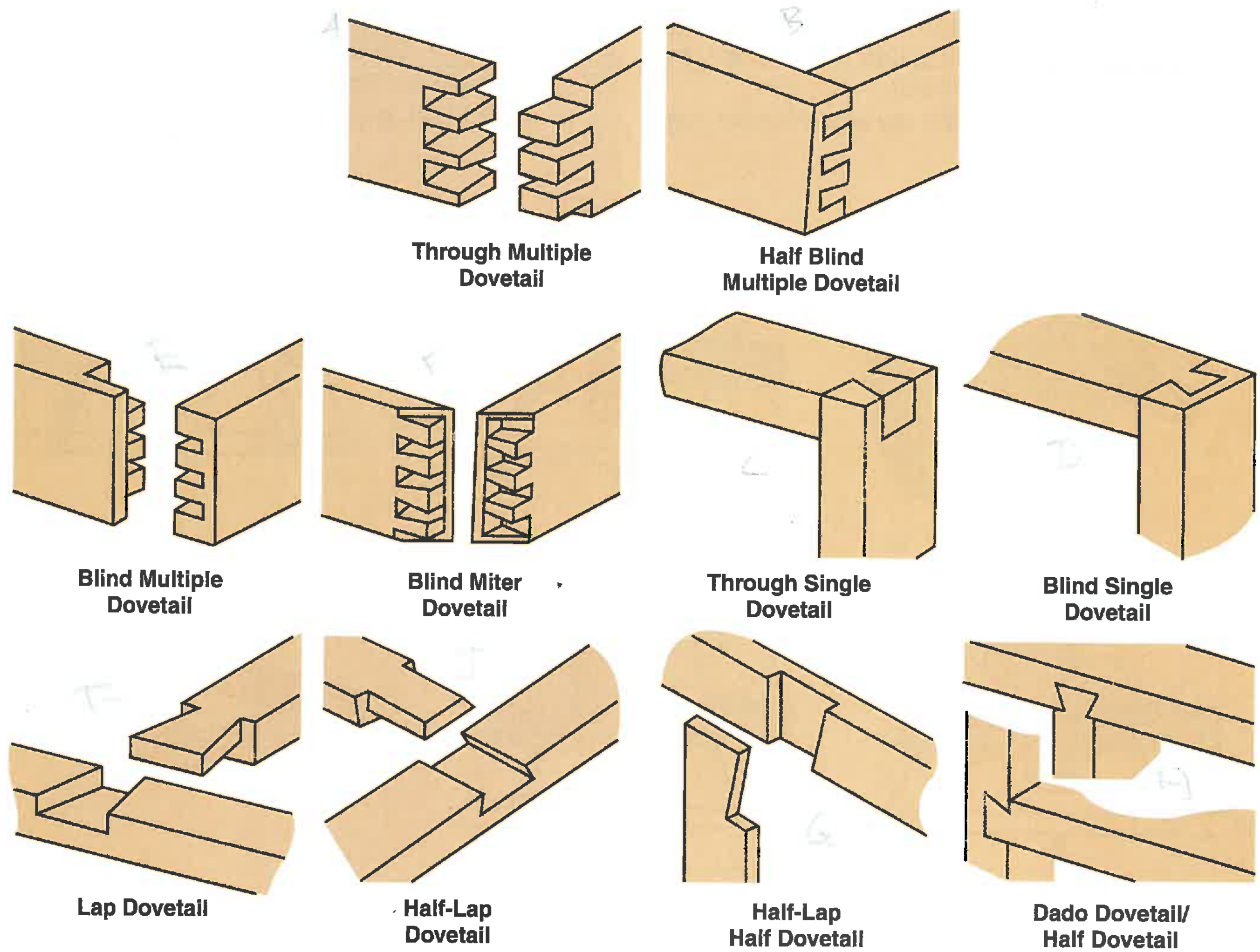



**Figure 29-50.** Dovetail variations. (Stanley Tools)

2. Attach the template guide to the base of the router. Insert the proper guide for the distance between template fingers. See **Figure 29-51A.**
3. Select a dovetail bit for your project. Depth of cut is critical. Set this distance. See **Figure 29-51B.** If you measure from the router base, add the thickness of the finger template. Make a gauge block for the bit you use regularly for quicker setup. This helps prevent inaccuracies. See **Figure 29-51C.**
4. You can make the first setup on the right or left of the jig. For either a small jewelry chest or drawer, this description begins on the left. See **Figure 29-51D.**
5. Make a test joint of scrap wood first. Make it of the same species as the production joint. When the cut is complete, let the router come to a complete stop before removing it from the jig.

**Warning**

Never raise the router out of the workpiece or jig while the motor is running.

Remove the two components and check the fit. See **Figure 29-51C.** If the joint is too loose, the bit was too deep. Raise it 1/64" (0.4 mm). If the joint is too tight, the bit was not deep enough. Lower the bit 1/64" (0.4 mm). In addition, if the joint is too shallow or deep, adjust the template position in or out accordingly.

6. Place the right side of the drawer or chest vertically. Its edge must be against a locating pin on the left (behind the front clamp bar). The surface that will be inside must face out (touch the front clamp bar). Clamp it lightly.
7. Position the chest or drawer front in the horizontal position against the locating pin on top. The horizontal piece should be the same height and must touch the vertical piece.
8. Tighten both the top and front clamp bars.
9. Attach the template to rest evenly on the material.
10. Hold the router on the template with the bit clear of the work. Turn on the motor and feed the bit slowly into the wood at the locating pin end. Continue to follow the template, cutting the socket and tails at the same time.
11. Position the left side of the drawer or chest vertically on the right. See **Figure 29-51E.** Have the inside out as before. Put it against a locating pin to the right. Hold it there with the front clamp.
12. Position the other end of the chest or drawer front against another locating pin on the right. Again, the front and side should be the same height and must touch.
13. Tighten both the top and front clamp bars.
14. Start on the right and complete the cut as on the left. The back and sides can be joined in a similar manner. Be sure to mark the matching corners. Always keep the bottom or top edges against locating pins.

It is best to make several trial cuts in scrap stock first. These test boards should be the same size as the stock to be joined.

To cut the blind dovetail joint in lip front drawers, the front or back and sides must be cut separately. See *Chapter 42* for details.

## Routing a through multiple dovetail

The procedure for routing a ***through multiple dovetail joint*** is almost the same as that for a blind dovetail. However, the workpiece thickness is limited to 3/8" (9.5 mm). You must place a shim under the horizontal component. See **Figure 29-52.** This prevents the router bit from hitting the jig. Align the components as explained in the previous procedure. Set the depth of cut to the thickness of the two parts.

## Routing blind and through single dovetails

Blind and through ***single dovetails*** and ***dado dovetails*** can be cut easily with the router and fence accessory. Insert the dovetail bit and set it to the proper depth. To cut the socket on an edge, center the bit on the edge of the workpiece. See **Figure 29-53A.** Adjust the fence to the workpiece.

To cut the socket in a face, clamp a straightedge to the workpiece for the router to ride against. See **Figure 29-53B.** To cut the tail, keep the depth setting the same. Adjust the fence so that one cut is made on each side to form the tail. See **Figure 29-53C.**

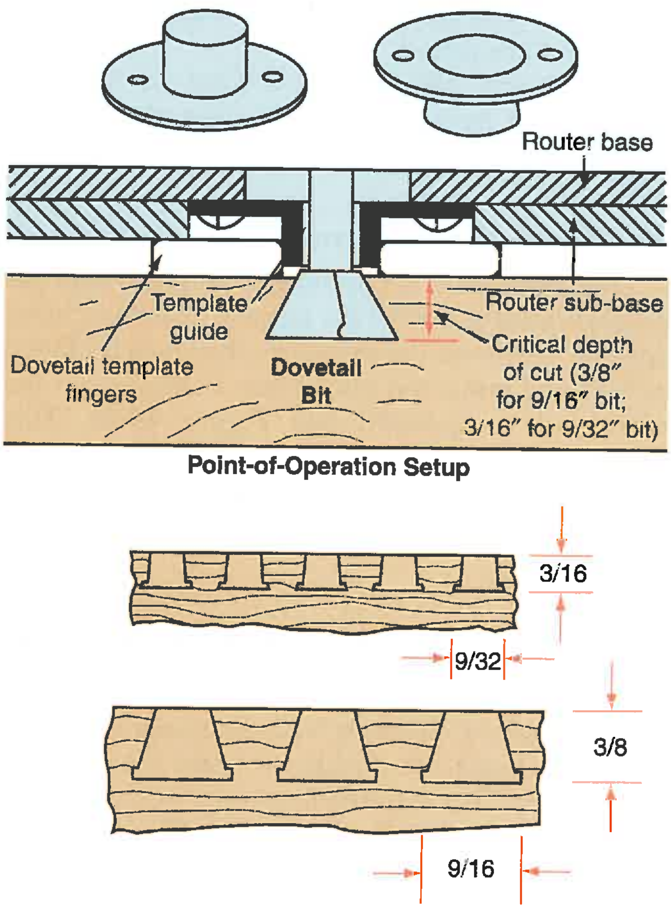
## Cutting dovetails by hand

The through single and lap dovetails can be cut by hand. Lay out each matching workpiece with a T-bevel and square. Cut them with a backsaw or dovetail saw and a chisel. **Figure 29-54** and the steps to follow show how to produce a dovetail joint by hand.

1. Lay out 80° angles on the socket piece end grain.
2. Square the depth of the socket (tail piece thickness).
3. Saw and/or chisel the excess within the sockets.
4. Lay out the tail piece using the socket for a template.
5. Saw and/or chisel away the excess from the tail.

## Dowel Joint

Dowels are wood or plastic pins that position and reinforce several other joints. Wood dowels are made of hardwood, such as maple or hickory, with diameters from 1/8" to 1" (3 mm to 25 mm). Dowel rod comes in 3′ (914 mm) standard lengths. Some are precut and may have grooves (flutes). Spiral cuts in the dowels allow adhesive to spread and air to rise from the dowel hole. They also retain adhesive, adding to a dowel's holding ability.

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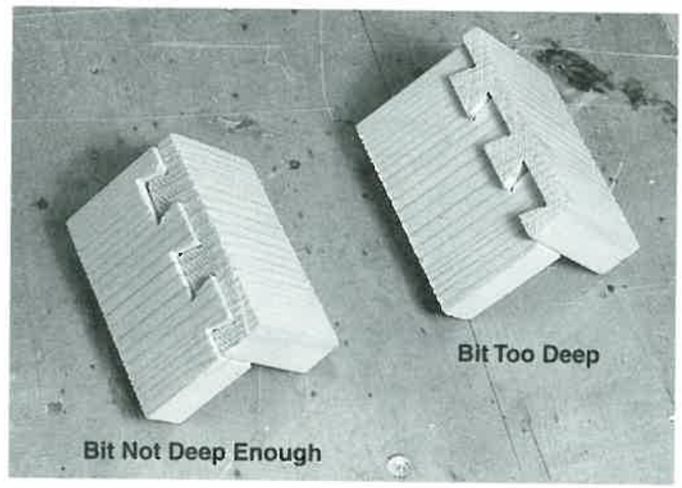


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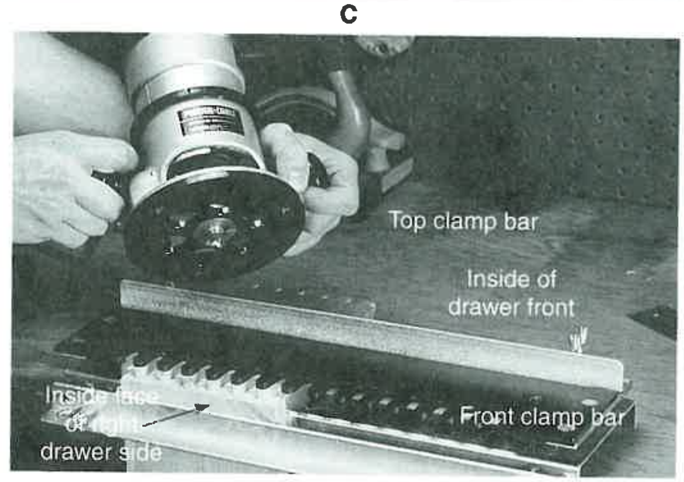


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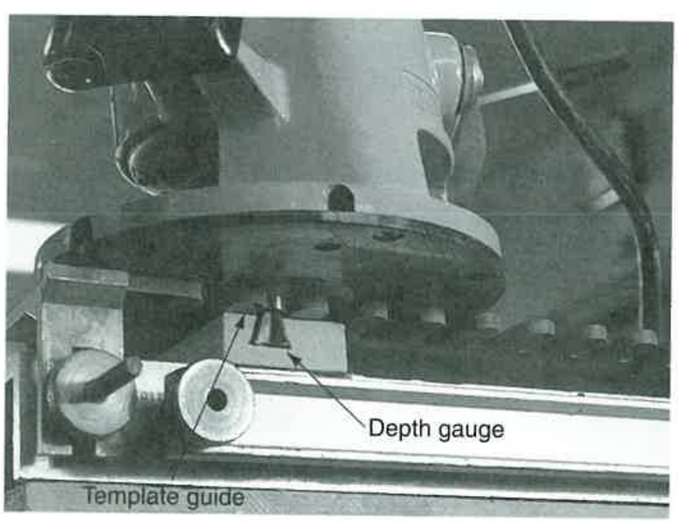


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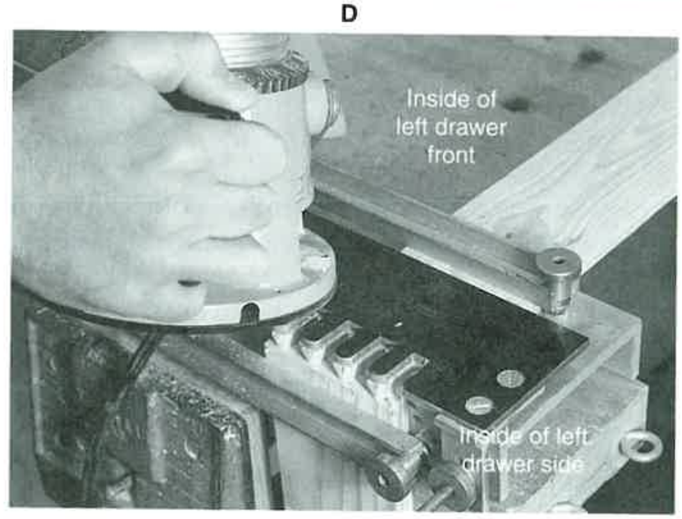



E

**Figure 29-51.** A—Sub-base and proper size template guide must be attached to the router for dovetailing. *(Klockit)* B—Setting the dovetail bit depth. A gauge is helpful. C—Improperly fit half-blind dovetail joint. D—Material positioned on the left side of the jig. *(Shopsmith)* E—Material positioned against locating pins on the right side of the jig.

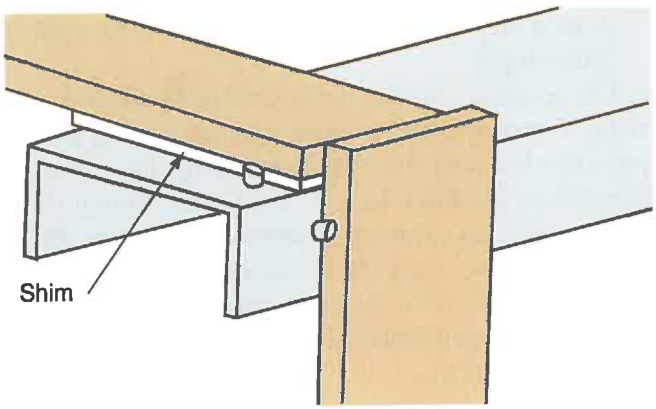



Figure 29-52. Add a shim to protect the jig when making through multiple dovetails.

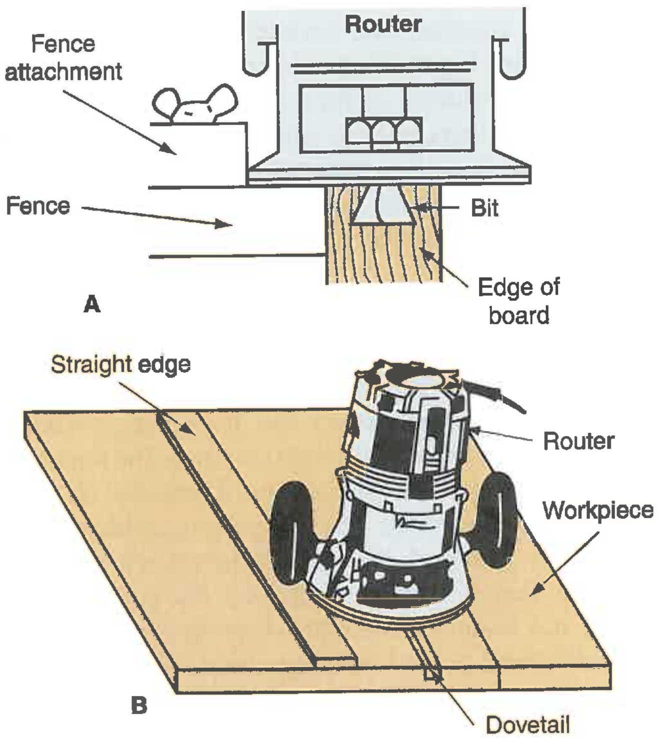



Figure 29-53. Making blind and through single dovetails. A—Routing the socket in an edge. B—Routing a socket in a surface. C—Routing the tail is a two-pass process.

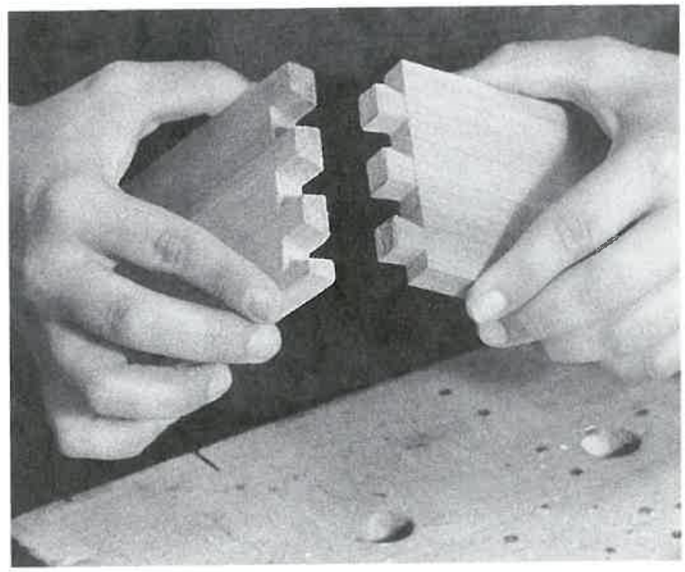


Figure 29-54. Test fitting a dovetail joint that was cut using hand tools.

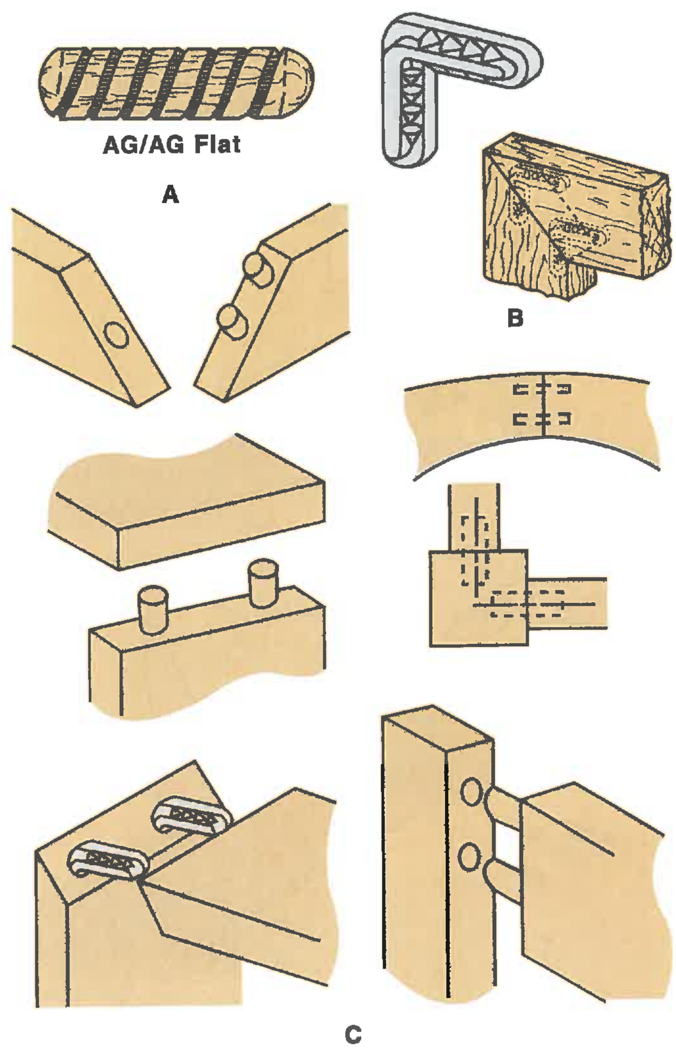



Figure 29-55. A—Spiral groove dowel. B—Plastic right-angle dowel for reinforcing miter joints. C—Various uses of dowels.

Plastic right-angle dowels are available for use in mitered corners. See **Figure 29-55.**

Wood dowels are best kept in a dry environment. When later inserted into a joint, they expand a little and add strength to the joint.

Some considerations to make when reinforcing a joint with dowels:

- Choose a dowel diameter not less than one-fourth nor more than one-half the thickness of the wood to be joined.

* Dowel length depends on the two workpieces being joined. A dowel should extend into each workpiece to a depth approximately 2½ times its diameter. For example, a 3/8″ (10 mm) diameter dowel should extend into each workpiece about 15/16″ (24 mm).
* Drill holes in each workpiece to a depth 1/8″ greater than half the dowel length.
* In any joint, use at least two dowels.

Dowel holes must be drilled accurately for the two parts to align. Therefore, make an accurate layout. Multiple parts to be drilled are aligned with a fixture or jig. This ensures that matching dowel holes are properly aligned.

When only a few dowel joints are being made, the best method to locate and drill dowel holes is with a doweling jig. The jig aids in aligning the drill to attain accurately centered holes for joining two parts end-to-end or edge-to-edge.

1. Square a line across both workpieces where the dowel will be located. See **Figure 29-56A.**
2. For each component, place the jig and align the jig's index mark on the layout line. There is a different mark for each guide hole. See **Figure 29-56B.**
3. Insert an auger bit or twist drill in the drill chuck.

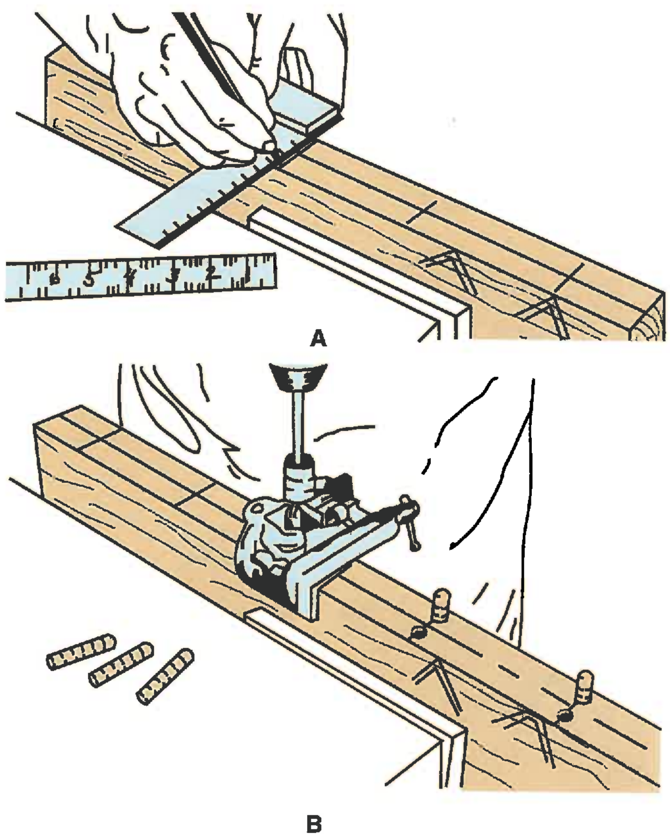



**Figure 29-56.** A—When marking locations for dowels in edge-to-edge joints, clamp the two parts and mark both at the same time. B—Placing the self-centering doweling jig over the edge. *(Brookstone)*

4. Drill the holes at each line to the proper depth. Use a depth stop or other method to control hole depth.

On occasion, paired holes cannot be drilled with the jig. For example, suppose you are joining a table apron to a leg with dowels. A doweling jig cannot be clamped to the thick leg. To accurately match these components, use dowel centers. See **Figure 29-57.** Drill the holes in one part. Insert dowel centers in the holes. Press the two parts together. Then, drill the other set of dowel holes at the indentations made by the center points.

## Plate Joinery

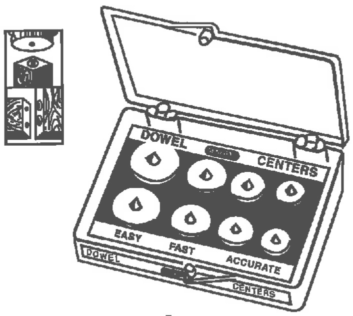
***Plate joinery*** is a strong, fast, and accurate method to join practically any woodworking material together. The joint is made with joining plates, also called biscuits and wafers, inserted into kerfs cut by a plate joining machine. See **Figure 29-58.** The process is used primarily in low volume custom production settings to join panel products, such as plywood or particleboard, to assemble frameless cabinets. In addition, plate joinery is excellent for connecting plastic-laminated materials that will not accept a glue bond.

### Plate joining machines

Plate joining machines are either stationary or portable power tools. The portable plate joiner looks much like a miniature power saw. It consists of a base, fence, handle, and circular blade or cutter. The base and adjustable fence align the machine. The blade remains hidden in the base until you place the machine against a workpiece and push the machine forward in the base. The cutter then enters the workpiece. The cut is slightly deeper and wider than a plate, leaving room for glue and movement of the two components when aligning the joint. The stationary plate joiner cuts plate kerfs in the edge of the workpiece or on the side near the edge. The cutting assembly is adjustable in elevation to change the distance of the cutter relative to the table. A foot actuator causes the compressed air to first operate the pneumatic clamp, then it moves the cutting assembly into the material. Adjust the feed rate to prevent stalling of the motor in dense woods. When the foot is removed from the actuator, the cutting assembly extracts itself.

### Plates

There are a variety of plates for use in different applications. See **Figure 29-59.** For joining wood and manufactured wood panels, plates made of compressed beech wood come in five sizes. See **Figure 29-60.** Several plates may be used in each joint.

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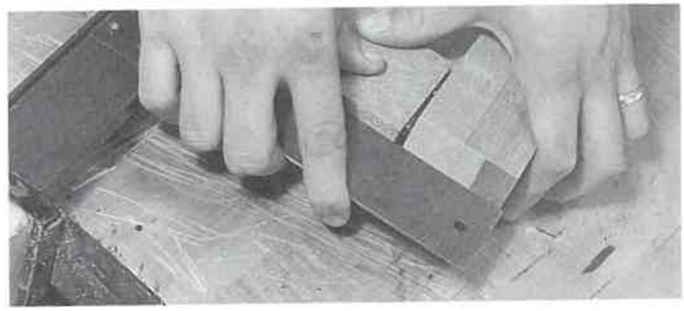

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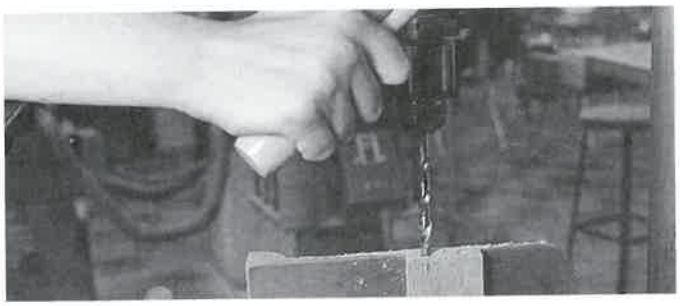

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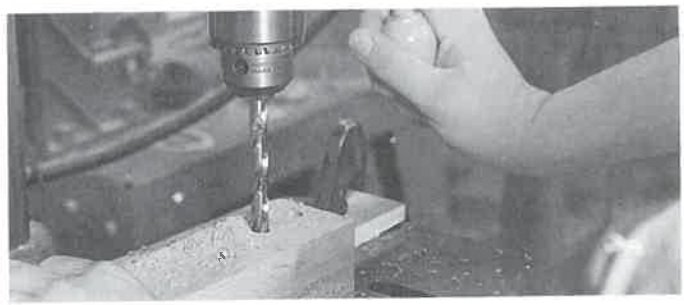

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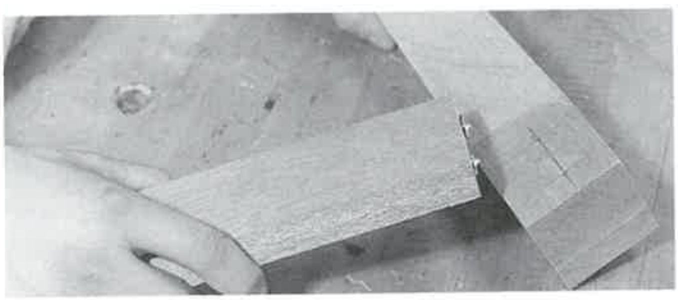

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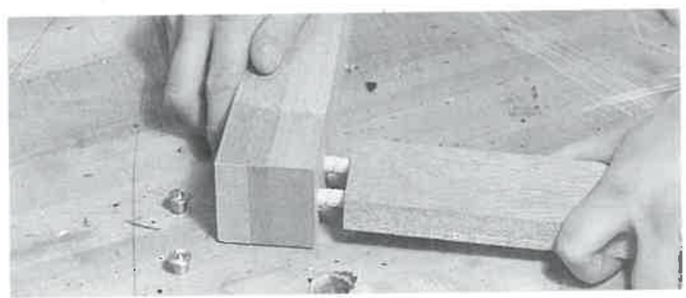


F

**Figure 29-57.** A—Dowel centers. B—Drilling holes in apron end for dowel joint to leg. C—Place dowel centers in the apron to mark hole locations. D—Keep the parts square while pressing the apron to the leg. E—Drill dowel holes in the leg at locations marked by the centers. F—Assembling the leg and apron.

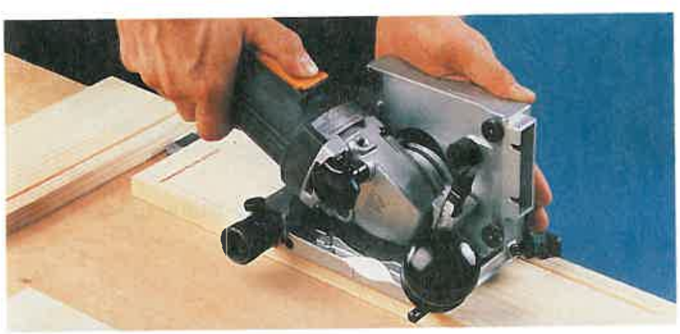


**Figure 29-58.** Using a portable power plate joiner to prepare components of a drawer for assembly. *(Black & Decker)*

The center of the first plate will be no more than 2" (51 mm) from each edge. Other plates will be positioned 3" to 6" (76 mm to 155 mm) on centers. Use two plates for materials over 1" (25 mm) thick.

Use prepared adhesives, such as polyvinyl acetate (PVA) or aliphatic resin glues, or use ones that are thinned or mixed with water, such as hide glue. These cause inserted plates to expand in the kerf, producing a tight fit. Because plates start to expand immediately, have clamps and clamping blocks ready. For this same reason, do not apply glue to the plate. Glue is to be applied only in the kerfs. Apply glue to the sides of the kerf where the plate contacts the workpiece. The best way to do this is to use an applicator that is designed for the purpose.

Other plates are made of aluminum or plastic. The aluminum plates are detachable. See **Figure 29-61.** There are two types of plastic plates. One has barbed cross ribs that are used without glue. The other is translucent and may be used in white solid surface materials.

## Making a plate joint

The steps taken to make a plate joint, with a portable power plate joiner, are as follows:

1. Set the depth of cut for the size plate being used.

| No. | Size | Where Used | Suitable Adhesives | Material |
|---|---|---|---|---|
| 20<br>10<br>0<br>S6<br>H9 | 56 × 23 × 4 mm<br>53 × 19 × 4 mm<br>47 × 15 × 4 mm<br>85 × 30 × 4 mm<br>38 × 12 × 3 mm | Joining surfaces, corners, frames; butt-jointed, offset or mitered; for solid wood and manufactured wood panels. | Polyvinyl acetate (PVA) or aliphatic resin | Beech wood |
| S | 56 × 23 × 4 mm | Detachable joining element for use at radiator enclosures, ceiling elements, screens, shelves, double doors.<br><br>This element requires an assembly tool for proper insertion. | 2 component adhesives, such as resorcinol and acrylic resins | Aluminum |
| K20 | 56 × 23 × 4 mm | The plate is made of plastic with barbed cross ribs that assure setting. Used as an assembly aid where clamping is difficult: screens, large workpieces, *etc.* | Normally used without an adhesive, but a white glue may be used. | Plastic |
| C20 | 56 × 23 × 4 mm | This plate serves for stabilizing and is used for joining marble-like solid surfacing materials. | Normally used without an adhesive, but the bonding agent used for the solid surfacing material may be used. | |

**Figure 29-59.** Plate joining elements. *(Colonial Saw, Lamello AG)*

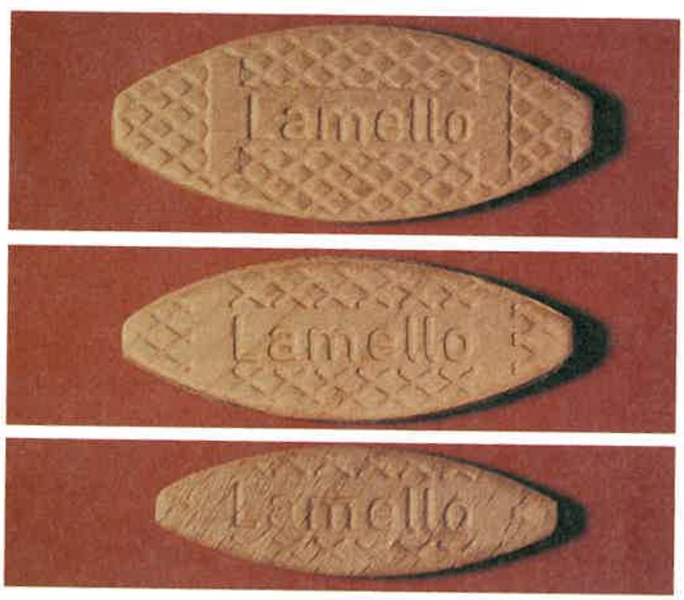



**Figure 29-60.** Beech wood plates. From top to bottom are sizes 20, 10, and 0. *(Colonial Saw, Lamello AG)*

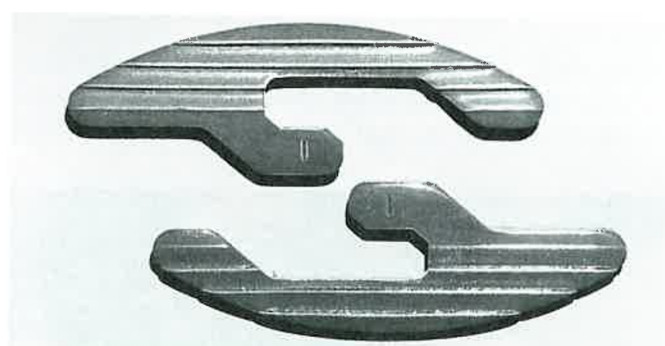


**Figure 29-61.** An aluminum two-part plate allows disassembly. *(Colonial Saw, Lamello AG)*

2. Lay out the positions of the joints. Hold the components together and mark the kerf locations freehand. The number of plates needed depends on the size, strength, and weight of the material being joined. Consider the stress the assembly will receive. Always try to use at least two plates, even on frame assemblies.
3. Set the machine fence depth and angle for the joint being cut. Some typical setups are shown in **Figure 29-62.** In a center butt joint (edge-to-surface joint), the joining workpiece is used to align the kerfs in the surface. To make edge kerfs, the fence must be positioned according to the joint: 90° for edge-to-edge joints; 45° for carcase (plain) miter or frame (flat) miter joints.

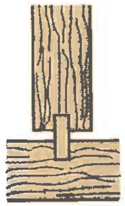
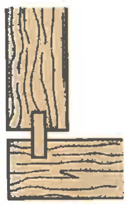
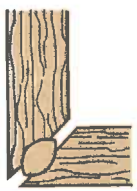
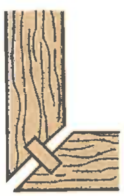
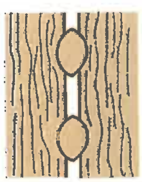
| Joint Type | When to Use It | Typical Joint-Strengthening Method | Procedure |
|---|---|---|---|
|  Center Butt | To assemble boxes: drawers, kitchen cabinets, stereo cabinets, bookcases, etc.; to install fixed shelves in cabinets | Glue and nail or screw, rabbet-and-dado, dovetail, dowel, mechanical knockdown fasteners, dado. |  |
|  Corner Butt | Cabinet face frames, frame-and-panel doors, picture frames. | Mortise-and-tenon, halflap, dowel, corrugated. |  |
|  Plain (Carcase) Miter | To assembel boxes. | Spline, rabbet. |  |
|  Flat (Frame) Miter | Cabinet face frames, frame-and-panel doors, picture frames. | Mortise-and-tenon, dowel, spline. |  |
|  Edge-to-Edge | To increase overall width. | Butt, dowel, spline |  |

**Figure 29-62.** Applications of plate joinery. *(Colonial Saw, Lamello AG)*

4. Hold the machine against the material and align the index mark with the layout line.
5. Switch on the motor and push the handle to feed the cutter fully into the material.
6. Release the handle and move the machine to the next joint location.

Use the following steps to make a plate joint with a stationary plate joiner:

1. For efficiency, cut kerfs for all parts that will receive edge cuts at one time and all that will receive side cuts at another.
2. Set the depth of cut for the size plate being used.
3. Either use index marks as with the portable machine or set the stops for the desired spacing of the plates.
4. Place the pneumatic clamp in a vertical position for edge cutting (as for cabinet bottoms, tops and stretchers, or drawer box front and back) See **Figure 29-63A.**
   Place the pneumatic clamp in a vertical position for miter cutting. Attach the miter fixture accessory. See **Figure 29-63B.**
   Place the clamp in a horizontal position for side cuts (as for cabinet side panels or for drawer box sides). See **Figure 29-63C.**
5. Make sure the compressed air line is connected and pressurized.
6. Switch the motor on.
7. Hold the material against the machine and either align the index mark with the layout line or slide the material against the stop.
8. Press and hold the foot operated switch until the cut is complete, then release the switch.
9. Move the material to the next joint location.

The stationary plate joining machine cannot cut grooves for plates away from the edge. The portable machine is to be used for that purpose. Cut distance blocks to assure like distances on each panel of the cabinet to be cut. See **Figure 29-64.**

## Spline Joint

A ***spline*** can be used to position and reinforce most joint assemblies. It is a thin piece of hardboard, plywood, or lumber inserted into grooves cut in the joining components. The spline functions much like a tongue in a tongue and groove joint. The groove can be cut through the edge to make the spline visible or not to make the spline hidden (blind). When using lumber for the spline, the spline grain must be perpendicular to the grain of the wood it joins. Otherwise the strength of the spline will be lost. See **Figure 29-65** and **Figure 29-66.**

**Figure 29-64.** Use a portable plate joiner to cut kerfs away from the edge of the panel. *(Chuck Davis Cabinets)*

A B C

**Figure 29-63.** Stationary plate joiner. A—Cutting kerfs in the edge of a base cabinet bottom panel. B—Using a standard accessory to cut kerfs for a miter joint. C—Cutting kerfs in the side of a cabinet side panel. *(Chuck Davis Cabinets)*

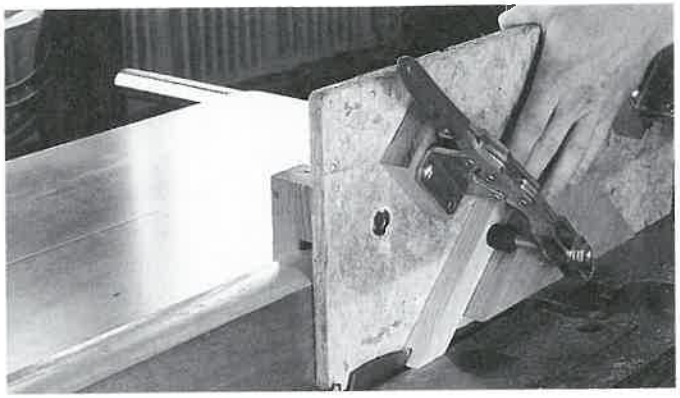
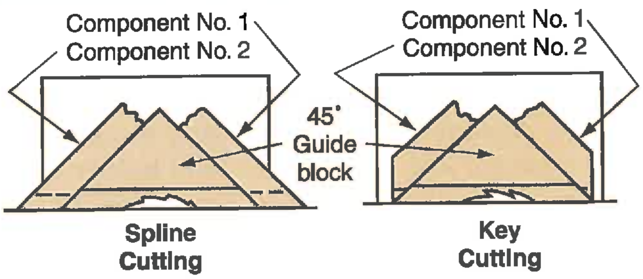




**Figure 29-65.** Jig for making splined flat miters and keyed splines.

A ***keyed spline*** is a short triangular spline. It fits into a kerf cut in the corner of a flat miter joint. The table saw cuts grooves into which the spline fits. Install a standard blade to cut 1/8" kerfs. Install a dado head to make cuts for thicker splines.

Set the blade height at half the width of spline. To cut grooves for an edge-to-edge joint, use the rip fence. For a splined flat miter or keyed spline, use the jig shown in **Figure 29-66.** For splined plain miters, use the jig shown in **Figure 29-67.** Always have matching surfaces of the two workpieces against the fence or jig.

Splines are not necessarily attractive. You may want them blind. Place stop blocks in front of workpiece or jig. Then make the necessary pass until you reach the stop block.

## Butterfly Joint

The ***butterfly joint*** is a combination of the dovetail and spline joints. In addition to reinforcement, it gives a decorative effect to the surface. See **Figure 29-68.** The butterfly's grain lies across the assembly it reinforces. The butterfly itself may be a decorative inlay or solid wood extending totally through the workpiece. See **Figure 29-69.**

Produce this joint by making the butterfly first. Then prepare the socket. For sawing the butterfly, set the table saw blade at 10° at a height half the stock thickness. Bevel the stock four times as shown in **Figure 29-70.** Then cut the stock into individual butterflies.

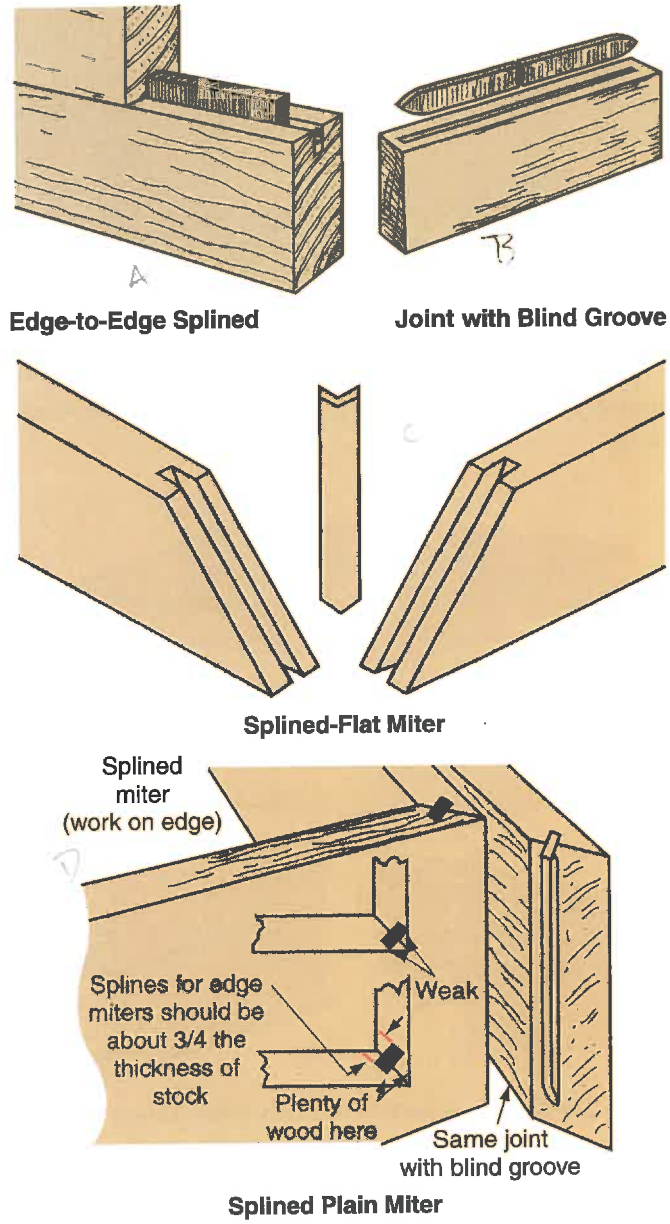



**Figure 29-66.** Use of splines in various joints. *(Delta International Machinery Corp.)*

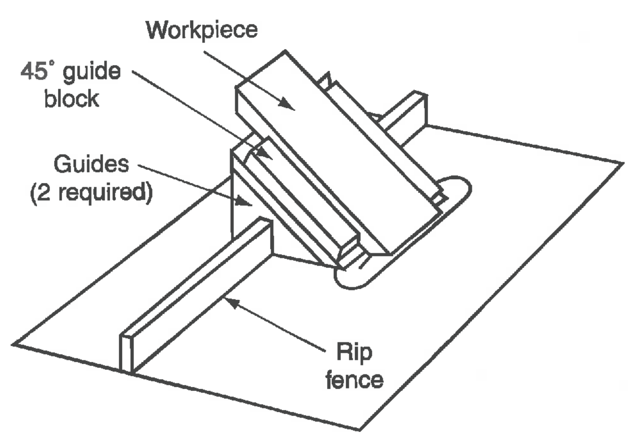



**Figure 29-67.** Jig for making splined plain miters.

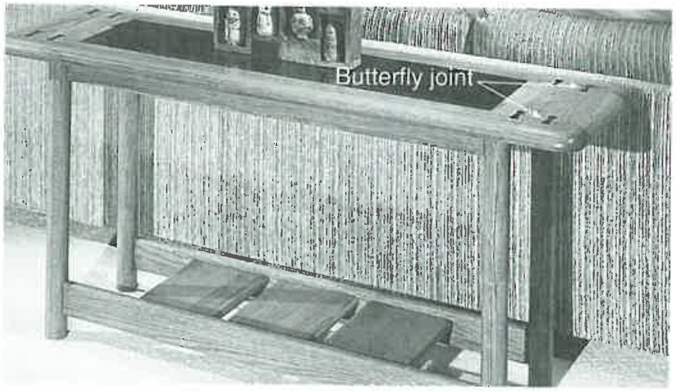



**Figure 29-68.** Butterfly joints in a sofa table. *(Mersman Tables)*

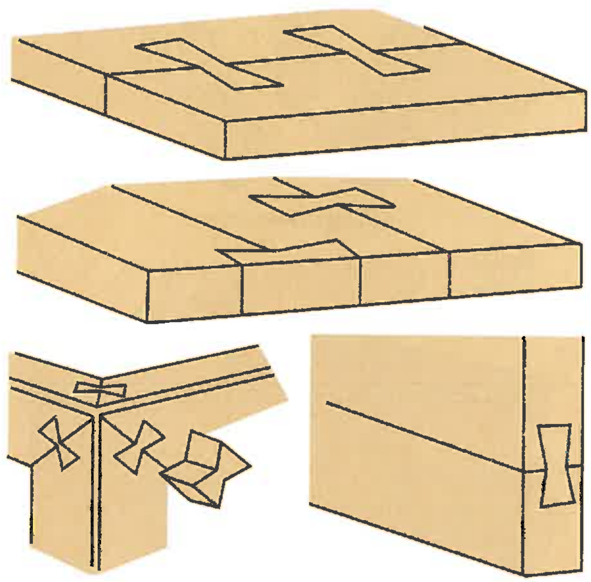


**Figure 29-69.** Various uses of butterfly joints. *(Shopsmith)*

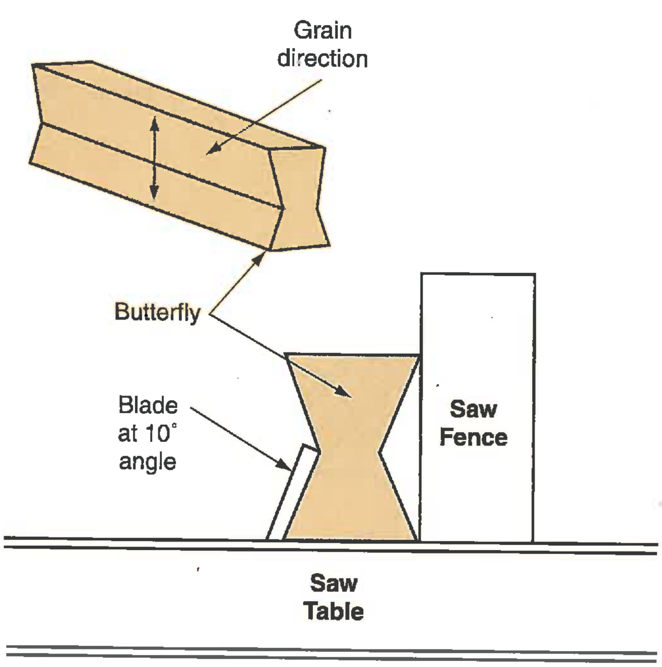



**Figure 29-70.** Cutting butterfly stock.

To make the socket, prepare a template of the butterfly. Use the template and knife edge to score the shape. Cut the recess with square-end bit and router, then chisel out the corners. You can also chisel out the entire recess by hand.

For a butterfly passing through the components, saw inside the template shape with a band saw or scroll saw. Finally, fit the butterflies in place. Use a knife or file to make minor adjustments to the shape of the butterfly and socket.

## Pocket Joint

The ***pocket joint*** allows the cabinetmaker to use screws to connect components end-to-edge or edge-to-edge. A stationary pocket cutting machine first routs a pocket and then drills a pilot hole from the edge to the pocket at 6°. See **Figure 29-71B.** The pocket and pilot are completed in 2 seconds. This low screw angle produces little lifting force, eliminating expensive clamping systems.

To make a pocket joint using the stationary pocket machine, make sure the air supply line is attached, and the power cord is plugged into the wall outlet. Then place the workpiece against the back plate depressing the safety switches. Depress the foot actuator. The machine will cycle in less than two seconds. The cycle consists of clamping, then the 3/8″ router bit emerges from beneath the table and cuts the pocket. The 3/8″ bit retracts and the 9/64″ stub flute cobalt drill bit emerges from behind the back panel and drills the pilot hole. The carriage returns to the original position and the clamp releases. Move the workpiece to the next location and repeat. Adjust the feed rate to prevent stalling of the motor in dense woods.

A pocket cutting drill press accessory and bit creates clearance and pilot holes at an angle. See **Figure 29-72.** Screws are driven through the pocket into the joining component.

Place some glue on the joint and use #6 × 1¼″ (32 mm) pan head, self-tapping screws in hardwood and #6 × 1½″ (38 mm) in softwood and manufactured wood panels. The #2 square recess drive does not slip out as easily as the Phillips recess. The pocket is cut into the component that joins at end grain. In this manner, the screw is driven into the part having edge grain. Since pockets are unsightly, they are usually hidden. Suppose you are joining parts that make up the face frame for a cabinet. Cut the holes in the back side of the frame. Once assembled, turn the frame around and attach it to the case. See **Figure 29-73.** If the end panels of the cabinet are to be hidden, cut pockets in the end panels, bottom

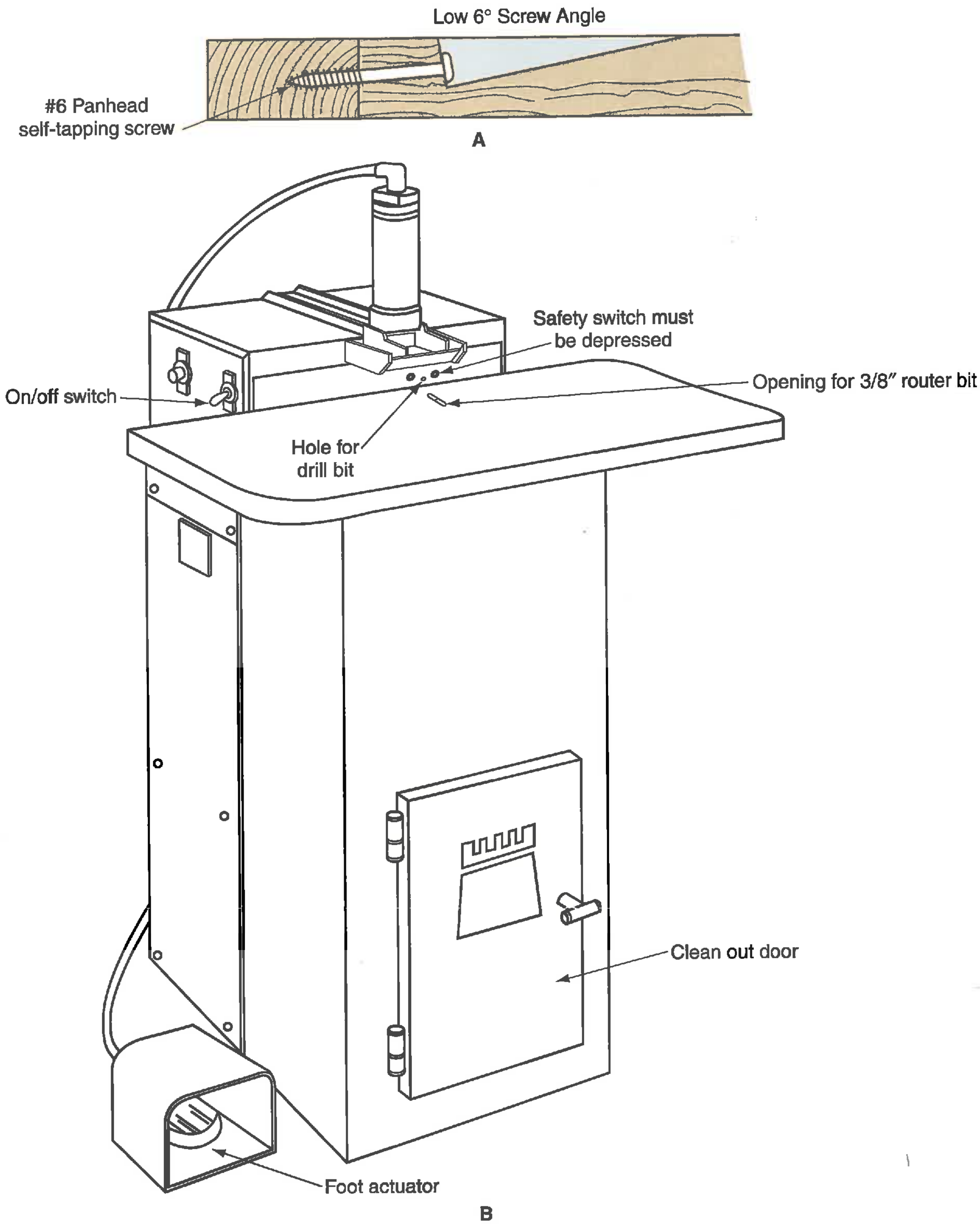



**Figure 29-71.** A—The pocket is routed and the pilot hole is then drilled. B—Stationary pocket machine. *(Castle, Inc.)*

panel, and top stringer, and then attach the face frame. There are no nail holes to fill, resulting in a superior face.

## Scarf Joint

A *scarf joint* connects components end-to-end. See **Figure 29-74.** It can be a decorative joint or simply used to join boards to increase the length of stock. Long lengths of molding consist of several pieces scarf jointed together. Decreasing the scarf angle increases the surface contact between joining parts. This, in turn, increases the strength of the joint. Saw the scarf at about a 5° to 10° angle on the table saw or radial arm saw in a miter position. By aligning grain patterns, the joint is almost invisible.

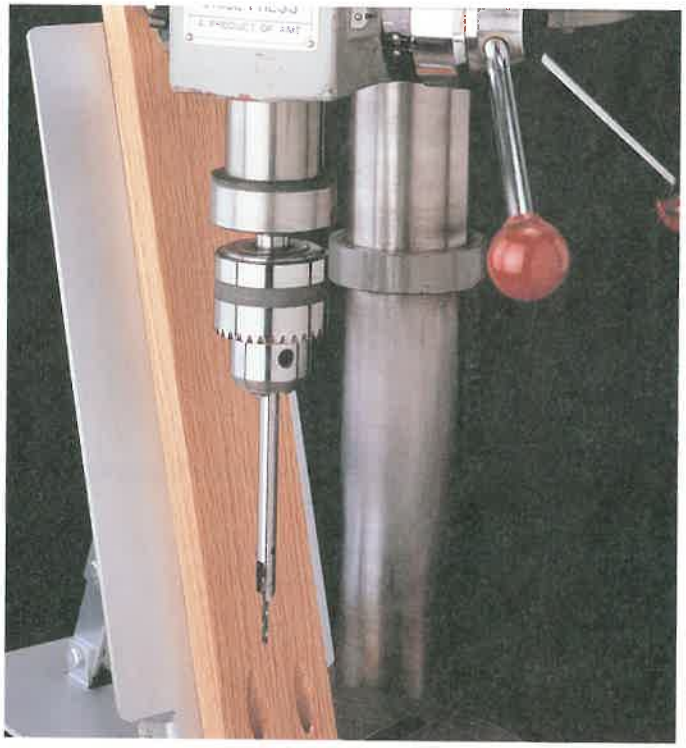


Figure 29-72. Jig for making pocket joints. *(Portalign Tool Corp.)*

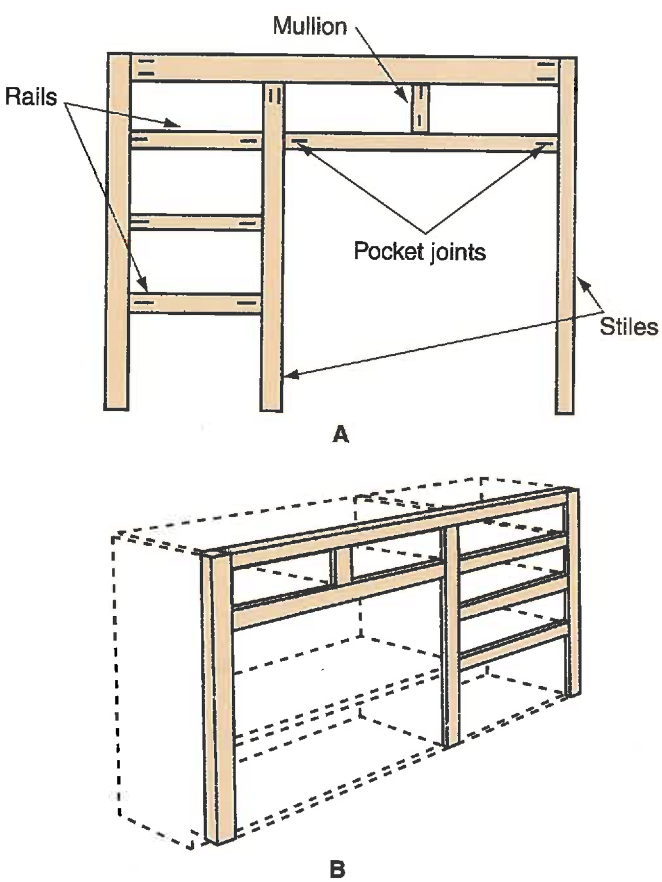



Figure 29-73. A—Pocket joint placement for assembling a face frame. B—When the frame is turned around and attached, the pockets are not visible.

## Structural Finger Joints

***Structural finger joints*** look like multiple scarf joints. See **Figure 29-75.** They position and add strength to the material being jointed. Some dimension lumber you buy may include finger joints. Short pieces of lumber are joined together rather than wasted. A production shaper cutter is used to make the joint.

## Threads

Like metal, wood can also be threaded. Notice that broom handles often thread into the bristle holder. You might also thread chair and table rails into the legs. To make a threaded joint, you need a ***wood tap and die***. See **Figure 29-76.** The standard size thread is ¾" (19 mm). Drill a hole 5/8" (16 mm)

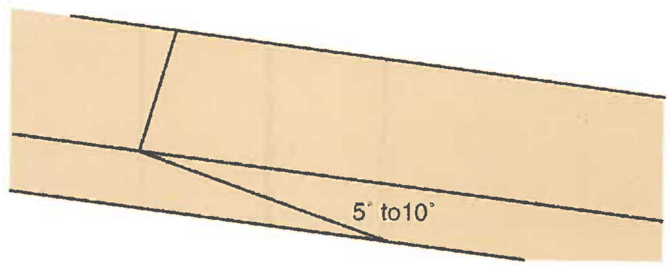



**Figure 29-74.** Scarf joint.

**Figure 29-75.** Structural finger joint. *(Forest Products Laboratory)*

**Figure 29-76.** Making threaded joints. The die produces external threads and the tap produces internal threads. *(American Machine & Tool Co.)*

in diameter. Then insert and turn the tap to create the internal threads. Select a ¾″ (19 mm) hardwood dowel for the joining component. Place the die over the dowel and rotate it one-half turn clockwise, then one-quarter turn counterclockwise. Continue this routine for the length of the thread.

### Think Safety—Act Safely

In making joints, various woodworking machines are used. You should review safety procedures for these machines. In addition, always observe these general rules:

- Never operate a machine when tired or ill.
- Think through the operation before starting. Be certain of what to do and what the machine can do.
- Make all the needed adjustments to the machine before turning it on.
- Feed the work carefully and not too fast for the machine.

## Summary

Joint making is a critical step of the furniture and cabinetmaking process. The type and quality of joint you choose greatly affects the stability and durability of a product. You have a choice of nonpositioned, positioned, and reinforced joints. Also important is the material. The grain direction of solid wood affects the strength of some joint types.

Throughout the design stages, there are many joinery decisions. It is best to choose the simplest joint that meets the strength requirements of the product. Equally important is the appearance of the joint. In some assemblies, the joint is visible. In others, it is hidden. Visible joints add a decorative effect to the product.

Butt joints are the simplest of all joints. The squared surface of one piece meets the face, edge, or end of another. In a dado joint, one component fits into a slot. The slot, or dado, provides a supporting ledge. The rabbet joint is much like the dado, except it is cut along the edge or end of the workpiece. With the lap joint, components fit into dadoes or rabbets cut in each. This forms a flush fit. To form a miter joint, the edges or ends of both components are cut at an angle. There are many variations of the miter joint to make it more secure. The mortise and tenon joint is a popular furniture construction technique. A tenon, or tab, fits into a mortise that provides a strong assembly. The box joint consists of interlocking fingers. The dovetail is like a box joint, except that the fingers are cut at an angle, forming tails and sockets. This gives a strong locking effect.

A number of joints consist of some standard joint with additional reinforcement. In a dowel joint, a wood or plastic dowel is used to provide a strong connection. Plate joinery connects parts with plates inserted into kerfs cut by a plate joining machine. This is a strong, fast, safe, and accurate method to join almost any material. The spline joint involves reinforcement by adding a spline into grooves cut in both components. A butterfly joint is a combination dovetail and spline that provides both reinforcement and decoration. A pocket joint consists of a butt joint reinforced with screws driven at an angle.

The primary purpose for the scarf and structural finger joints is to create usable stock from shorter material. A scarf joins several pieces of stock end-to-end to make longer material. Long lengths of molding usually consist of shorter lengths scarf jointed together. A structural finger joint is a multiple scarf joint, often found in dimensioned lumber.

## Test Your Knowledge

*Do not write in this text. Answer the following questions on a separate sheet of paper.*

1. List three factors affecting joint strength.
2. Explain why there is a limited number of joints you can choose for joining panel products.
3. The three general categories of joints are _____, _____, and _____.
4. During layout, make all joint measurements from _____.
   a. one face of the material.
   b. a common starting point.
   c. the edge of the material.
   d. the end of the material.
5. When might you choose to use a blind dado to mount a shelf rather than a through dado?
6. List three ways to cut a dado.
7. Describe how a rabbet joint is similar to, and different from, a dado joint.
8. A lap joint where the two components meet at an angle other than 90° is called a(n) _____.
9. List alternate names for, and give one application of, the flat miter and plain miter joints.
10. Identify two uses of the tongue and groove joint.
11. List three ways to create the mortise of a mortise and tenon joint.
12. List two methods to create the tenon of a mortise and tenon joint.
13. A drill press can be converted to a mortiser by adding a(n) _____ _____ and inserting a(n) _____ _____.

14. The most popular of the mortise and tenon joint variations is the _____.
    a. blind mortise and haunched tenon
    b. open-slot mortise and tenon
    c. blind mortise and tenon
    d. through mortise and tenon
15. What must you do to a routed mortise to insert a sawn tenon?
16. To accurately cut a box joint on the table saw, you must obtain or make a(n) _____ _____ _____.
17. Why do you place a guide block between the jig stop and workpiece when cutting one component of a box joint?
18. The tail and socket of a dovetail joint are cut at an angle to provide a(n) _____ _____.
19. The most popular dovetail is the _____ _____ _____.
20. The two basic sizes of dovetail bits are _____ and _____. Depth of cut with the smaller bit is _____. With the larger bit, it is _____ deep.
21. To rout a through multiple dovetail, a(n) _____ is placed under the component clamped horizontally in the dovetail jig.
22. Explain how you would calculate the diameter and length of dowel to use based on the thickness of the joining parts.
23. Dowel holes can be accurately drilled in edge and end grain using a(n) _____ _____.
24. Identify how you would accurately locate dowel holes in material too thick for the doweling jig.
25. Joining plates come in what three sizes? How are these sizes labeled?
26. Explain why you are able to lay out location marks for joining plates freehand, rather than using layout tools.
27. A pocket joint consists of a butt joint reinforced with _____.
28. The primary purpose of a scarf joint is to _____.
    a. join stock to make wider workpieces
    b. join stock to make longer workpieces
    c. join stock to make thicker workpieces
    d. reinforce butt joints

# Abrasives

30

## Objectives

After studying this chapter, you will be able to:

* Select abrasive materials for smoothing surfaces.
* Identify the major natural and synthetic abrasive materials.
* Choose abrasive grain type and grit size.
* Recognize the adhesives and backings for various coated abrasives.
* Describe the use of abrasives in solid and loose form.

## Important Terms

abrasive grains
abrasives
aluminum oxide
backing
coated abrasives
emery
flexed
garnet
grain sizes
grinding wheel
industrial diamond
loose abrasives
pumice
rottenstone
silicon carbide
solid abrasives
stone
synthetic abrasives
tripoli

***Abrasives*** are used by cabinetmakers to smooth surfaces in preparation for assembly or finishing. See **Figure 30-1.** Various types and forms of abrasives are available.

***Coated abrasives*** are grains of a natural mineral or synthetic substance bonded to a cloth or paper backing. They are manufactured into sheets, disks, and many other forms. When the abrasive is rubbed against a surface, each grain acts as a miniature cutting tool. Coated abrasives are commonly called sandpaper, however, the grains are not sand.

***Solid abrasives*** are grains bonded into stones and grinding wheels. These are used to sharpen planer knives, chisels, and other cutters.

***Loose abrasives,*** such as pumice and rottenstone, are finely crushed abrasives. These are mixed in water or oil solvent and applied when rubbing a built-up finish.

**Figure 30-1.** Abrasives are used to smooth workpieces before finishing. *(Montachusett Regional Vo-Tech School, Fitchburg, MA)*

Besides grains, there are ***abrasive tools*** such as files, rasps, Surforms®, textured metal sheet abrasive, and metal screens. In some instances, a file may be more appropriate than a coated abrasive.

***Steel wool,*** a fiber steel mesh, is another abrasive material. It is rubbed over a dried built-up finish to remove brush marks and dust particles.

## Abrasive Grains

*Abrasive grains* may be natural or synthetic. See **Figure 30-2.** Natural abrasives are crushed minerals. Synthetic abrasives are manufactured and are generally harder and more durable than natural minerals. However, they often are more expensive.

**Figure 30-2.** Abrasive grains are the essential ingredient for making solid and coated abrasives. *(Norton)*

### Natural abrasives

Cabinetmakers use several natural mineral abrasives. These are garnet, emery, pumice, rottenstone, and tripoli.

*Garnet* is a hard glasslike material. It is made by crushing semiprecious garnet jewel stone. The grains produced are narrow, wedge shapes. Garnet is found mostly as a coated abrasive for hand and light machine operations, usually to prepare a surface for finish. It has a distinct red color.

*Emery* is a black mineral that is very effective on metals. It is limited mostly to tool sharpening and cleaning rust-coated machine surfaces. Do not use it on wood because it clogs easily.

*Pumice* is a white, porous, volcanic rock. It is ground into flour and mixed with water or oil. Rubbing the mixture on built-up finishes produces a high luster.

*Rottenstone* is a flour form of limestone. It is brown or tan and is finer than pumice. Mix it with rubbing oil for the same use as pumice.

*Tripoli* is finely ground limestone. It typically contains some impurities that give it a white, gray, pink, or yellow color. It is formed into solid cakes and used for polishing plastics.

### Synthetic abrasives

*Synthetic abrasives* are manufactured from natural materials. They undergo a process that melts the minerals in an electric furnace. After the minerals cool, they are crushed. The result is a more effective and durable abrasive. Synthetic abrasives used by cabinetmakers include aluminum oxide, silicon carbide, aluminum zirconia, and industrial diamond.

*Aluminum oxide* is a very efficient abrasive for sanding woods. It is brown or gray in color and crushed into wide wedge grains. Aluminum oxide lasts several times longer than garnet. It is used as a coated abrasive and as a bonded solid for grinding wheels, stones, and hones.

*Silicon carbide* is one of the harder synthetic abrasives in common use. It is black, shiny in color, and may be ground finer than other abrasives. Open coat material can be used whenever filling or loading is a problem. It gives excellent performance on cedar, pine, and mahogany. You use wet-or-dry sheets for smoothing wood sealer coats, finish coats, or plastics. Silicon carbide is also made into honing stones for sharpening tools.

Aluminum zirconia, sometimes referred to as alumina zirconia, is second only to diamonds in hardness. *Aluminum zirconia* is an alloyed abrasive formed by zirconia deposited in an alumina matrix. An *alumina matrix* is an alloy of aluminum oxide and zirconium oxide. The abrasive is used for heavy stock removal of either metal or wood and high pressure grinding. It exhibits self-sharpening characteristics.

*Industrial diamond* abrasive materials are manufactured to grind and sharpen carbide cutters. They are bonded onto grinding wheels made of metal or another stable core. Synthetic diamond chips are pressed into the cutting surface. While grinding, coolant flows over the point of operation to prevent overheating. Another use for industrial diamond wheels is cutting ceramic materials. Chips are pressed into the edge of a metal disk, much like teeth on a circular saw blade. Again using coolant, you can cut ceramic tile and glass.

## Abrasive Grain Sizes

Abrasives are crushed into grit, powder, and flour sizes. A series of procedures are used to reduce minerals into small grains. Raw material is broken into 6" (152 mm) or smaller chunks by jaw crushers. Chunks are then grated to about 2" (51 mm) in diameter or smaller. Next they are crushed by rollers or presses to usable grain sizes.

The grains are sifted through a set of shaking screens to separate grain sizes. Screens are made of woven wire or silk. Grit size refers to the screen holes per linear inch. (Window screen has about 16 openings per inch, or 256 holes per square inch.) Grains stop falling when they can no longer go through the screen's openings. The range of abrasive sizes is created using a series of screens, each with a different opening size. This method is used for sizes from 16 to 220 grit.

Smaller grit sizes are called powder or flour grades. These are separated by floating. The tiniest particles float higher in water or air than heavier particles. Powdered grades are 240 to 600 grit sizes. Silicon carbide is powdered into these sizes. Flour grades are F, FF, FFF, and FFFF, with FFFF being the smallest. Pumice is graded by this system.

Two systems for grading coated abrasives are found in products available to the cabinetmaker. The two systems were developed by the ***Coated Abrasive Manufacturers Institute*** **(*CAMI*)** and the ***Federation of European Producers of Abrasives*** **(*FEPA*)**. The CAMI grit number and FEPA "P"-number scales, along with the relative size in inches and microns, are shown in **Figure 30-3.** To eliminate the need for a grading system, abrasives are available with the actual size of the grains stated in microns. A micron is a unit of length equal to 1/1000 millimeter.

## Coated Abrasives

*Coated abrasives* are the most widely used for hand and machine sanding. Grains are bonded with adhesive to a backing material. The coated material is then cut as a sheet, or formed into belts, disks, sleeves, and other shapes. The sheets are shown in **Figure 30-4.**

### Backing

*Backing* materials include paper, cloth, and fiber. See **Figure 30-5.** They have weight and strength differences.

Paper backing is identified by letters A through E, with E being the heaviest. The weights for paper backing shown in **Figure 30-6** refer to 480 sheets measuring 26" by 48" (660 mm by 1219 mm). Lighter backings are coated with finer abrasives. Heavy backings are coated with coarse or fine abrasives for machine sanding.

Cloth backings include J, or jeans cloth, and X, or drill cloth. *J grade* cloth backings are light and flexible. They are for belt and hand sanding machines. The *X grade* is heavier, stronger, and treated for durability. It is used for flat sanding belts on large production machinery.

Fiber backings are made of a chemically treated, laminated paper and cotton rag base. They are able to withstand the heat from prolonged sanding. Heavy-duty disk and drum abrasives are made with fiber backing.

Combination backings are two layers, paper and cloth. See **Figure 30-7.** Abrasives are bonded to the cloth side. These are used for extra heavy duty disk sanding.

| CAMI Grit No. | FEPA Grit No. | Average Particle Size in Inches | Average Particle Size in Microns | Common Name | Application |
|---|---|---|---|---|---|
| | P1200 | .00060 | 15.3 | Very Fine | Polishing after finish has been applied |
| 600 | | .00062 | 16.0 | | |
| | P1000 | .00071 | 18.3 | | |
| 500 | | .00077 | 19.7 | | |
| | P800 | .00085 | 21.8 | | |
| 400 | | .00092 | 23.6 | | |
| | P600 | .00100 | 25.75 | | |
| 360 | | .00112 | 28.8 | | |
| | P500 | .00118 | 30.2 | | |
| | P400 | .00137 | 35.0 | | |
| 320 | | .00140 | 36.0 | | |
| | P360 | .00158 | 40.5 | | |
| 280 | | .00172 | 44.0 | | |
| | P320 | .00180 | 46.2 | | |
| | P280 | .00204 | 52.5 | | |
| 240 | | .00209 | 53.5 | | |
| | P240 | .00228 | 58.5 | | |
| | P220 | .00254 | 65.0 | | |
| 220 | | .00257 | 66.0 | | |
| 180 | P180 | .00304 | 78.0 | Fine | Smoothing before applying finish |
| 150 | | .00363 | 93.0 | | |
| | P150 | .00378 | 97.0 | | |
| 120 | | .00452 | 116.0 | | |
| | P120 | .00495 | 127.0 | | |
| 100 | | .00550 | 141.0 | Medium | Removing small marks and scratches |
| | P100 | .00608 | 156.0 | | |
| 80 | | .00749 | 192.0 | | |
| | P80 | .00766 | 197.0 | | |
| | P60 | .01014 | 260.0 | | |
| 60 | | .01045 | 268.0 | | |
| | P50 | .01271 | 326.0 | Coarse | Removing saw and planer marks |
| 50 | | .01369 | 351.0 | | |
| | P40 | .01601 | 412.0 | | |
| 40 | | .01669 | 428.0 | | |
| | P36 | .02044 | 524.0 | | |
| 36 | | .02087 | 535.0 | | |
| | P30 | .02426 | 622.0 | Very Coarse | For very rough surfaces and fast removal of stock with power sanders |
| 30 | | .02488 | 638.0 | | |
| 24 | | .02789 | 715.0 | | |
| | P24 | .02886 | 740.0 | | |
| 20 | | .03530 | 905.0 | | |
| | P20 | .03838 | 984.0 | | |
| 16 | | .05148 | 1230.0 | | |

**Figure 30-3.** Abrasive grains are sized by two systems, both are based on the grit size. FEPA or P-graded products are easily identified by a "P" preceding the grit number. CAMI grade numbers do not have any letter preceding the grit number. *(Klingspor Abrasives, Inc.)* One micron equals 1/1000 of a millimeter.

**Figure 30-4.** Types of abrasive paper (from right to left): Silicon carbide (blue black), aluminum oxide (tan), flint paper (light tan), and garnet paper (reddish brown).

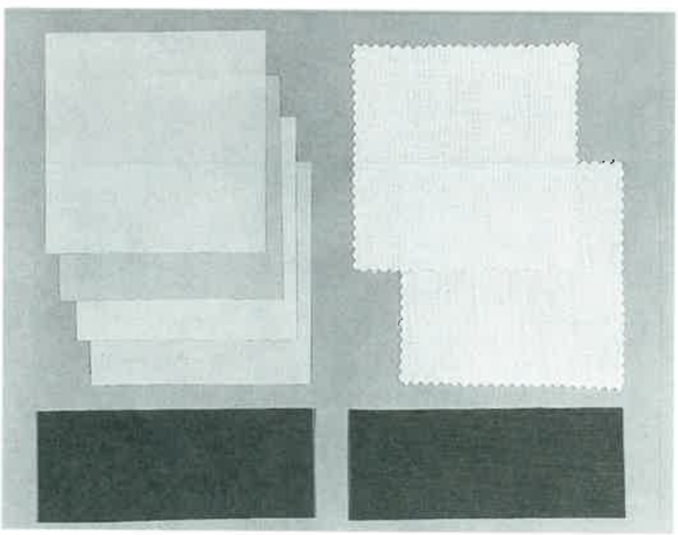


**Figure 30-5.** Backing materials. Top-left—Paper. Top-right—Cloth. Bottom—Fiber composition. *(Norton)*

| Paper Product Identification | | | |
|---|---|---|---|
| **Letter** | **Weight (lb)** | **Duty** | **Use** |
| A | 40 | Light | Hand |
| C | 70 | Light to medium | Hand and light, portable electric pad sanders |
| D | 90 to 100 | Medium to heavy | Portable and stationary belt and disk sanders |
| E | 130 | Heavy | Drum, stroke and wide belt machines |

**Figure 30-6.** Letters specify paper product backing weight.

## Adhesive

Abrasive grains are attached to the backing by a two-step process. The first layer of adhesive, referred to as ***make coat,*** is coated to the backing. The abrasive grains are bonded to this coat. A second coat of adhesive, referred to as ***size coat,*** anchors the abrasive firmly. See **Figure 30-8.** There are five basic adhesive combinations for the make and size coats.

- ***Glue over glue.*** Traditionally, hide glue has been used for both the make and size coats with paper-backed coated abrasives. Glue-bonded products have low resistance to sanding heat and moisture. Prolonged storage of this type permits moisture to separate the grit and backing.
- ***Glue and filler.*** Filler material is added to the glue in both layers. It produces a more durable bond.
- ***Resin over glue.*** The hide glue make coat and adhered grains are covered with a synthetic resin. This combination has greater resistance to heat than glue over glue.
- ***Resin over resin.*** Both make and size coats are synthetic resins. This is the toughest, most durable, heat resistant bond.
- ***Waterproof.*** This is a special make and size coating of synthetic resins. It is used on waterproof paper backing. The coated abrasive can then be used with water or oil.

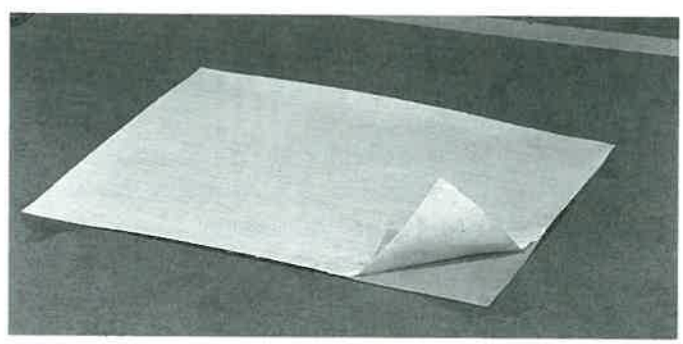


**Figure 30-7.** Combination backings consist of paper and cloth layers. *(Norton)*

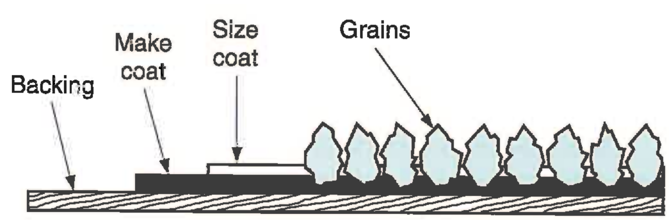



**Figure 30-8.** Abrasive grains are attached to the backing between two separate coatings of adhesive. *(Norton)*

## Coating practices

Coated abrasives are made with one of two types of abrasive coatings. These are open coat and close coat.

An open coat refers to space between the mineral grains. Only 40% to 70% of the backing is covered with abrasive grains. Although it leaves a somewhat rough surface, this type cuts faster and clogs less. A special coating of zinc stearate may be sprayed on to open coat abrasives to further resist clogging.

A close coat means that grains cover the entire surface. This type can be found for the full range of abrasive grades. Use finer grit, close coat abrasives where loading (wood chips becoming stuck between abrasive grains) is not a problem and where a smoother finish is desired.

# Manufacturing Coated Abrasives

Abrasive products are manufactured in a continuous process. Backing material is fed from large rolls through coating, bonding, drying, flexing, cutting, and forming processes.

## Bonding grains

Grains are deposited in one of two ways depending on grain size. See **Figure 30-9.** They are either deposited by gravity or electrostatically and are described as follows:

- ***By gravity.*** Grains of 150 grit or coarser are dropped directly on the wet make coating.
- ***Electrostatically.*** Finer grits are dropped onto a conveyor belt. They then move through an electromagnetic field and are magnetically attracted upward to the make coat. The electrostatic process actually aligns grains better for more efficient cutting. Once the grains are bonded, the size coat is applied.

## Flexing

Once the grains, backing, and adhesive cure, the coated abrasive is *flexed.* The adhesives are not especially flexible. Thus, the coated paper or cloth is bent at 90° and/or 45° angles. The direction and spacing of the breaks are important for abrasive contouring. **Figure 30-10** shows the four different flexing practices.

## Cutting and forming

After flexing, the abrasive coated backing is cut into sheets or formed.

Sheets are commonly cut into 9" by 11" (229 mm by 279 mm) sheet sizes. When torn into halves, thirds, or quarters, these pieces fit popular makes of portable power sanders. See **Figure 30-11.** Some manufacturers produce 4½" by 5½" (114 mm by 140 mm) sheet sizes for small ¼ sheet portable power sanders.

Forms include belts, disks, blocks, sleeves, flapwheels, rolls, spirals, and pencils. These fit a number of sanding machines.

***Belts*** range from less than 1" (25 mm) to 52" (1.32 m) wide, with lengths of 12" (305 mm) and

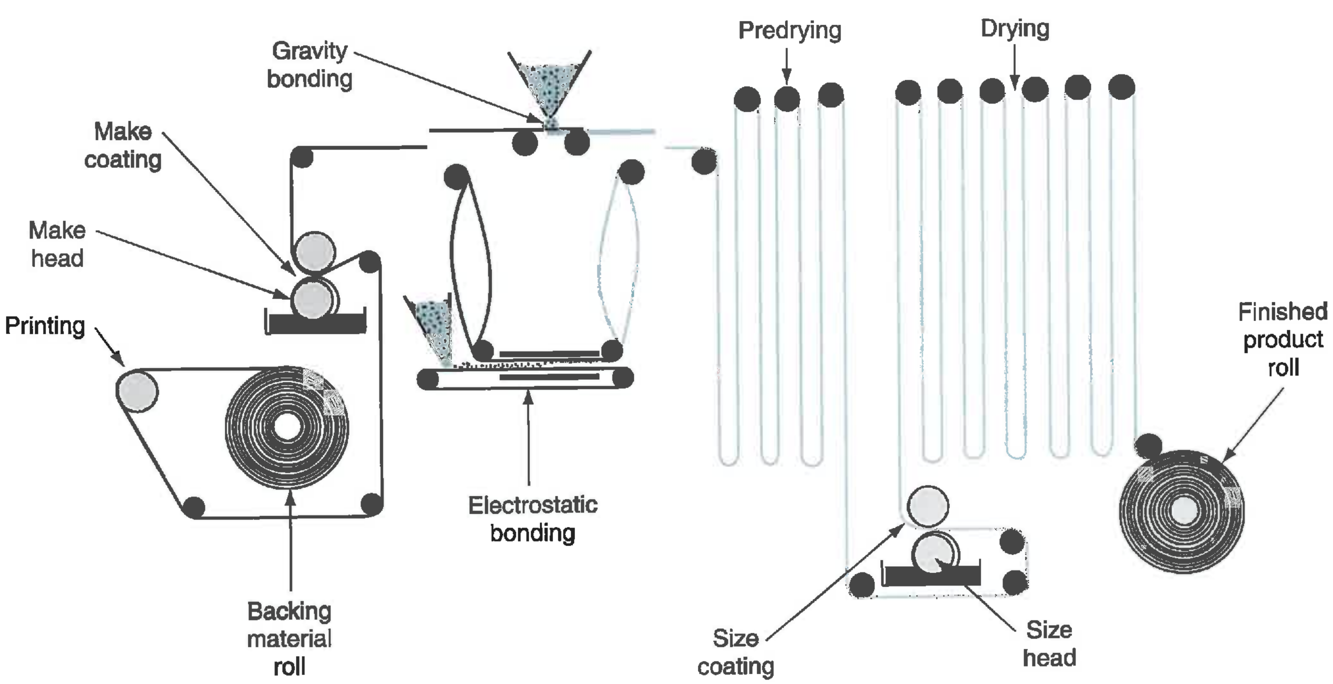
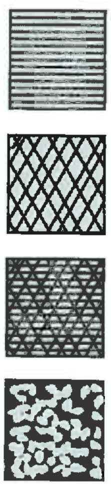



**Figure 30-9.** Manufacturing process for coated abrasives.



SINGLEFLEX. The bond is broken at a 90° angle to the width. The abrasive product is stiff in one direction, flexible in the other. This prevents ruptures from occurring when the abrasive is in use over a drum, pulley, or curved surface. Singleflex is standard for most cloth sheets.

DOUBLEFLEX has the bond broken at two 45° angles to the width. This flex is desirable for sanding contours such as moldings.

TRIPLEFLEX is a combination of single and double flexing. It is specified for sanding sharp or irregular contours.

Q-FLEX provides a uniform flex over the entire surface in all directions. Its excellent self-cleaning property makes it ideal for edge-sanding applications.

**Figure 30-10.** Coated abrasives are flexed in one or more directions to give flexibility. *(Norton)*

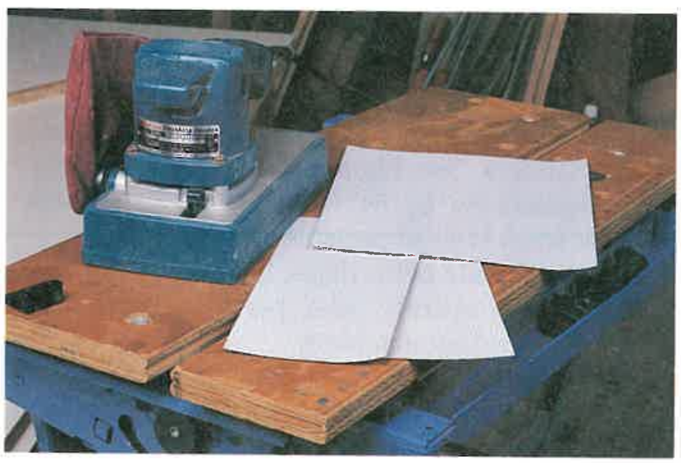


**Figure 30-11.** Sheet abrasive is commonly used with portable orbital sanders. Tear full sheets in half for this sander. Other sanders use ¼ sheets. *(Chuck Davis Cabinets)*

longer. The smaller belts are used on portable equipment such as the belt sander. See **Figure 30-12.** Larger belts are used on stationary machines such as stroke sanders, wide belt sanders, and abrasive planers.

*Disks* are found in diameters of 4½" through 12" (114 mm through 305 mm). Smaller diameters are used for portable random orbit disk sanders. See **Figure 30-13.** There is a variety of attachment methods. Some have a hole punched in the center to attach the disk to the sander, some use hook and loop, while others use a ***pressure sensitive adhesive*** (PSA) to bond the disk.

***Sanding blocks*** are coated abrasives bonded to a flexible sponge. See **Figure 30-14.** They can be used on flat or contoured surfaces. The adhesive used is waterproof so the block can be used for wet or dry sanding.

**Figure 30-12.** Abrasive belts are used on portable belt sanders. *(Chuck Davis Cabinets)*


**Figure 30-13.** Disks for portable power random orbital sanders are punched with several holes to facilitate dust removal. *(Chuck Davis Cabinets)*


**Figure 30-14.** A—One relatively new form of coated abrasive is the sanding block. B—The block is flexible to fit contours. *(Red Devil)*

*Sleeves* are made for arbor mounted drum and spindle sanders. See **Figure 30-15.** Various diameters and lengths are available. You slide the abrasive sleeve over a drum or spindle which is then expanded to secure it.

*Flap wheels* are scored sheets of abrasive bound to a center core with a shaft. The flap wheel is mounted to the shaft of a stationary electric motor, or inserted into a portable drill chuck. See **Figure 30-16.** The many narrow pieces of abrasive smooth contoured surfaces.

Abrasive rolls come in several forms. ***Cloth and backed rolls*** are from 1″ to 6″ (25 mm to 152 mm) wide and up to 75′ (22.9 m) long. They are used for hand sanding in close quarters where folding and repetitive flexing would render paper-backed paper useless. ***Paper rolls*** that are 4½″ wide by 75′ in length (114 mm by 23 m) are to be cut to size and are for use in portable oscillating sheet sanders. ***Pressure-sensitive, adhesive paper-backed rolls*** that are 4½″ wide by 75′ in length (114 mm by 22.9 m) can be cut to size and stuck to your hand sanding block or power sheet sander. ***Heavy paper-backed, hook and loop attachable rolls*** that are 4½″wide by 75′ in length (114 mm by 22.9 m) can be cut to size and attached to power sanders equipped for hook and loop material. Other rolls are 3½″ (88.9 mm) wide, up to 164′ in length (50 m) and are rolled in a spiral fashion on wide drum sanders.


**Figure 30-15.** Coated abrasives in sleeve form are ready for use on this spindle sander. *(Ryobi America Corp.)*

**Figure 30-16.** Flap wheels mounted on a drill will smooth in tight corners and around contours. *(Chuck Davis Cabinets)*

Other forms include strips, cords, and spirals. See **Figure 30-17.** ***Strips*** with tapered ends are made for wide drum sanders. The length varies with the size of the drum. Rolls narrower than 1/16″ (1.5 mm) are called *cords*. These can be threaded through hard-to-reach areas. ***Spirals*** are used for sanding fillets, recesses, and small contours. They are used with metal mandrels. Pencils are used for sanding channels, recesses, and bottoms of blind holes. They are attached to a metal mandrel.

## Solid Abrasives

***Solid abrasives*** are a combination of abrasives and bonding agent. This mix is formed into stones and grinding wheels to sharpen tools. See **Figure 30-18.**

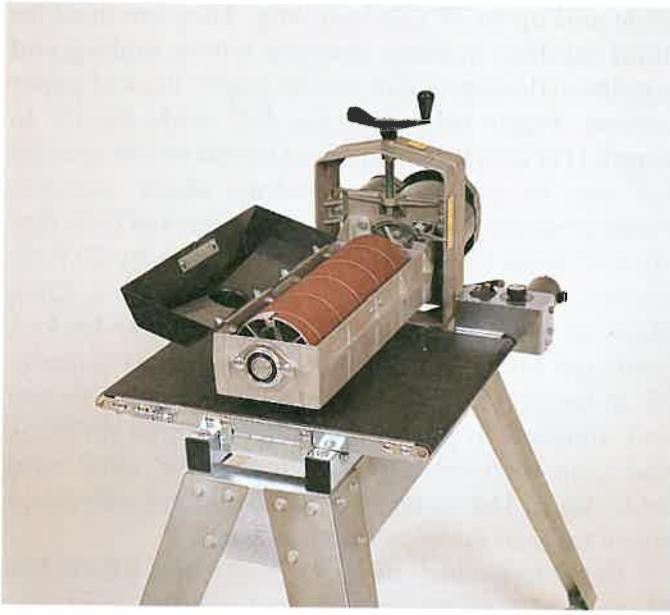
The process for manufacturing solid abrasives is complex. The abrasive grains and bonding agent are first mixed. The mixture is then pressed into molds. Next, they are heated slowly in an oven. Here the product is fused. After heating, the solid abrasive is left to cool slowly.

The most common bonding process is called *vitrified bond*. A silica agent, when heated, liquefies into glass. This permanently bonds the material in the shape of the mold.

### Grinding wheels

***Grinding wheels*** are most commonly a vitrified bond of aluminum oxide grains. There is a broad range of grits and sizes. For most purposes, 46 grit and 60 grit are suitable for grinding tools and blades. As the chart for **Figure 30-19** shows, grinding wheels are labeled to reflect the qualities in six specifications. These specifications are:

- ***Abrasive type.*** It may be aluminum oxide or silicon carbide.



A

B


C

**Figure 30-17.** Other abrasive forms. A—Strips mounted on wide drum sander. *(Performax Products, Inc.)* B—Spirals. *(Norton)* C—Detail sander. *(Ryobi America, Inc.)*

- ***Grain size.*** This will usually be 46 to 60, but grain sizes from 10 to 600 are available.
- ***Grade.*** Grade refers to the hardness of the wheel. Grades A through H are soft. Grades I through P are medium-hard. Grades Q through Z are hard. Tool sharpening is done with medium-hard wheels.

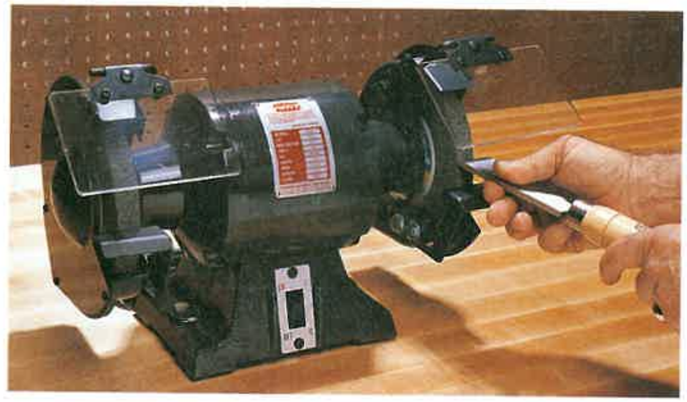


**Figure 30-18.** Grinding wheels are solid bonded abrasive wheels. *(American Machine and Tool Co.)*

- ***Structure.*** Structure is the spacing between abrasive grains. Grains that are more dense are called close. A less dense structure is called open. Structure is rated from 1 (dense) to 15 (open). A smoother finish is achieved with a dense structure.
- ***Bond.*** Usually vitrified bond is preferred over other agents, such as silicate, rubber, shellac, and resinoid.
- ***Dimensions.*** This is the outside diameter and width. Wheels generally come with sleeves to adapt to fit machine shafts.

## Stones

Sharpening and honing tools often are done with natural and synthetic abrasive ***stones.*** Natural stones are called Arkansas stones. These are rated by either a hard or soft bond. A natural stone with coarse grains is named a Washita (wash'-ih-tah) stone.

Synthetic stones are silicon carbide (black) or aluminum oxide (gray or brown). Grit sizes are coarse or fine. Coarse stones cut faster and wear quicker. Fine stones (both hard and soft grades) cut slower and wear longer.

Stones come in a variety of shapes and sizes. Cabinetmakers use bench, slip, and file stones. See **Figure 30-20.** Rectangular bench stones may be single or combination grit. Combination stones are made of coarse and fine synthetic grains or synthetic and natural grains. Slips are identified by their round edges. File stones are flat, round, and half round, as are steel files.

Cake abrasives (made of tripoli) are for polishing with a buffer. They are a mixture of abrasive and a soft bonding agent. The raw mixture, similar to cake batter, is poured into cake molds. The liquid evaporates and the cakes are removed for use.

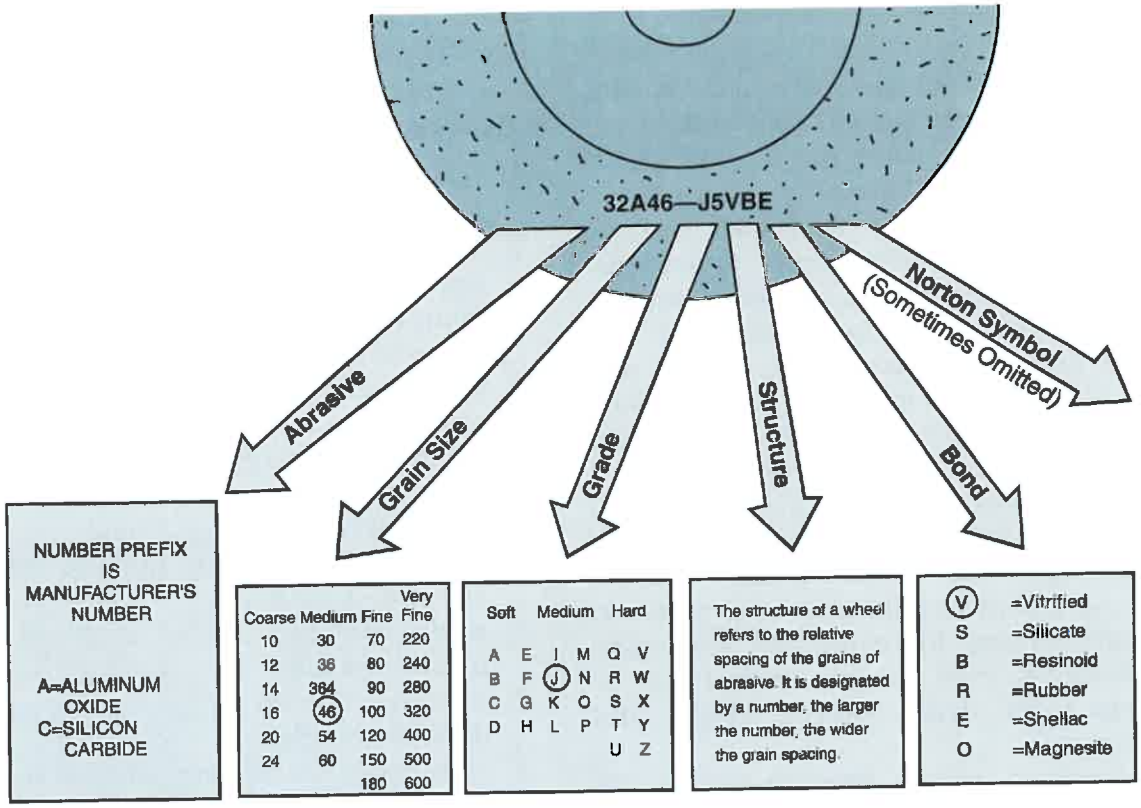



**Figure 30-19.** Grinding wheels are classified by a number of factors.

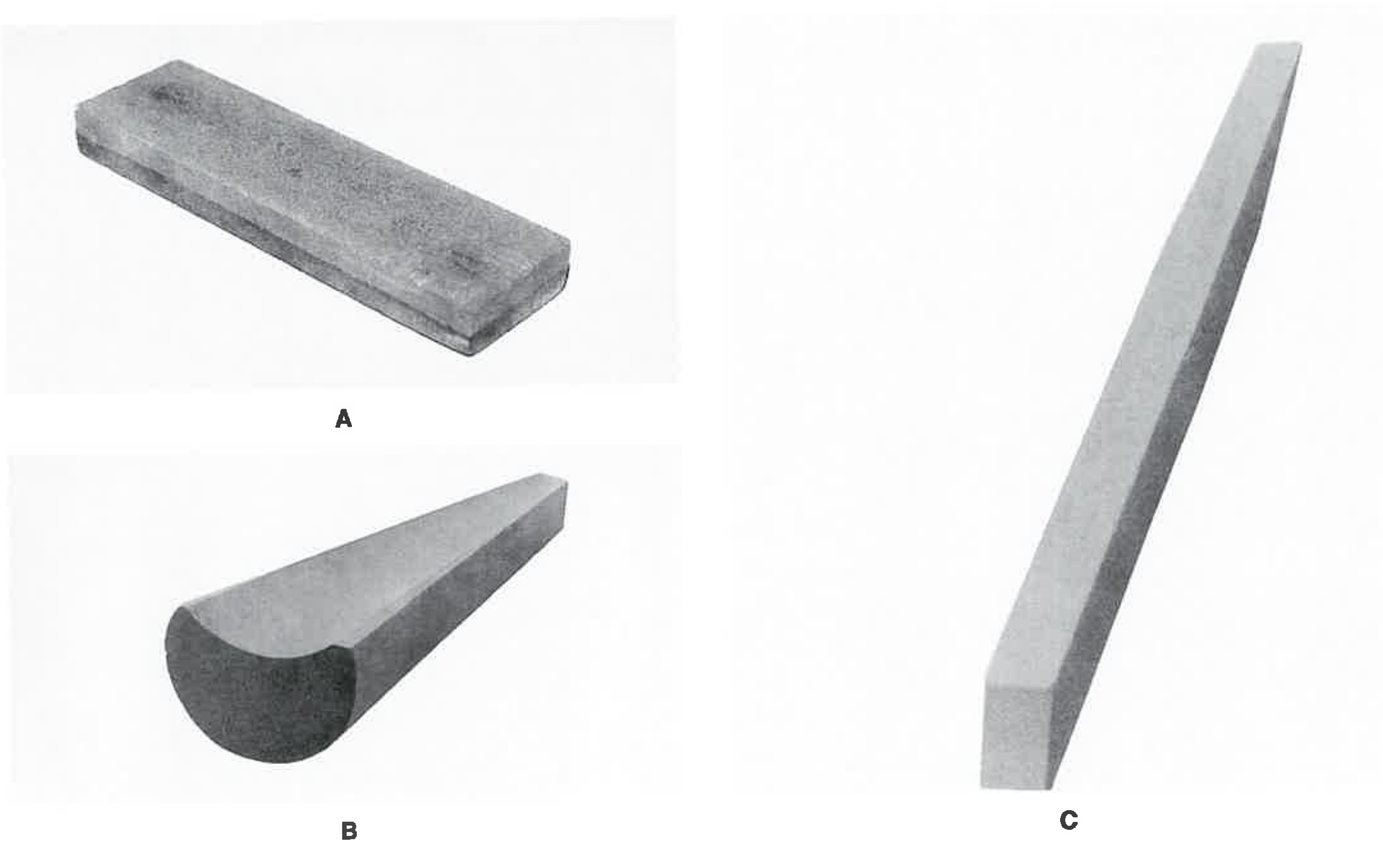



**Figure 30-20.** Stones. A—Bench, combination grit. B—Slip. C—File. *(Woodcraft Supply Co.)*

## Summary

Abrasives include tools and materials to smooth surfaces. Abrasive tools include files, steel wool, rasps, and screens. Products using abrasive grains include coated, solid, and loose abrasives. Abrasive grains may be natural or synthetic. Natural grains include, garnet, emery, pumice, rottenstone, and tripoli. Synthetic abrasives include aluminum oxide, silicon carbide, and industrial diamond.

Abrasive grains are sized by grit, powder, and flour sizes. Sizes from 16 to 220 are sifted through screens with varying hole sizes. Smaller sizes are floated in air or water to separate them.

Coated abrasives consist of a backing, two layers of adhesive, and the grains. Backings include paper, cloth, fiber, and a combination of paper and cloth. Adhesives include glues and resins, in varying combinations for make and size coats. Coated abrasives may be cut into sheets or formed into belts, disks, sleeves, blocks, and flap wheels.

Solid abrasives include grinding wheels and stones. Both are made by mixing abrasive grains in a bonding agent. The mixture may then be left to cure or heated in an oven for greater durability.

## Test Your Knowledge

*Do not write in this text. Answer the following questions on a separate sheet of paper.*

1. List six natural abrasives and a typical application for each.
2. List three synthetic abrasives and a typical application for each.
3. How do abrasive manufacturers separate the different size grains?
4. Smaller grain sizes are called _____ and _____ grades.
5. Name four types of abrasive backings.
6. The two coatings of adhesive when making coated abrasives are _____ and _____ coats.
7. Which of the following adhesive combinations is the most durable?
   a. glue over glue
   b. glue and filler
   c. resin over resin
   d. resin over glue
8. How might you identify an open coat abrasive as compared to a close coat abrasive?
9. Gravity and electrostatic coating are two methods of _____.
10. Why are coated abrasives flexed?
11. List the four methods of flexing coated abrasives.
12. Identify three common forms of coated abrasives.
13. Abrasive rolls that are narrower than 1/16″ are called _____.
14. Name five features by which you would select a grinding wheel.
15. List the three stone shapes.

31

# Using Abrasives and Sanding Machines

## Objectives

After studying this chapter, you will be able to:

- Inspect material surfaces to decide if abrading is necessary.
- Select abrasives by type and grit size.
- Use abrasives by hand.
- Operate various portable and stationary power sanding equipment.
- Inspect surfaces ready for product assembly or finishing.
- Maintain electrical and air-operated power tools.

## Important Terms

| | |
|---|---|
| abrading | platen |
| abrasive planer | portable belt sander |
| belt sander | portable disk sander |
| disk sander | portable drum sander |
| drum sander | random orbital action |
| finishing sander | sander/grinder |
| hand sander | spindle sander |
| in-line action | stroke sander |
| locking quill | table trunnion lock |
| orbital action | wide belt sander |

**Figure 31-1.** This assembled product is abraded with an in-line sander before applying finish. *(Porter-Cable Corp.)*

Smoothing with abrasives is the process of removing wood fibers to achieve a smooth, blemish-free surface. See **Figure 31-1.** The terms *abrading* and *sanding* are used interchangeably to describe the smoothing process. There are abrasive planers and sanding machines, such as the disk sander and belt sander. However, the term ***abrading*** is the most proper because coated abrasives are not covered with sand. Products other than coated abrasives will smooth a surface by abrading. A file is an example.

Abrading leaves scratches in the surface. The depth of the scratch is determined by the abrasive grit size or file's cutting edge. Abrading is done along the grain; thus scratches follow the grain and are less noticeable than those across the grain. By using successively smaller grit sizes, the scratches become even shallower. Eventually, you cannot detect grit marks in the wood. The surface is then ready to finish. Face and edge grain should need the least amount of abrading. End grain will require more effort.

## Inspecting the Wood Surface

Inspecting follows sawing, surfacing, shaping, and turning. These processes should bring workpieces to their final size. However, they usually leave marks that need to be removed. If sharp tools mounted on quality machinery are used for processing, this task is minimized.

You should inspect all surfaces before using abrasives. Look for any cuts, marks, or other wood defects, especially the following:

- Saw tooth marks.
- Rippled (washboard) effects left by jointers, shapers, and planers.
- Grooves caused by planing or scraping.
- Dents from dropping a tool or other object on the wood surface.

Small marks may not be detected at first. Hold the wood toward a light source and look across the surface. You will likely see scratches and dents you could not find before. A bare bulb incandescent light source is preferable to fluorescent lights for exposing scratches and dents.

## Selecting Abrasives

Select abrasives by grain type (natural or syntehtic), form, and grit size. Flint is rarely used because it lacks toughness and durability. Garnet, the most widely used natural abrasive, is for abrading softwoods and for finish sanding all wood types.

Abrasives come in several forms. When hand sanding, sheets are used. For production sanding, select the form (disk, belt, sheet, sleeve, etc.) that fits the sanding machine.

Syntehtic abrasives are more acceptable. Aluminum oxide is harder, tougher, cuts faster, and lasts longer than natural abrasives. It is excellent for smoothing hardwoods and for production sanding. Although not as hard as aluminum oxide, silicon carbide is used widely for portable belt sanders. Wet-or-dry, fine silicon carbide may be used with water or oil to abrade dry, finished surfaces.

## Abrading Process

Selecting the proper grit size is important. The correct grit will make considerable difference in the speed and quality of your work. For heavily marked surfaces, it is easier to use a sequence of abrasives from #80 to #120 to #180. For a planed surface, you might start with #150 paper, then use #180. Use a very fine (#220) paper last. Each finer grit size removes the marks of the abrasive before it. Depending on the wood species, the finish to be used and its application method, #150 may be the finest grit size to be used. Oak will accept stain better when the finest grit is #150.

Before using abrasive paper, you should have raised dents and removed saw marks. Dents are simply crushed wood cells. Open the cells in the dented area with steam. Place a damp cloth over the dent and apply heat with a medium hot iron. This will cause swelling of the wood cells. See **Figure 31-2.** Pencil marks should be removed with an eraser.

For saw kerf marks, a hand scraper is quicker. Then choose the first grit size abrasive (#80). After smoothing the surfaces as much as possible with it, go on to a finer abrasive.

Increase grit size by no more than two grade numbers at a time. After each grit change, remove dust with a tack cloth or air pressure. As you continue, using finer abrasives will polish the grain making it more visible.

**Figure 31-2.** Raise dents with steam created by applying a hot hand iron to a damp pad before abrading. *(Chuck Davis Cabinets)*

The entire surface must be abraded equally. Often the sections near corners receive less attention. This causes grain cloudiness; you cannot see the grain near the edges as clearly. A poor quality finish will result.

## Hand Sanding

You can make or buy tools for sanding by hand. Most manufactured ***hand sanders*** have a rubber or padded rectangular flat surface, **Figure 31-3.** You might also cut sanding blocks from a 3″ by 4″ (76 mm by 102 mm) block of wood. Avoid holding the abrasive with only your hand. This causes more sanding to be done under the fingertips. However, you can use just your hand for contoured surfaces or in areas difficult to reach.

Tear a 9″ by 11″ (229 by 279 mm) sheet into fourths, thirds, or halves to fit the portable sander or wood block. Use a steel bench rule or hacksaw blade jig. See **Figure 31-4.** Insert the paper into the hand sander clamps or fold it over the edges of the sanding block.

Even though working across the grain seems faster, sanding should be done *along the grain.* See **Figure 31-5.** Abrasive marks made across the grain are extremely hard to remove.

**Caution**

Be careful when abrading plywood and other veneered surfaces. It takes little effort to go through the thin veneer.

When sanding end grain, it is a good idea to place scrap wood on each side of the workpiece. See **Figure 31-6.** This prevents tilting the sander at the edge of the lumber, causing chamfers. Contours can be sanded by using a contoured sanding block or strips of abrasive. See **Figure 31-7.**

## Stationary Power Sanding Machines

There are many types and sizes of stationary sanding machines. Some are designed for mass production of furniture parts. Others have applications for small cabinet shops and the home cabinetmaker. The most common are belt sanders, disk



**Figure 31-3.** Hand sanders. A—This sander holds 1/3 of an abrasive sheet over a felt pad. B—One-quarter sheet hand sanders are more common. *(Red Devil)*

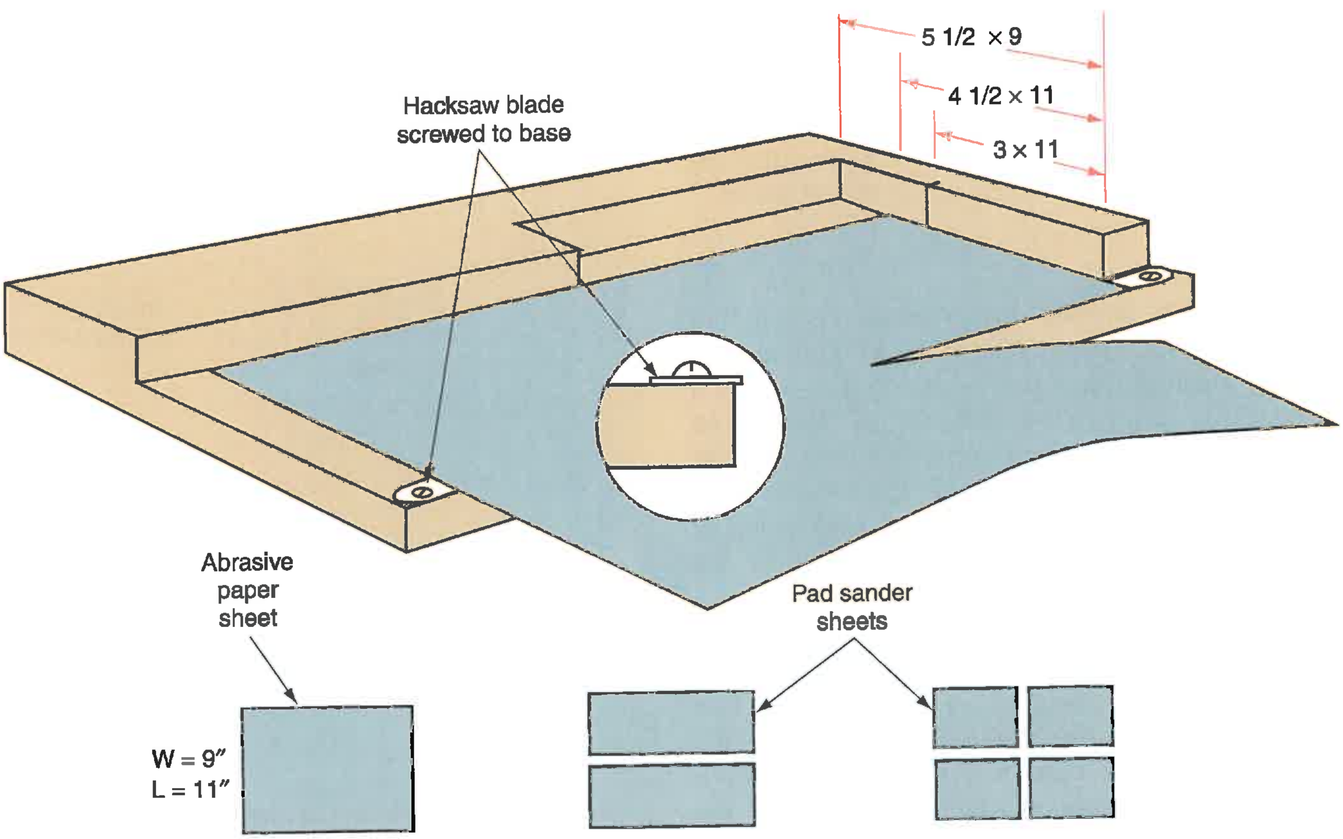



**Figure 31-4.** Prepare a jig to tear abrasive paper. Mark standard sheet sizes.

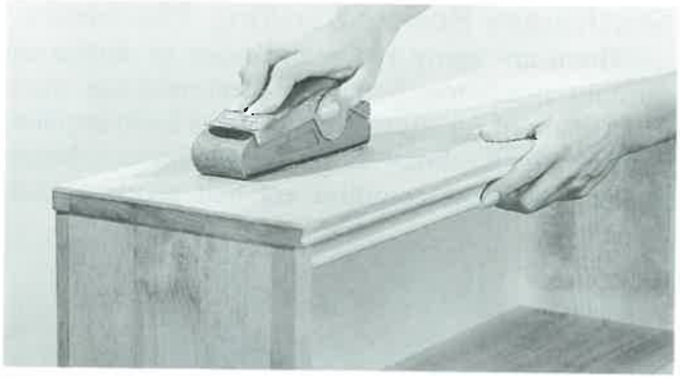


Figure 31-5. Sanding along the wood grain makes abrasive scratch marks less visible. *(Norton Co.)*

Figure 31-6. Use C-clamps to secure scrap wood when sanding end grain.

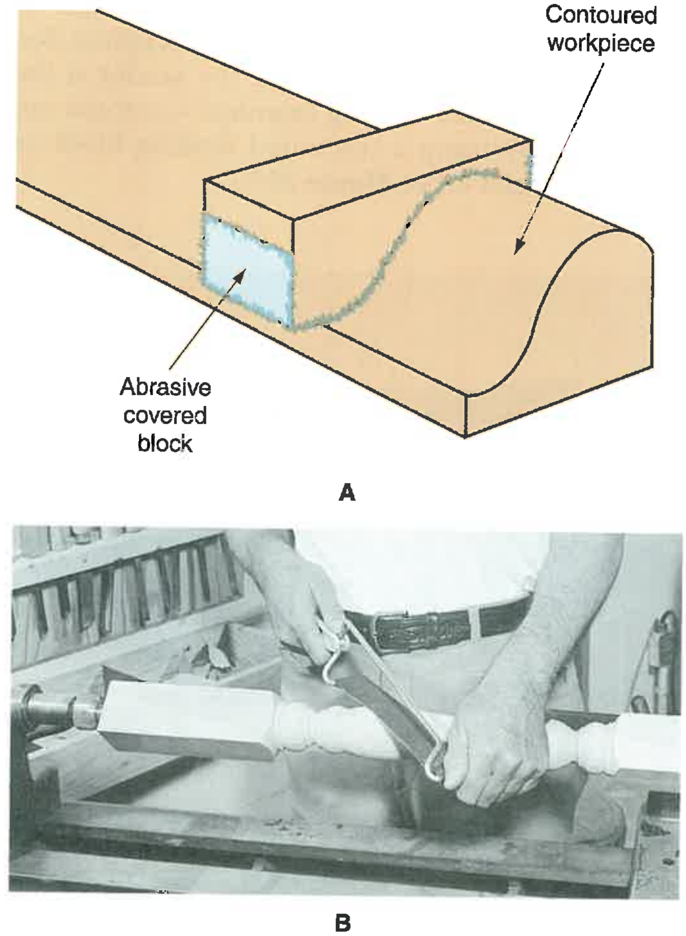



Figure 31-7. A—Make a contour block to sand moldings, trim, and other curved surfaces. B—Strips of abrasive used by hand or in a bow sander work well with turned pieces. *(Glit, Inc.)*

sanders, spindle sanders, arbor mounted drum sanders, wide drum sanders, and abrasive planers. Each requires a different form of coated abrasive.

## Belt sander

**Figure 31-8** consists of a 6" abrasive belt that travels over two drums. A flat 6" by 15" (152 mm by 381 mm) steel platen is behind the belt to assure a flat sanding surface. The belt can be tilted from vertical to horizontal. See **Figure 31-9.** The end cap can be removed for special operations. See **Figure 31-10.** Some machines have fences along or across the belt. Other machines provide for additional widths of abrasive belts.

### Adjusting table and belt angles

Changing the position of the abrasive belt requires loosening the ***locking quill.*** Adjust the angle of the belt and tighten the quill. To adjust the table, loosen the table trunnion lock and tilt the table to the desired angle. Tighten the trunnion lock firmly. Set table and belt angles using a T-bevel.

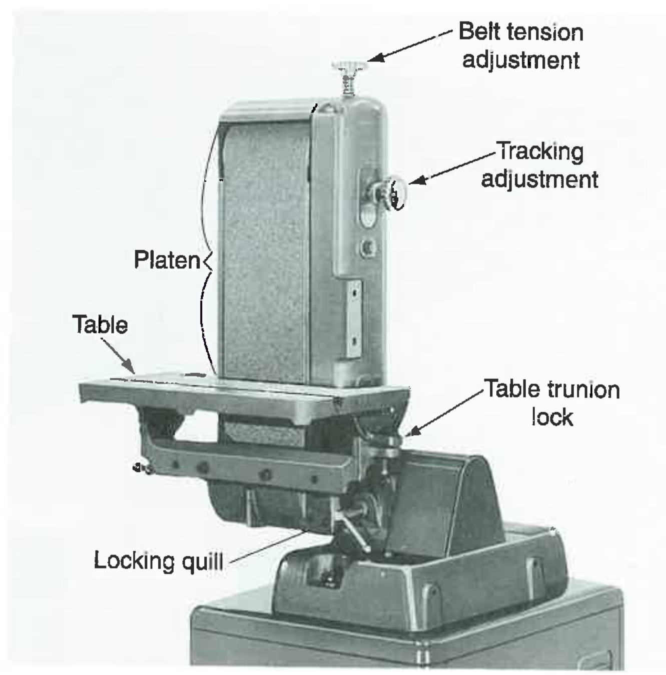
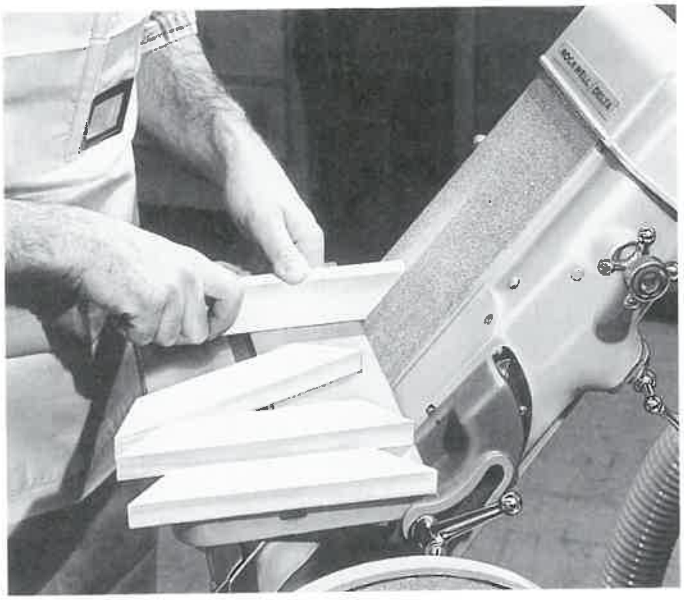



Figure 31-8. Locate adjustment levers and knobs on your belt sander. *(Powermatic Houdaille)*



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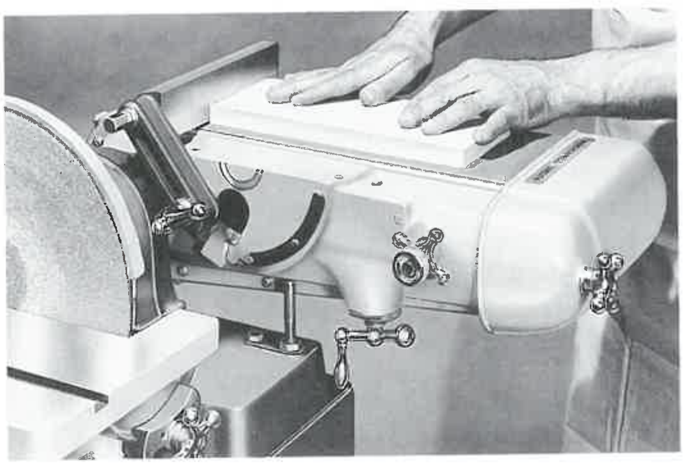

B

**Figure 31-9.** Tilt the belt sander table for convenience. A—Smoothing miter cuts. B—Smoothing surfaces. The table keeps your work positioned on the abrasive. *(Delta International Machinery Corp.)*

## Installing belts

Turn off the switch and disconnect electrical power before servicing any machine. Remove the end cap guard and side panel. Loosen the idler drum adjusting screw to release belt tension. Slide belt over drums. Be sure belt is mounted properly—arrow printed on belt indicates direction of motion. Tighten the drum adjusting screw to increase belt tension. Rotate the belt with your hand to check tracking. The belt should stay centered on the drums. If not, turn the tracking adjusting screw either direction until tracking is correct. Reinstall guards and restore electrical power. Recheck tracking when you first turn on the machine. If the belt moves off-center, reset the drum adjusting screw.

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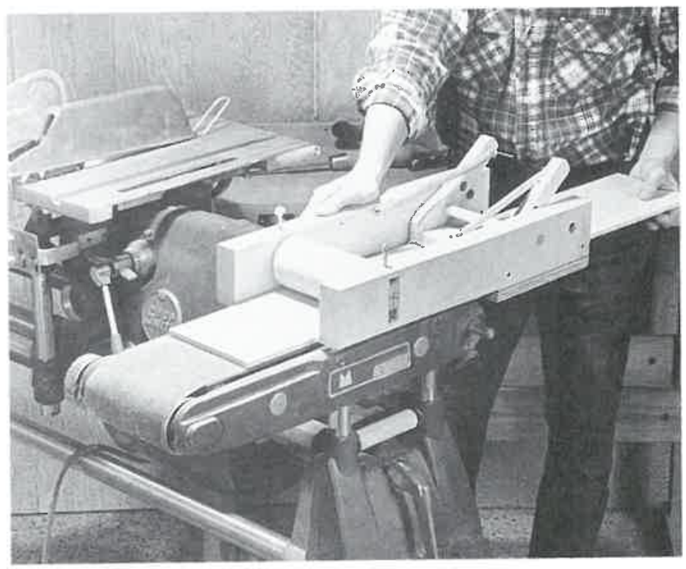

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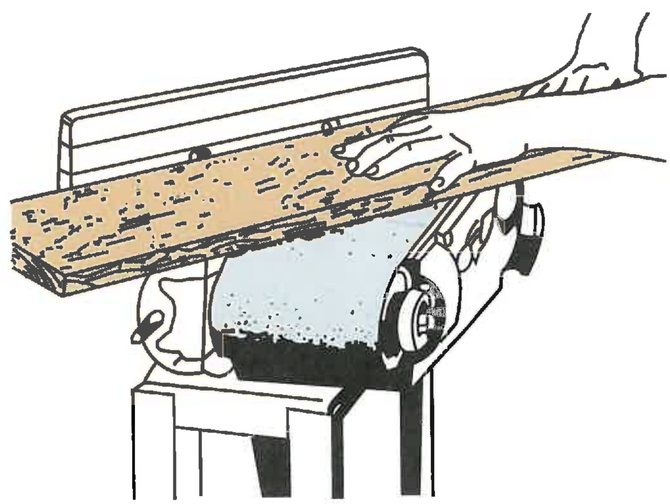
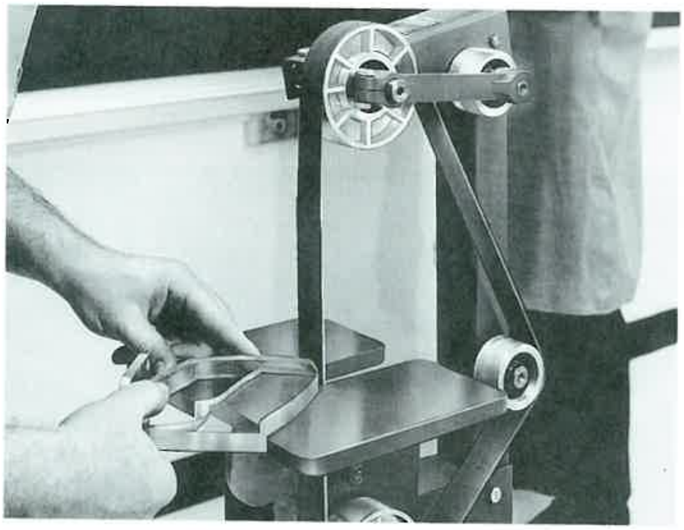


C

**Figure 31-10.** Some belt sander tables and end caps can be removed. A—Using the top drum to smooth contours. B—Both the end cap and table are removed to use the abrasive planer jig. *(Shopsmith)* C—When necessary, smooth wide boards by tilting the table angle while the belt is horizontal. Scratches made across the grain can later be removed with some difficulty with a finishing sander.

### One inch belt sander

The 1″ (25 mm) belt sander, also called a ***sander/grinder,*** is for sanding small workpieces. The table will tilt to sand bevels. You can use it on outside as well as inside surfaces, **Figure 31-11.** You must alter belt roller positions when you make this change. Belts from 1/8″ to 1″ (3 mm to 25 mm) will fit.



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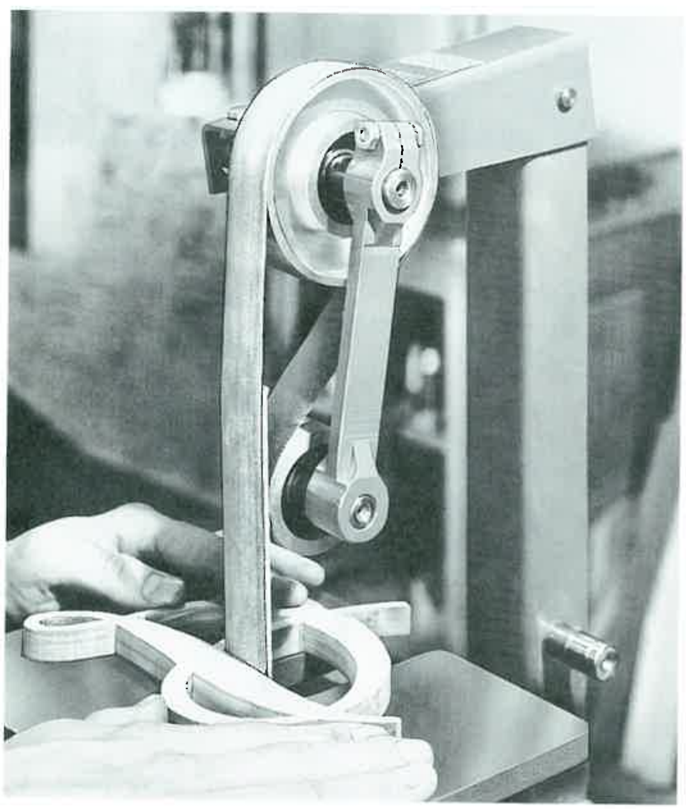


B

**Figure 31-11.** A—The 1″ (25 mm) belt sander is useful for small workpieces. B—By adjusting the idler wheel, the sander can be used for inside surfaces. *(Delta International Machinery Corp.)*

## Disk sander

The ***disk sander*** is used for smoothing edge and end grain. See **Figure 31-12.** The table can be adjusted for bevels. A miter gauge fits in the table slot to guide workpieces with angled surfaces.

### Installing abrasive disks

The abrasive disk bonds to a metal sanding machine disk with pressure sensitive, nondrying adhesive. Worn abrasive disks can be peeled off. Clean off any dirt or old adhesive from the metal disk. New disks often come with an adhesive backing. Remove the protective plastic cover and press the disk in place. If the disk does not have a coating, then stick or liquid adhesive must be applied to the metal before mounting the abrasive disk.

### Using the disk sander

*Only use the half of the disk that rotates downward.* The other half throws chips and dust upward. Keep the workpiece moving along the disk to prevent heat buildup. Heat reduces disk life and causes the wood to burn. Set table angles with a square or T-bevel as needed. A miter gauge guides workpieces at the proper angle to the disk. A clamp assists working with larger components. See **Figure 31-13.**

## Spindle sander

***Spindle sanders*** have a rotating and oscillating spindle. See **Figure 31-14.** The spindle turns and

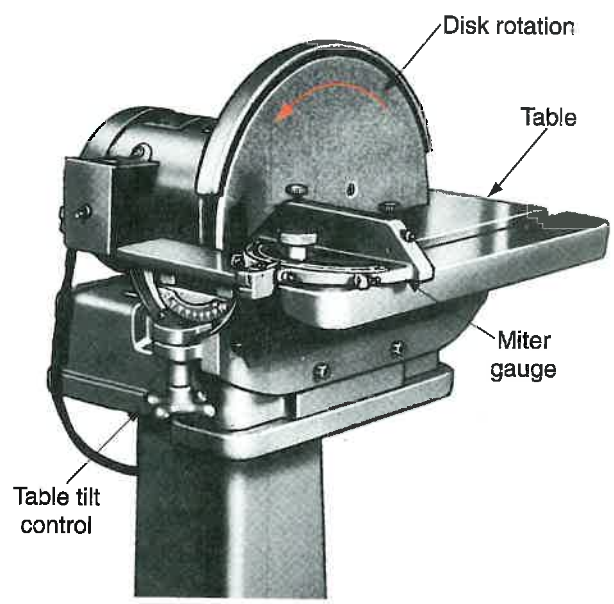



**Figure 31-12.** Locate table adjustment controls and rotation of the disk before using the disk sander. *(Powermatic Houdaille)*

moves up and down. This allows more of the abrasive sleeve to be used and provides faster (more aggressive) stock removal.

This machine is primarily used to sand the edges of irregular curves. Different diameter spindles accommodate small and large curved workpieces.


**Figure 31-13.** By using a miter gauge and a tilting table, many different workpieces can be abraded. *(Delta International Machinery Corp.)*

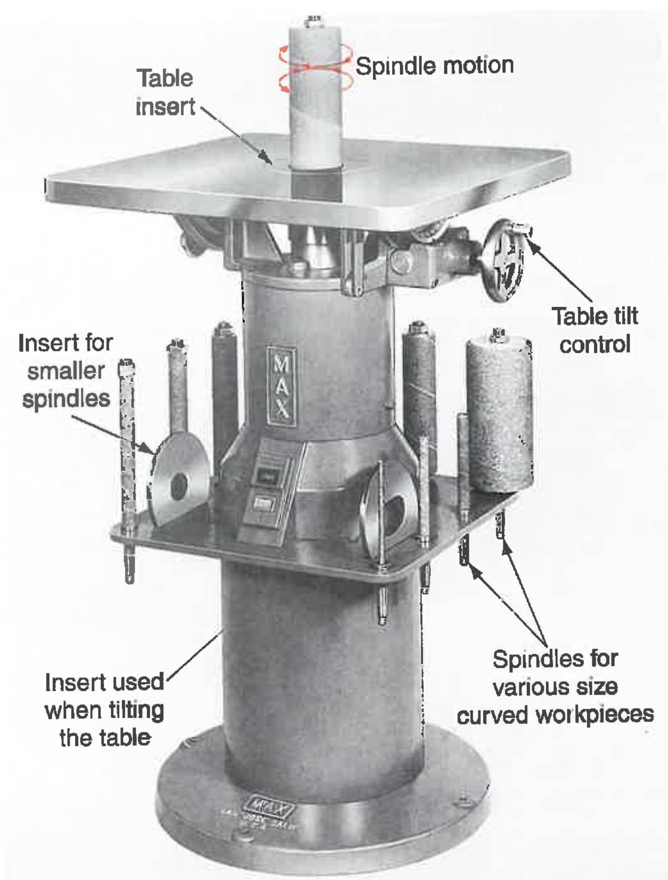



**Figure 31-14.** The spindle sander smoothes irregular curves. Install the largest spindle size and table insert to fit the workpiece. *(Brodhead-Garrett)*

Change table inserts when a different size spindle is installed. The insert supports workpieces near the spindle. The insert opening is oval so that the table can be titled without rubbing against the abrasive.

Abrasive paper for spindle sanders may be sheet or sleeve form. Sheet abrasive is attached in a spindle slot and held by turning a key. For abrasive sleeves, loosen the nut on the top of the spindle. Slide the sleeve on the spindle. Tighten the nut only enough to keep the sleeve from slipping. (The rubber drum expands as you tighten.)

To use the spindle sander, choose the proper size spindle. Use the largest one possible because you get more abrasive action per revolution. Hand tighten it in the machine. Then adjust the table angle and place the proper table insert. While sanding, keep the workpiece moving to prevent burning.

## Drum sander

***Arbor-mounted drum sanders*** work similarly to spindle sanders. However, drum sanders do not have an oscillating motion. Workpieces are held by hand and moved back and forth across the abrasive. See **Figure 31-15.**

Some drums are inflated. These consist of a metal housing with a rubber tube and canvas jacket. The sleeve abrasive slips over the jacket. Then the tube is filled with air. Varying the air pressure allows the drum to conform more to the workpiece contour.

## Wide drum sanders and abrasive planers

Compared to arbor-mounted drum sanders, wide drum sanders bring added function to small- and medium-sized shops. Open end models, used for light-

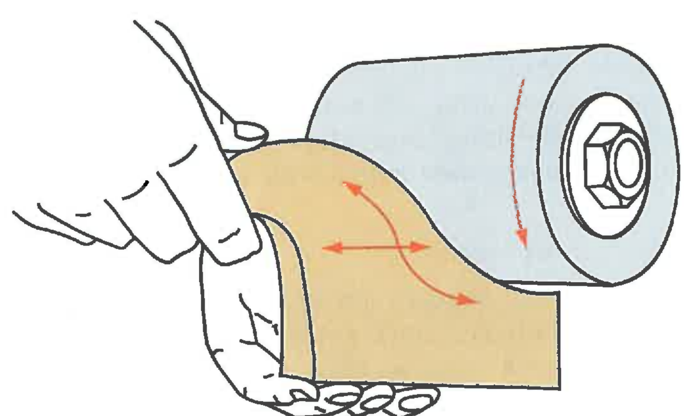


**Figure 31-15.** Move workpieces across the arbor mounted drum to obtain good abrasive action and prevent clogging (loading) the abrasive.

duty purposes, can surface material twice as wide as the drum is long by making two passes. See **Figure 31-16A.** Stock up to 3″ (76 mm) thick may be surfaced. Minimum thickness is 1/64″ (0.4 mm). Unlike knife-type planing machines, the wide drum sander can abrade workpieces as short as 2½″ (57 mm).

## Abrasive planers

***Abrasive planers*** are an alternative to knife-type planing machines. The abrasive does not tear grain around knots, burls, and reverse grain. It also eliminates planer skip, chatter, grain tear out, and wavy dressing.

***Wide drum sanders*** may be used as abrasive planers. Install #36 grit abrasive strips. Two drum models can remove material faster. See **Figure 31-16B.** The second drum is independently adjustable relative to the first. Surface rough-sawn stock with coarse grit on both drums. Later, combine grits to perform either course and medium, or medium and fine sanding in a single pass.

A typical problem when abrasive planing rough lumber is that the stock may vary wildly in dimension—cupped or warped. Refer to *Figure 11-14.* The wide drum sander in **Figure 31-16B** is equipped with an electronic display for accurate dimensioning. The machine's automatic control decreases the feed rate when the load on the drum motor increases. When the *problem area* has been passed, the feed rate returns to normal.

Abrasive planers may use wide abrasive belts. See **Figure 31-17.** Some wide belt abrasive planers surface both sides of the stock in a single pass. A self-centering feature assures that equal amounts are removed from both sides. See **Figure 31-18.**

Machine capacity of wide belt abrasive planers may vary from 13″ to 64″ (330 mm to 1626 mm). Thicknesses from near 0″ to 5½″ (140 mm) can be planed. Abrasive planers use 20, 24, or 36 grit sizes. These coarse grits will not produce a surface suitable for finishing. Secondary sanding is required, and is usually done with a wide belt sander.

## Wide belt sanders

Wide belt sanders are very similar to abrasive planers. Both feed stock automatically into abrasive belts for stock removal. However, wide belt sanders produce a finished surface only on one side. See **Figure 31-19.** The stock must then be turned over, if both sides require sanding.

Wide belt sander heads use contact rollers and/or platens to hold the belt against the stock. Contact rollers are used for aggressive sanding with coarser abrasives. The platen is for flat polishing and holds a thickness tolerance within 0.007″. Typically, a contact roll is used on the first head. It has a grit size from 50 to 120. A platen is used on the second head with 120 to 220 grit abrasive. See **Figure 31-20.** Three- and four-head sanders are available. These surface rough lumber to finished size in one pass.


A


B

**Figure 31-16.** Wide drum sanders. Use dust collectors with these machines. A—Open end single drum model. B—Two drum model with hood open to show abrasive strip. *(Performax Products, Inc.)*

## Setting up abrasive planers and wide belt sanders

Before servicing machinery, turn off the switch and disconnect electrical power. Then remove guards covering the abrading heads. To remove an abrasive belt, release the belt tension. Tension may be set mechanically (a screw mechanism) or with air pressure. Remove the old belt. Slip the new belt over the contact rollers or platen and reset the tension. Reinstall guards and connect electrical service. Tracking may then have to be set. Tracking assures that the belt remains centered on the rollers. A belt that travels to one side can be ruined. Tracking must be set manually while the machine is running. Some machines automatically set tracking by sensing the position of the belt.

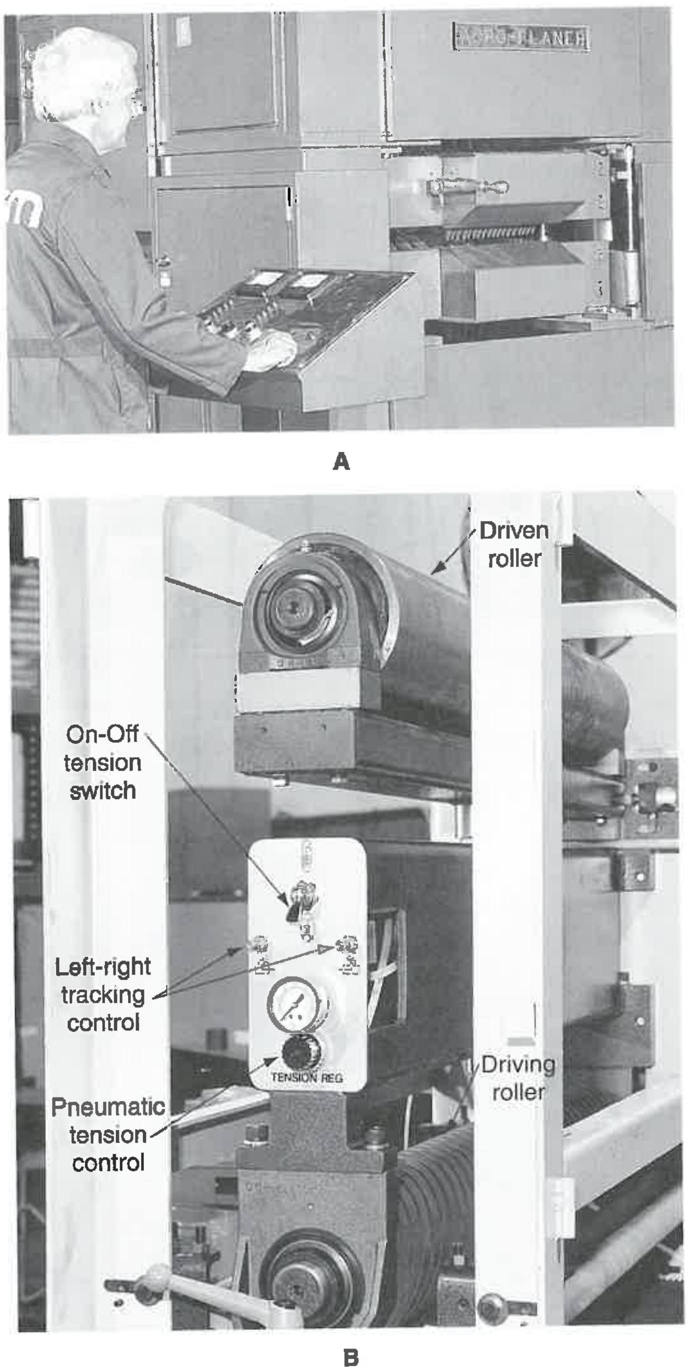



Figure 31-17. A—The abrasive planer heads are enclosed in a large guarding and dust collection enclosure. B—The planer head has tension and tracking controls. The abrasive belt is placed over the two rollers. *(Abrasive Engineering and Manufacturing Inc.)*

## Operating abrasive planers and wide belt sanders

The depth of cut set depends on the type of machine and number of heads. The maximum cut for most abrasive planers and single head sanders is 1/4" (6 mm). However, check the machine operating manual for accurate cut depths according to abrasive grit size. Three- and four-head machines can surface and smooth rough lumber. These single-pass machines are set according to the desired final thickness.

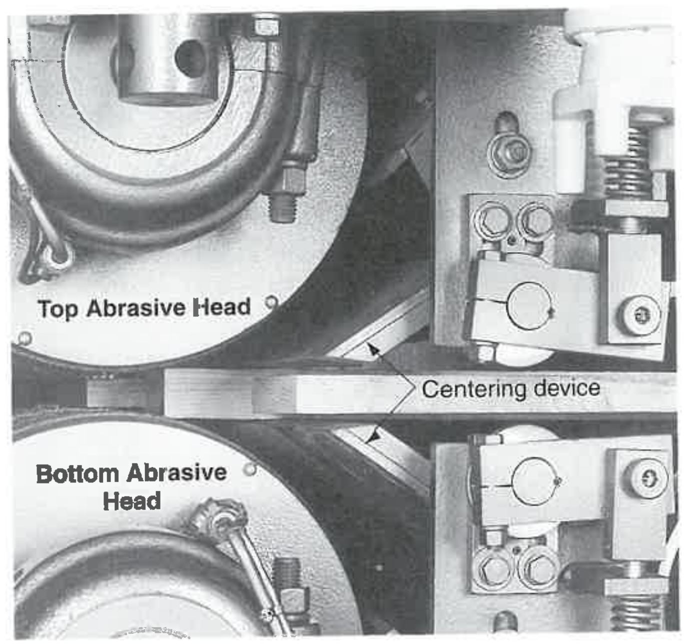



**Figure 31-18.** The self-centering device positions lumber equally between abrasive heads. *(Timesavers, Inc.)*

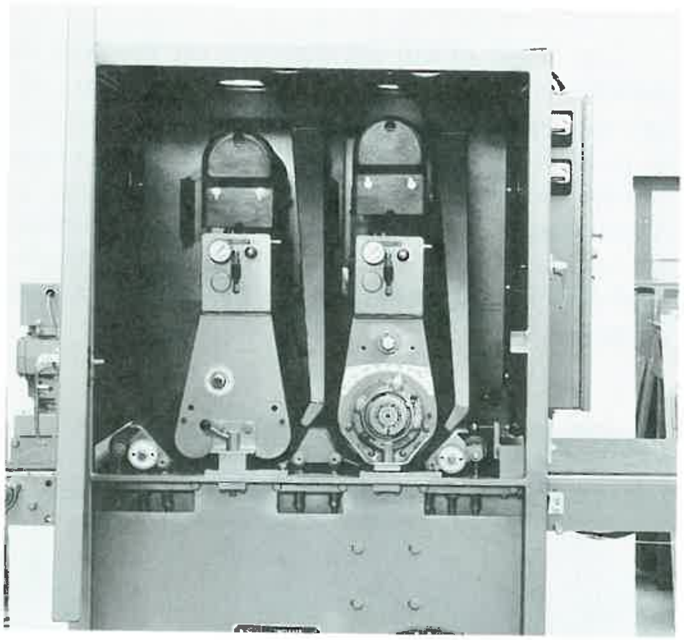
**Figure 31-19.** Wide belt sanders typically smooth only one surface at a time. *(Timesavers, Inc.)*

A feed belt draws stock into the abrasive heads. The operator should support the workpiece as it exits the outfeed side of the table.

## Stroke sander

The ***stroke sander*** is an abrasive belt sander for smoothing large surfaces. See **Figure 31-21.** It has a movable table under a long belt suspended between two pulleys. With one hand, you hold a pad over the belt and against the workpiece surface. The other hand controls table movement.

To use the stroke sander, place the workpiece on the table with the grain direction in line with the belt. You can smooth the surface by moving the table slowly toward or away from you with the pad in one place. Moving the table too fast will produce cross grain scratches. A second method is to move the pad along the length of the workpiece without moving the table. Then position the table to the next section to be smoothed.



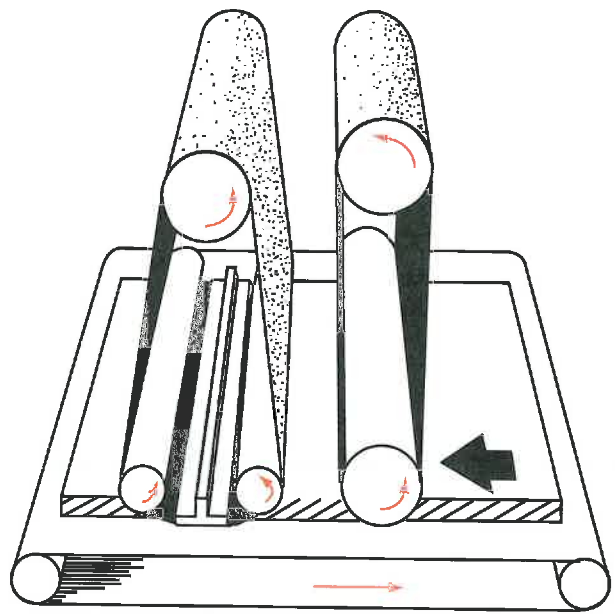


**Figure 31-20.** Double head sanders generally have both a platen and contact roller. The roller does the initial smoothing while the platen completes the surface. *(Timesavers, Inc.)*

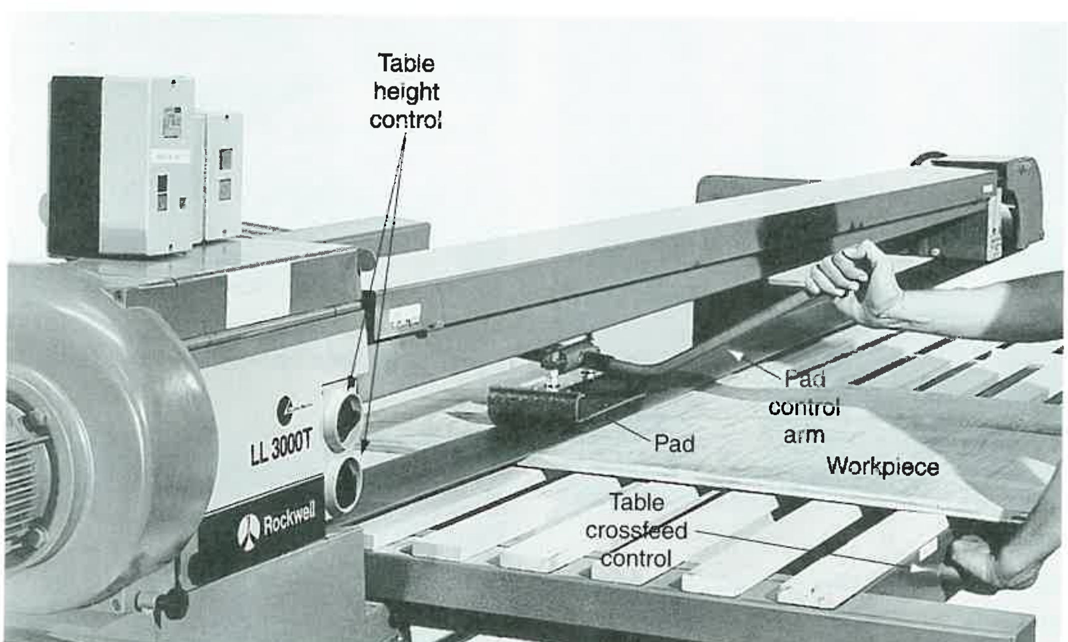



**Figure 31-21.** Large, flat surfaces can be smoothed with the stroke sander. *(Delta International Machinery Corp.)*

## Portable Sanding Tools

Portable sanding tools are commonly used when stationary equipment is not available. They are also used for small workpieces. Portable machines may be powered by electricity or compressed air. They are handy to use when preparing for the assembly finish. Portable sanding tools include the portable belt sander, portable finishing sander, portable disk sander, and portable drum sander.

### Portable belt sander

***Portable belt sanders*** are very similar to stationary belt sanders. They are sized according to belt width and length. Belt sizes range from 2″ to 4″ (51 mm to 102 mm) wide and 21″ to 27″ (533 mm to 686 mm) long. A dust collection bag is attached to the machine. See **Figure 31-22.** Portable belt sanders are used to cut scribe lines where cabinets or countertops meet the wall. In this case, use #36 belts and move back and forth rapidly. To install or replace belts, proceed as follows:

1. Disconnect power to the machine.
2. Place the movable pulley in the locked position to relieve belt tension. This is typically done with a lever on the side or inside the belt loop.
3. Remove the worn belt and slide the new belt over the pulleys. Look for the arrow printed on the belt. It must be pointed in the direction the belt will move.
4. Align the belt even with the end of the pulley.
5. Release the locking mechanism to restore belt tension.
6. Reconnect electrical service after making sure the trigger switch is in the off position.
7. Hold the sander so the belt is not against any surface.
8. Turn the machine on with the trigger switch. (Do not engage the trigger lock button.) The belt should remain aligned with the pulleys. If it moves off center, adjust the tracking knob located on the side of the sander. Turn it until the belt remains centered.
9. Release the switch and place the machine down after the belt stops coasting.

When using the belt sander, use care when you engage the trigger lock mechanism. If you lose grip of the sander, it will move rapidly across the workpiece and might be damaged after falling from the workbench. The trigger lock may also be used when the machine is mounted under a stand. In this manner, you can use it as a stationary machine. To operate the sander, proceed as follows:

1. Lift the sander above the workpiece.
2. Start the machine.
3. Lower the machine on the workpiece. Place it carefully and evenly onto the surface. The belt should run in the direction of the grain.
4. Keep the sander moving in overlapping strokes as shown in **Figure 31-23.**
5. To smooth the outer edges, allow the belt to extend beyond the edge slightly. Make sure the sander doesn't tilt.
6. After smoothing the entire surface, lift the sander off the surface; then turn it off.
7. Change to finer abrasive belts as necessary.

Belt sander manufacturers know the weight of the machines. That weight is sufficient pressure for the sander to operate efficiently. All the user should do is guide the machine. Downward pressure can slow belt movement, overheat the machine, and possibly cause damage. It can also gouge the wood.

**Figure 31-22.** Portable belt sanders are commonly used abrading tools. *(Makita U.S.A., Inc.)*

**Figure 31-23.** Move the belt sander in short overlapping strokes. Check the tracking for proper adjustment before and while using the tool. *(Chuck Davis Cabinets)*

## Finishing sander

*Finishing sanders* are used with fine abrasives to prepare workpieces for finish or to smooth between finish coats. They are not designed for removing saw marks. The sander is held by hand. The abrasive is attached to a pad. The pad moves in an in-line, orbital, or a random orbital motion. Finishing sanders that use sheet abrasives are generally in-line or orbital, while finishing sanders that use disks are generally random orbital.

### In-line finishing sander

*In-line finishing sanders* move the abrasive back and forth in a straight line. See **Figure 31-24.** Scratches blend with the direction of the grain. These sanders are used just before finish is applied.

### Orbital finishing sander

*Orbital action finishing sanders* move the abrasive in a 3/32″ (2 mm) circular motion. See **Figure 31-25.** This action removes wood quickly, but leaves circular scratches across the grain. They must be removed by hand sanding or by using an in-line finishing sander. *Orbital action* is practical where grain direction is not a factor. One example is abrading successive coats of built-up finish. Orbital action tends to smooth brush marks and spray overlap.

Orbital sanders may accept ¼, 1/3, or ½ of a regular 9″ by 11″ (229 mm by 279 mm) sheet. The abrasive is held against the sanding pad by two clamps or two screws. For faster access to unused abrasives, place multiple sheets on the machine when reloading, then simply tear off the worn sheet to expose the next abrasive sheet.

### Random orbital finishing sander

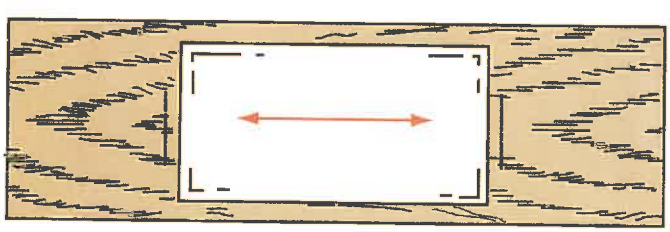
Finishing sanders may aggressively remove material from the workpiece with a ***random orbital action.*** The action is virtually swirl free.

Disks for random orbital finishing sanders are generally hook and loop attachment. See **Figure 31-26.** Some abrasive disks have pre-applied pressure sensitive adhesive (PSA). Just remove the protective cover and press the abrasive in place.

## Disk sander

*Typically portable disk* sanders typically are used when the grain will be hidden or appearance does not matter. The circular motion of the disk

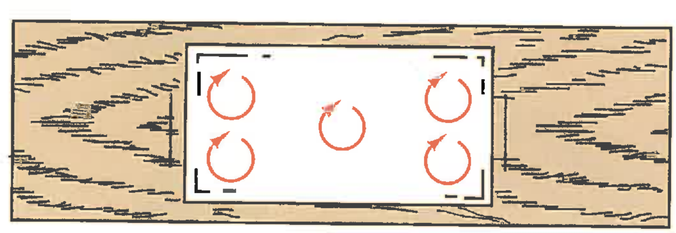
A



B

**Figure 31-24.** A—In-line finishing sanders prepare surfaces for finish. *(Makita U.S.A., Inc.)* B—The in-line motion abrades along the grain pattern.


A



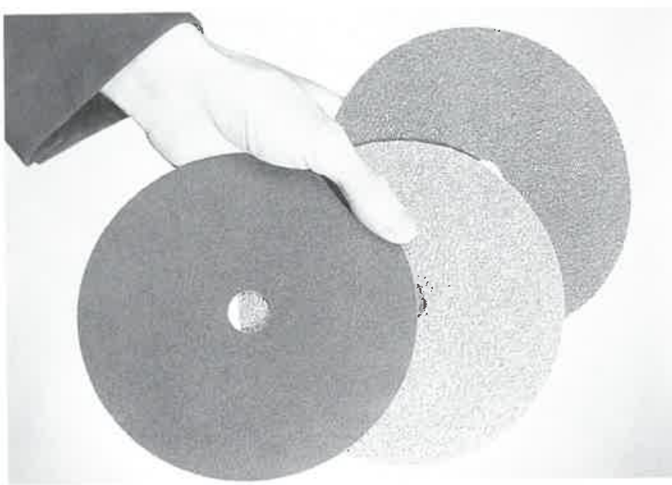
B

**Figure 31-25.** A—Orbital sanders may leave swirl marks. *(Chuck Davis Cabinets)* B—Marks are less noticeable when only the weight of the machine is used.

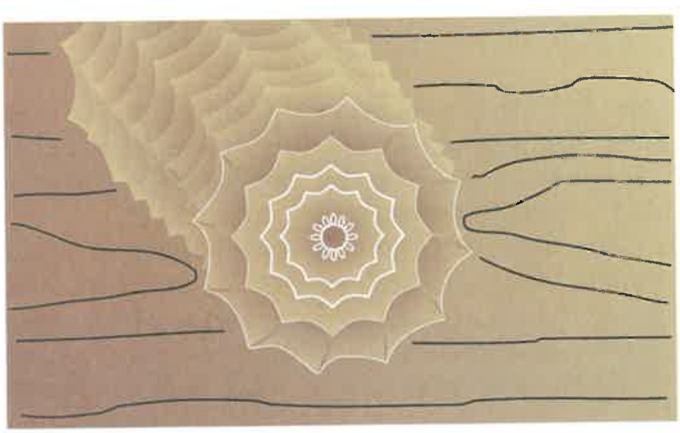
leaves swirling scratches that are difficult to remove. See **Figure 31-27.** Scratch size is determined by the disk radius where contact occurs. Usually, you use this machine on surfaces to be painted. When clear finish is to be applied, use belt and in-line finishing sanders.

## Profile sander

***Portable profile sanders*** provide an in-line motion to remove the machining marks on concave, convex, or flat profiles. These extremely versatile machines have a variety of pads, profile holders, and profiles. Select the sanding pad or profile holder that fits the job at hand. The pads and profile holders are aligned to the machine by two posts and a latch button. Pads may be used with either precut PSA abrasives or precut hook and loop abrasives. Profiles use pieces cut from 2½″ (64 mm) rolls of PSA abrasives. Available abrasives range from 80 to 220 grit.



A



B

**Figure 31-26.** A—Abrasive disks are used on random orbital finishing sanders. *(Chuck Davis Cabinets)* B—Ultra fine, swirl free finishes result from aggressive stock removal.

When fitted with a concave profile, convex edges of moldings and tabletops may be quickly smoothed. See **Figure 31-28A.** Concave profiles are available in radius dimensions from 1/8″ to 5/8″ (3 mm to 16 mm).

For the convex portions of the workpiece, slip in a concave profile and smooth the like-shaped portions. See **Figure 31-28B.** Convex profiles are available in radius dimensions from 1/8″ to 5/8″ (3 mm to 16 mm).

The pointed tip on a diamond shaped pad is used for sanding flat surfaces into corners and other intricately shaped areas. See **Figure 31-28C.**

The machine is to be guided over the workpiece with one hand. Do not put additional pressure on the machine. Let the sander do the work.

## Drum sander

***Portable drum sanders*** compare with stationary horizontal arbor mounted drum sanders. However, portable units are more versatile. They may be powered by electricity or compressed air. Drums are either solid rubber or inflated to hold the abrasive in place. They may be hand-held or inserted into portable power drills. See **Figure 31-29.**

# Adapting Machines for Abrading

Certain power equipment can be fitted to become an abrading tool. Three of these are the radial arm saw, drill press, and lathe.

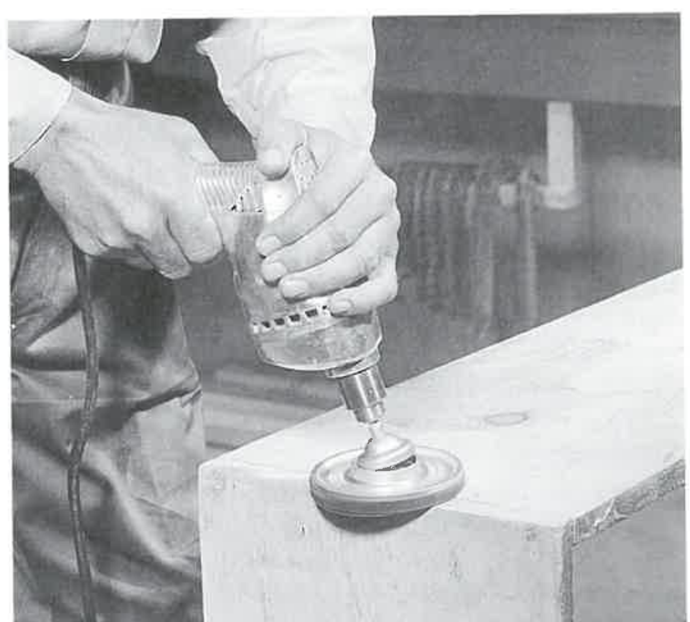


**Figure 31-27.** Use disk sanders when the surface will be hidden. *(Norton Co.)*

A B C

**Figure 31-28.** Profile sander. A—The convex edge of this drawer finger pull is smoothed. B—A quick change of pad, and the sander is smoothing the concave groove. C—The pad has been mounted for sanding into corners on this flat panel door. *(Chuck Davis Cabinets)*

A B C

**Figure 31-29.** Portable drum sanders. A—Inflatable drums used with a portable drill. B—Hard rubber drums used with a portable drill. *(The Fine Tool Shops)* C—Air-operated inflatable portable drum sander. *(Elstrom, Carlson)*

You can buy disk and drum attachments to fit in a radial arm saw. To use the drum, you should raise the table surface around it. See **Figure 31-30A.** This permits use of the full length of abrasive. You could also clamp a board next to the drum. See **Figure 31-30B.** The radial arm saw disk is excellent for smoothing at various angles. See **Figure 31-30C.** Make sure you have a fence behind the workpiece. Otherwise, the wood might be thrown.

The drill press is often used for drum sanding. You can insert a piece of abrasive paper attached to a wood dowel in the chuck. See **Figure 31-31.** Like the radial arm saw, you should clamp a scrap piece of wood to the table. Cut a hole in it just larger than the dowel. Raise the table so the dowel fits in the hole. Flap wheels are also used with a lathe or drill press. See **Figure 31-32A.** The wheel is made of many thin strips of abrasive. See **Figure 31-32B.** It is used to smooth contours.

The lathe can be used as a horizontal drum sander. Turn a hardwood cylinder and attach an abrasive sheet to it as shown in **Figure 31-33.** Make sure to secure the wedge tightly.

Some band saws can be used as belt sanders. Use the procedures in the machine's operating manual to install the necessary accessory. See **Figure 31-34A.** Sanding is very rapid. To avoid ridges, be sure to keep the workpiece moving at an even pace. Set the machine to the desired tilt for bevels. See **Figure 31-34B.**

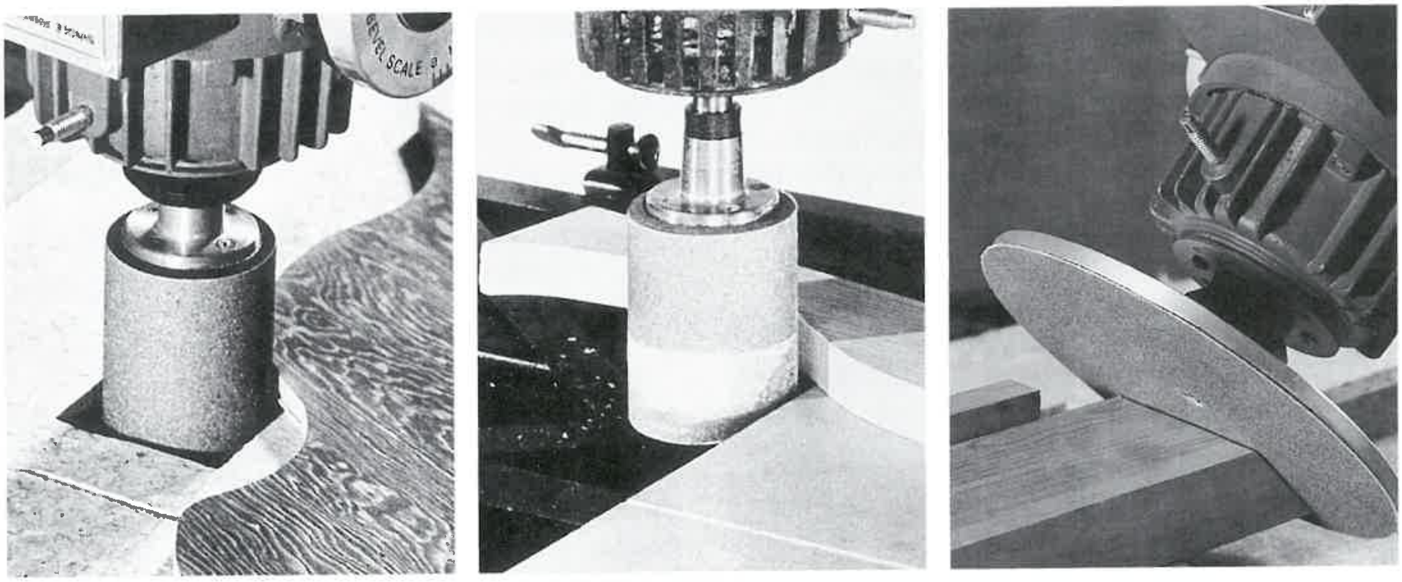



Figure 31-30. A—Two pieces of particleboard raise the table surface when using a radial arm saw as a vertical drum sander. B—The raised table surface allows the drum to pass below, allowing more usable abrasive surface. C—A disk accessory changes the radial arm saw into a disk sander. *(DeWalt)*

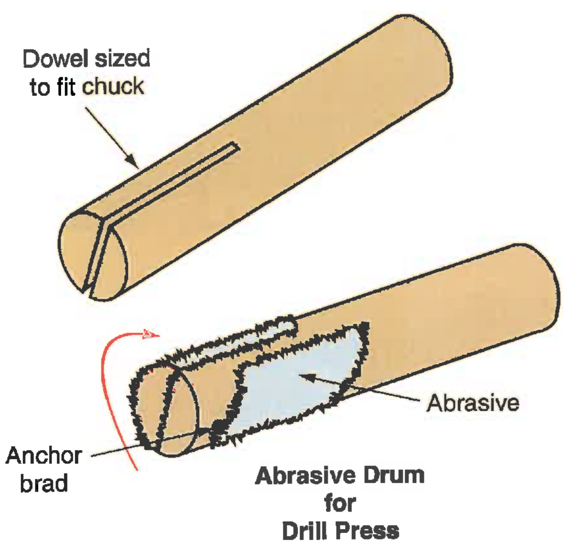



**Figure 31-31.** Slit a dowel with a band saw to make an abrasive drum for the drill press.

## Abrasive Tool Maintenance

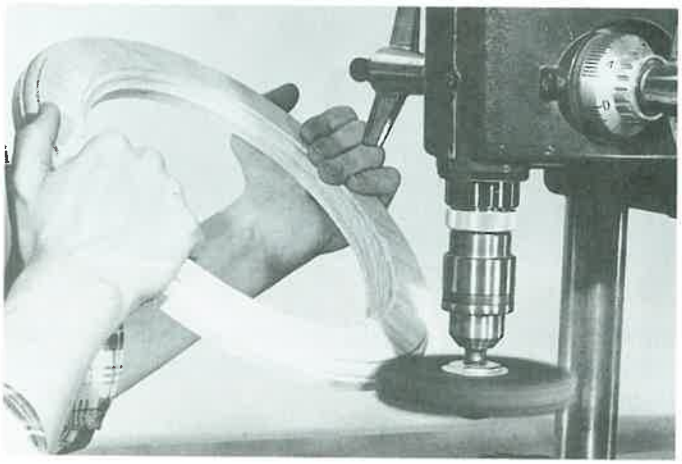
There are general and tool-specific maintenance guidelines. The following list covers both types.

### General

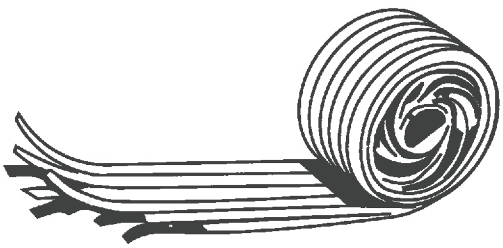
- Check dust collection hoses and bags for tears and loose connections.
- Empty dust from collection storage and make sure exhaust system is operating properly.
- Check electrical cords and air hoses for damage and wear. Keep cords and hoses away from the abrasive.
- Replace those which have cracked, deteriorated, or have been damaged by the machine.
- With an air hose, blow dust from all moving parts, electrical boxes, and motor vents.
- Remove rust from machine tables and metal surfaces with fine steel wool. Wipe them with paraffin wax.
- Check abrasives for excessive wear or chip loading (clogging). Replace if necessary.
- Secure tables by tightening clamps, trunnion locks, and quill pins.
- Check motor belt tension.
- Check all adjustments, bolts, and fittings for wear. Lubricate if specified by manufacturer.
- Follow the machine maintenance schedule included with the machine. It may be necessary to oil the bearings, lubricate parts, clean the brushes, or check other important features.
- Secure and tighten all safety guards properly.
- Remove resin and chips from loaded and clogged abrasives with a rubber cleaning block. See **Figure 31-35.** Some soft shoe soles can be substituted for the blocks. Rub the cleaning block against the moving abrasive. This extends the effective life of the abrasive.
- Some air-operated machines have oil added in the air line to lubricate bearings. Check the oil level periodically. Use separate hoses for abrading and spray finishing operations.

## Belt sander

- Inspect the abrasive belt for loose, torn, or raveled conditions.
- Check tracking and tension adjustments.
- Check the platen position. It should extend 1/32″ (1 mm) beyond the front of the drum surface.

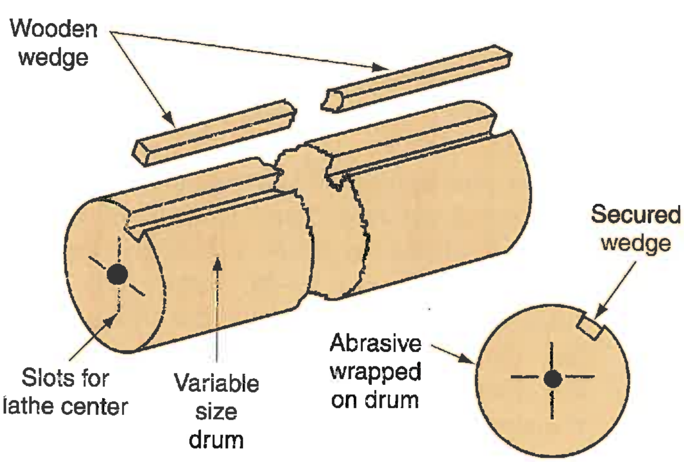


A



B

**Figure 31-32.** A—Flap wheels can smooth contoured surfaces. B—The flap wheel is made of scored abrasive strips. *(Shopsmith)*




**Abrasive Drum for Lathe**

**Figure 31-33.** You can make an abrasive drum for the lathe from a hardwood cylinder and a wooden wedge.

## Disk sander

- Check abrasive disk for proper adhesion.
- Square table to disk.

## Spindle sander

- Check the spindle fit. It should be snug, but not too tight.
- Adjust table trunnions properly.
- Install the correct table insert.


A


B

**Figure 31-34.** An accessory installed on a band saw enables the machine to be used as a belt sander. A—A curved workpiece is quickly sanded. B—Bevel sanding is done by setting the band saw to the angle selected on the tilt scale. *(Chuck Davis Cabinets)*

**Figure 31-35.** A rubber-like cleaner removes resin and chips from abrasives. *(Chuck Davis Cabinets)*

## Summary

Smoothing with abrasives is the process of abrading workpieces in preparation for assembly or finishing. Abrasives are chosen according to the workpiece surface. Coarse abrasives remove saw or other machine marks. Medium abrasives remove coarse abrasive marks. Continue with finer abrasives until a quality surface is achieved. Minimum use of abrasives is recommended, so stop when the surface quality is acceptable.

Abrading may be done by hand or machine. By hand, the process is slow. Do so only when a sanding machine is not available or in hard-to-reach places. Electric or air-powered sanding machines reduce abrading time. With stationary machines, you hold and move the workpiece. With portable machines, you move the tool over the workpieces.

## Test Your Knowledge

*Do not write in this text. Answer the following questions on a separate sheet of paper.*

1. The purpose for abrading is to obtain _____.
2. List four items you should check on the workpiece before abrading.
3. Why should you use a series of coarse to fine abrasives, rather than starting with a fine abrasive?
4. Each finer abrasive grit size removes the _____ of the abrasive before it.
5. Explain how you would position the belt sander and miter gauge to smooth the following surfaces.
   a. Square edge of a flat-sawed board.
   b. Flat face of a board, 4" (102 mm) across the grain and 6" (152 mm) with the grain.
   c. Bevel across the end.
   d. Bevel across the edge.
   e. Face of a board, 7" (178 mm) across the grain and 48" (1219 mm) with the grain.
   f. Square end of a quarter-sawed board.
6. A disk sander is primarily for _____ and _____.
7. Two stationary power sanders for smoothing contours are the _____ and _____.
8. The main advantage of an abrasive planer over a knife planer is _____.
9. Describe the differences between abrasive planers and wide belt sanders.
10. Large, flat workpieces can be abraded easiest on a _____.
    a. sander/grinder
    b. disk sander
    c. belt sander
    d. stroke sander
11. Describe why an in-line finishing sander better prepares a workpiece for finish than an orbital sander.
12. Use a trigger lock on a portable sander only _____.
    a. if you are using a fine belt
    b. if the tool is stationary in a stand
    c. when smoothing clamped workpieces
    d. while smoothing large workpieces
13. Tracking means _____.
14. To clean a coated abrasive, use a(n) _____ or possibly a(n) _____.
15. How is an abrasive belt marked to show direction for movement?
16. Before servicing any power equipment, first _____.
17. List six general maintenance items you should check before and after using a sanding machine.

A solvent-base contact cement was used to bond the plastic laminates to the various workpieces.

# Adhesives

32

## Objectives

After studying this chapter, you will be able to:
- Select the proper adhesive for assembling your product.
- Identify adhesive characteristics that affect the assembly time and strength of your product.
- Describe the proper application of adhesives.

## Important Terms

| | |
|---|---|
| acrylic resin | grout |
| adhesion | wall paneling adhesive |
| adhesive | radio frequency (RF) gluing |
| assembly time | ready-to-use adhesive |
| catalyst | resorcinol |
| clamp time | shelf life |
| cohesion | tile adhesive |
| curing time | two-part adhesive |
| cyanoacrylate adhesive | vinyl adhesive |
| drying time | water-mixed adhesive |
| epoxy adhesive | |

Cabinetmakers bond many kinds of workpieces together with adhesives. In the early stages of production, you might bond lumber together to make wider components. Later you may assemble the cabinet with adhesives, then apply veneer and plastic laminates.

Today, you can find an adhesive to bond almost any two materials. The adhesive may have single (join similar materials) or multiple uses (join dissimilar materials). Included are lumber, paneling, paper, cloth, leather, ceramics, rubber, vinyl, and numerous other materials. See **Figure 32-1.**


**Figure 32-1.** By selecting the proper adhesive, you can bond plastic, veneer, metal, lumber, vinyl, hardboard, and plastic laminate. *(United Gilsonite Laboratories)*

## Selecting Adhesives

The term ***adhesive*** can be confusing. It may or may not be printed on the container label. Instead, the words cement, glue, mastic, or resin could appear. Each of these are adhesives that will bond similar and/or dissimilar materials.

***Adhesion*** occurs by adding some substance, liquid or solid, which *sticks* two objects together. See **Figure 32-2A.** Do not confuse adhesion with cohesion, discussed in *Chapter 15* when bonding plastics together. Cohesion is different from adhesion. ***Cohesion*** occurs when a solvent is applied to plastic that dissolves the surfaces. See **Figure 32-2B.** Material flows together, the solvent evaporates, and the bond is complete.

### Adhesive terms

Select adhesives according to the materials they will bond. Also consider shelf life, assembly time, clamp time, drying time, and curing time.

#### Shelf life

***Shelf life***, or ***storage time***, refers to how long the adhesive may be stored and yet remain effective. A manufacture or expiration date may appear on the

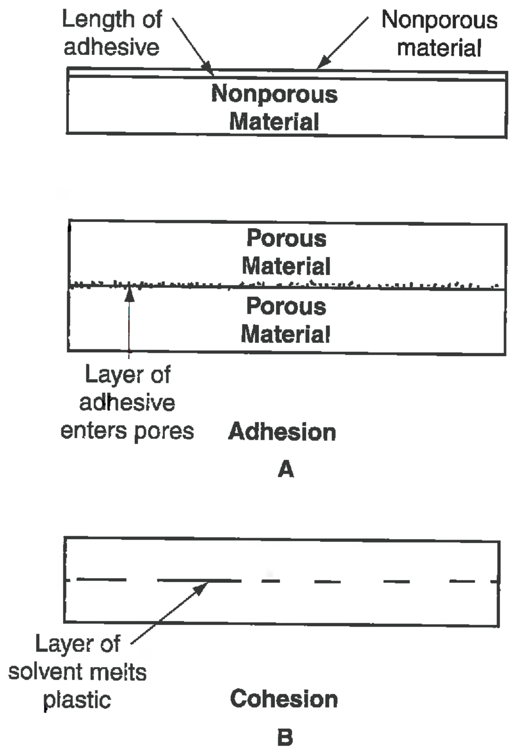



**Figure 32-2.** Materials may be bonded two ways. A—Adhesion results when a thin layer of adhesive "sticks" two components together. B—Cohesion results when cement solvents dissolve and blend the surface of two workpieces.

container. Suppose the shelf life of a glue is one year and you use one quart a year. Do not buy five gallons. Over time, heat, moisture, and chemical reaction will cause the adhesive not to bond. Most containers read: *Store in a Cool, Dry Place.*

## Assembly time

***Assembly time,*** or ***open time,*** is the time you have after glue application to fit the pieces together. This time varies with the type of glue being used. Choose an appropriate glue with a long assembly time when assembling a complicated piece.

## Clamp time

***Clamp time,*** or ***set time,*** is the amount of time that is required for the pieces being bonded to remain in the clamps while the adhesive sets. When an adhesive sets, the solvents (water or thinner) evaporate. This leaves only a solid bonding substance. Then, the adhesive will hold the components together. This may take seconds, minutes, or hours. Once the adhesive is set you can remove any clamps that held the workpieces together. ***Drying time*** is from spreading the adhesive to when clamps are removed. However, the bond does not reach full strength until the assembly dries, or cures.

## Curing time

***Curing time*** refers to the time after the adhesive sets and before the joint reaches full strength. The water or solvent must fully evaporate. Then the resins bond to each other and the material. For most adhesives, curing time is more than an hour. However, for some contact cements and "super" glues, it occurs in seconds.

Read the adhesive manufacturer's instructions carefully. For any material or condition, you must select and apply the proper adhesive. The type you choose depends on two important factors:

* The material to be fastened.
* The conditions to which the assembled product will be exposed.

## Clamp pressure

***Clamp pressure*** is measured in pounds per square inch (psi) or kilo Pascals (kPa). General requirements for woods are:

* For softwoods, such as pine, 100 psi to 150 psi (690 kPa to 1030 kPa).
* For medium density woods, such as cherry and soft maple, 150 psi to 200 psi (1030 kPa to 1380 kPa).
* For hardwoods, such as oak and birch, 200 psi to 300 psi (1380 kPa to 2070 kPa).

## Materials

Materials may be porous or nonporous. ***Porous*** woods allow the adhesive to flow into nearby wood cells increasing setting time of the glue. Metal and plastics are ***nonporous.*** A thin layer of adhesive must be able to bond to the surface of these materials. Carefully select an adhesive to bond porous to nonporous materials. Check the container label that lists materials it will bond.

The nature of the wood surfaces being joined affects the strength of a bonded joint. The best bonds result when wood with a 6% to 8% moisture content is glued face-to-face, face-to-edge, or edge-to-edge. Poor bonds result when end grain is bonded. Wood glues, when dry, tend to pull out of end grain pores.

Jointwork quality, in any grain direction, affects the strength of the glue bond. The more surface contact between workpieces, the better the joint. Poorly made joints have less surface contact, thus are weak. For example, a dado is better than a butt joint due to the mechanical restrictions of the joint.

Joints should slip together easily when assembled. Excessively tight fits may cause too much adhesive to squeeze out. The result can be a weak, "glue starved" joint.

## Exposure

The environment where products bonded with adhesives are to be used and stored is very important. Temperature, moisture, and stress affect the joint's durability. Use waterproof glue on outdoor furniture, for example. If the product will be exposed to stress, such as chair legs are, the joint should be strong, but flexible.

Certain adhesives leave a colored *glue line* when dry. The line will be wider and the joint weaker when this is a poor fit. If the glue line might be visible in the finished product, apply an adhesive that dries clear or is of a matching color.

Also consider whether the adhesive is toxic. Is it hazardous to people when applying it or using the product? Be especially concerned about ventilation when applying toxic materials.

Many *brand name* products are available. However, there are relatively few types. You must determine which ones meet requirements. The types discussed in this chapter are:

- Wood adhesives.
- Contact cements.
- Construction adhesives.
- Specialty adhesives.

# Selecting wood adhesives

Wood adhesives are available in three forms:

- ***Ready-to-use.*** Mixing is not required.
- ***Water-mixed.*** A powdered resin is mixed with water.
- ***Two-part.*** Two substances must be mixed together. They are a liquid resin and powdered catalyst.

Each of these adhesives achieve a strong, permanent bond when applied properly. It should be stronger than the wood itself. See **Figure 32-3.**

**Figure 32-3.** Shear test on wood glue bonds show that glue can be stronger than the wood itself.

## Ready-to-use adhesives

***Ready-to-use adhesives*** are the most popular among commercial and home woodworkers. They are widely used for joints, veneers, and laminates. The most common of these are glues, such as liquid hide, polyvinyl acetate, aliphatic, and polyurethane. See **Figure 32-4.** Apply them directly from the container by brushing, dipping, rolling, or spraying.

Ready-to-use adhesives have different characteristics. They are spreadability, wet tack, and temperature range.

***Spreadability*** is the ease of application. ***Wet tack*** is how well the adhesive initially sticks to the workpiece. Wet tack reduces spreadability by brushing, but does not affect it when glue is forced to spread. For example, tack prevents glue from being scraped off a tight dowel inserted into a dowel hole. However, when the dowel is forced in by clamping, the glue still spreads. Temperature affects adhesives differently. Cooling causes them to thicken. This lessens spreadability. Exposure to heat has the opposite effect; it causes the adhesive to become thin. Prolonged heating of hide glue at about 140°F (60°C) causes it to lose strength. Heating aliphatic resins and polyvinyl acetates to 120°F (49°C) has the same weakening effect.

Humidity also affects drying time. Very humid air may increase drying time up to 30%.

### *Hide glue*

***Hide glue*** is a natural protein emulsion and is a clear, amber, multipurpose adhesive. It is among the oldest types available. You can buy it as a liquid or a solid. Both are manufactured from animal hides, bones, and tendons.


**Figure 32-4.** Ready-to-use adhesives: hide glue, polyvinyl acetate "white glue," and aliphatic resin. *(Franklin International)*

Liquid hide glue is ready to use. See **Figure 32-5.** The solid type must be placed in lukewarm water overnight or prepared to manufacturers' instructions. The glue is then heated temporarily to about 150°F (66°C) in an electric glue pot. A double boiler can also be used for heat. Hide glue, reheated several times, will lose its strength.

Setting time is two to three hours, slow compared to that of other ready-to-use adhesives. It has excellent gap-filling properties. Drying time is eight hours or more, depending on humidity, which increases drying time.

Unlike most wood adhesives, hide glues do not clog abrasives during sanding.

### Polyvinyl acetate glue

***Polyvinyl acetate (PVA) glue*** is one of the most common ready-to-use adhesives. It is known as *white glue*, and should be used for porous applications. Its primary use is in home, school, and craft projects. It is washable and won't stain clothing, making it ideal for children of all ages.

PVA is nontoxic, nonflammable, and odorless. It spreads smoothly without running. Clamping is necessary during the one hour setting time. Surplus glue should be cleaned with a damp cloth while the adhesive is wet. Curing requires about 24 hours. When dry, PVA is clear. However, it may be softened by some solvents in finishing materials.

### Aliphatic resin glue

***Aliphatic resin glue*** is a cream colored, multipurpose product. Most of its characteristics are similar to PVA. However, it is stronger, and set time is only 20 to 30 minutes. It can be applied at lower temperatures, but the setting and curing times increase.


**Figure 32-5.** Construction adhesive is easily applied with a caulking gun. *(Chemrex, Inc.)*

Aliphatic glues are unaffected by solvents in varnish, lacquer, or paint. Therefore, they are more suitable to these finishes than is PVA. Aliphatic glue can also be colored with water soluble dyes to match the finish. Use dyes if a light glue line would be very obvious.

A list of characteristics for aliphatic resin, polyvinyl acetate, and liquid hide glue is given in **Figure 32-6.**

### Polyurethane glue

***Polyurethane glue*** is a waterproof glue that can be used for multipurpose applications. It is ideal for wood, metal, plastic, ceramics, high-pressure decorative laminates (HPDL), stone, and some solid surface countertops.

**Comparison of Typical Ready-Use Adhesives**

| Charactistic | Aliphatic Resin Glue | Polyvinyl Acetate Glue | Liquid Hide Glue |
|---|---|---|---|
| Appearance | Cream | Clear white | Clear amber |
| Spreadability | Good | Good | Fair |
| Acidity (pH level*) | 4.5–5.0 | 4.5–5.0 | 7.0 |
| Speed of Set | Very fast | Fast | Slow |
| Stress Resistance† | Good | Fair | Good |
| Moisture Resistance | Fair | Fair | Poor |
| Heat Resistance | Good | Poor | Excellent |
| Solvent Resistance‡ | Good | Poor | Good |
| Gap Filling | Fair | Fair | Fair |
| Wet Tack | High | None | High |
| Working Temperature | 45°–110°F | 60°–90°F | 70°–90°F |
| Film Clarity | Translucent | Very clear | Clear but amber |
| Film Flexibility | Moderate | Flexible | Brittle |
| Sandability | Good | Fair (will soften) | Excellent |
| Storage (shelf life) | Excellent | Excellent | Good |

*pH–glues with a pH of less than 6 are considered acidic and thus could stainacid woods such as cedar, walnut, oak, cherry, and mahogany.
†Stress resistance–refers to the tendency of a product to give way under constant pressure.
‡Solvent resistance–ability of finishing materials such as varnishes, lacquers, and stains to take over a glued joint.

**Figure 32-6.** Ready-to-use adhesives differ in application, appearance, and durability. *(Franklin International)*

## Water-mixed adhesives

As the name implies, ***water-mixed adhesives*** are dry powder resins mixed in water. Powders must be kept covered tightly except while mixing. Air moisture let into the container can shorten the adhesive's shelf life.

There are two basic types of water-mixed adhesives. They are casein and plastic resin. Each has a relatively short assembly time.

### Casein glue

***Casein glue*** is made from nontoxic milk protein and has a light beige color. You mix the protein powder with cold water. Once mixed, it has about an eight hour assembly time. Clamp casein glue bonds two to three hours and let the joint cure at least 24 hours.

Casein glue is moisture resistant but not waterproof. It has many exterior product applications, especially if the wood is later painted.

The glue has some special applications and cautions. It will bond wood species that feel oily, such as teak. Other glues are not effective on oily wood. You should not apply casein on dark or acid woods. It tends to stain them.

### Plastic resin glue

***Plastic resin glue***, also called ***urea formaldehyde***, is a light tan color. It is made from urea resins that are highly water resistant and very strong, but brittle. If applied to poorly fitting joints, it will be weak.

Plastic resin has a short, 30 minute assembly time. You must mix small amounts and spread it quickly. Use cold water for mixing, then allow the mixture to set for several minutes. Then re-stir it. This should produce a smooth, creamy texture. If lumps remain after mixing, the resin is too old. Plastic resins require clamps during the 12 hour set time. Curing takes another 12 hour waiting period. Plastic resins leave little or no glue line.

## Two-part adhesives

A ***two-part adhesive*** is packaged in two containers. One holds the resin liquid and the other a powder catalyst. The ***catalyst*** hardens the resin once the two are mixed. Two-part adhesives include resorcinol and acrylic resin.

Combine two part adhesives in measured amounts specified by the manufacturer. Prepare small amounts because the adhesive has a short assembly time.

### Resorcinol

***Resorcinol*** is a high-strength, waterproof adhesive for wood. One part is a light tan powdered hardener (catalyst). The other is a cherry-red resin. See **Figure 32-7.** The resulting mixture is dark brown with a two to three hour assembly time. Changes in the mixture and/or room temperature shorten or lengthen that time. The adhesive sets faster than others and cures in 10 to 12 hours. At a temperature higher than 70°F (21°C), resorcinol begins to cure quicker. At 90°F (32°C) it will cure in about five hours.

**Figure 32-7.** Measure proportions of resin and catalyst in two-part adhesives accurately. *(Franklin International)*

Excess resorcinol, while wet, can be wiped away with a rag and warm water. Dry adhesive is removed with a scraper.

### Acrylic resin glue

Like resorcinols, ***acrylic resins*** are waterproof and strong. Besides wood, this glue bonds metal, glass, and concrete, but not plastic. Setting time, normally about 5 minutes, is adjusted by the mix of powder and liquid. Acetone is used to remove excess adhesive. Clamping is needed only to position the joint. **Figure 32-8** lists the characteristics of typical water-mixed and two part adhesives.

## Selecting Contact Cements

***Contact cements*** are liquid, multipurpose adhesives. They bond similar and dissimilar porous and nonporous materials. Contact cement is used to bond wood, cloth, leather, plastic, rubber, metal, and ceramic products. It has high heat and moisture resistance. It fills gaps well and does not require clamping.

The application of contact cement is unique. Adhesive is applied to both surfaces of the workpieces to be joined. However, the parts are not immediately joined. The adhesive first must set and lose its tack (stickiness to the touch). The film should be clear, feel slightly tacky, and appear glossy. If it is dull after drying (dull appearace after tackiness is gone), apply another coat to both surfaces.

| Comparison of Typical Water-Mixed and Two-Part Adhesives | | | |
|---|---|---|---|
| **Characteristic** | **Casein** | **Plastic Resin** | **Resorcinol** |
| Appearance | Cream | Tan | Dark reddish brown |
| Spreadability | Fair | Excellent | Good |
| Speed of Set | Slow | Slow | Medium |
| Stress Resistance | Good | Good | Good |
| Moisture Resistance | Good | Good | Waterproof |
| Heat Resistance | Good | Good | Good |
| Solvent Resistance | Good | Good | Good |
| Gap Filling Ability | Fair to Good | Fair | Fair |
| Wet Tack | Poor | Poor | Poor |
| Working Temperature | 32°–110°F | 70°–100°F | 70°–120°F |
| Film Clarity | Opaque | Opaque | Opaque |
| Film Flexibility | Tough | Brittle | Brittle |
| Sandability | Good | Good | Good |
| Storage (shelf life) | 1 year | 1 year | 1 year |

**Figure 32-8.** Water-mixed and two-part adhesives have similar characteristics. *(Franklin International)*

When the adhesive on both surfaces has set, press the components together. The bond is instantaneous and once joined the pieces cannot be moved. No clamping is necessary.

Contact cement bonds many materials, however there are some surfaces to which it will not bond. One example is the decorative face of plastic laminate. Contact cement adheres to the laminate back but not to the face. To test whether contact cement will bond to a surface, apply a small amount to a test piece of material. When the cement sets, rub the coated surface with your hand. If the cement rolls up, it did not adhere to that surface.

Cement can be applied by brushing, dipping, rolling, spraying, and troweling. Spraying is the preferred application method for production work. A notched trowel may be used as an applicator. See **Figure 32-9.** A short nap roller spreads the material evenly and fairly quickly. Discard the roller when finished. Otherwise use a discarded natural bristle paintbrush with a wood handle. Keep applicators for cement spreading separate from those for applying finishes. Cleaning cement applicators is difficult. Some solvents may dissolve the bristles of the brush. Tool cleaning must be done while the cement is wet.

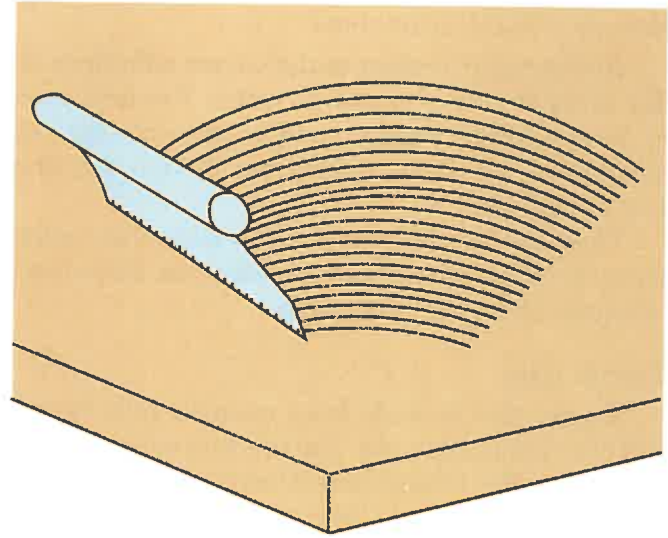


**Figure 32-9.** Apply contact cement with a notched spreader.

Control the spread of contact cement carefully. Apply a thin even layer only to the surfaces you want bonded. If some is spilled, wipe it up according to the instructions on the container label.

There are three types of contact cement. They are: solvent-, chlorinated-, and water-based. The characteristics of each are given in **Figure 32-10.**

## Solvent-base contact cement

***Solvent-base contact cements*** are quick drying, high strength adhesives used primarily for bonding a plastic laminate to a particleboard or MDF substrate. They come in two grades: spray and brush. Spray grades are thinned with solvents. Brush grades are thicker and can be applied by dipping, rolling, or troweling. Apply solvent-base contact cements in a well-ventilated area. They are both toxic and flammable.

## Chlorinated-base contact cement

***Chlorinated-base cements*** provide the cabinetmaker with a nonflammable alternative to solvent-based cements. Chlorinated cements are very fast drying, develop high strength, and can be applied in a variety of manners.

The chlorine odor of this cement can be irritating. It may produce a burning sensation in the eyes. Apply it only in well-ventilated areas.

| | Color | Speed of Set | Grades | Flammable | Toxic |
|---|---|---|---|---|---|
|  | Tan | 5-10 Minutes | Two | Yes | Very |
| Solvent | | | | | |
|  | Green | 5-10 Minutes | One | No | Slightly |
| Chlorinated | | | | | |
|  | Milky White | Up to One Hour | One | No | No |
| Water | | | | | |

**Figure 32-10.** Three available contact cements. *(Bordon, Inc.; Franklin International)*

Solvents for cleanup include xylene, toluene, and other products recommended by the manufacturer. Clean tools while the cement is still wet. If the cement has set or cured, soak the tools in solvent for a few minutes. Then scrape and wipe away the softened cement.

### Water-base contact cement

***Water-base cements*** are nontoxic and nonflammable. They also come in brush and spray grades. They are commonly used where other cements could be a health hazard. They are also well suited to foam plastics that would melt if a solvent-base cement were applied.

Water-base cements will not damage lacquered, painted, or varnished surfaces. Wipe up spills and clean tools with water while the cement is wet. Chlorinated solvents will remove dried cement. Some water-base cements contain alkaline solutions that are eye irritants. Check the label before applying the cement.

Water-base cements should not be used with metal surfaces. The adhesive may cause metal to rust. Wood veneer should have a backing to prevent the cement from bleeding to the surface, leaving a stain. Another disadvantage for this product is the relatively long setting time.

You can use spray equipment that will add heat to the cement as you spray to accelerate drying. With proper infrared heat equipment, water-base cements can be force-dried. Besides heat, a contributing factor is air movement. In some cases, home-type fans can be used. The same drying system can be used to enhance the drying rate for water-base coatings.

## Selecting Construction Adhesives

Construction adhesives bond a variety of materials such as paneling, vinyl trim, tile, and brick veneer. Adhesives are available in cans and cartridges. See **Figure 32-11.** One product, grout, is a powder and mixes with water or a solvent.

### Panel adhesive

***Wall paneling adhesives*** may be multipurpose or single purpose. They bond unfinished and prefinished plywood, hardboard, and similar panels to wood, metal, and concrete. See **Figure 32-12.** Most panel adhesives have good wet tack, meaning long-term pressure or clamping is not necessary. The caulking gun cartridge form of adhesive is most common.

## Vinyl-base adhesive

Vinyl-base adhesives can be installed where paneling, tile, or some other material meets the floor. It typically replaces wood trim. ***Vinyl adhesives*** are designed to attach vinyl trim. See **Figure 32-13.** They are applied with a putty knife, trowel, or caulking gun and have good wet tack. Some are waterproof and others are moisture resistant.


**Figure 32-11.** Some popular construction adhesives are applied by cabinetmakers. *(Franklin International)*

**Figure 32-12.** Prefinished plywood panels are attached with panel adhesive that has been applied to wall studs. *(Franklin International)*

## Tile adhesives

Various kinds of tile require different adhesives. Tile materials include slate, ceramic, metal, and plastic. The tile manufacturer will recommend an adhesive to suit their products. ***Tile adhesives*** will be moisture resistant or waterproof. Apply tile adhesives with a trowel. See **Figure 32-14** and refer to *Chapter 15.*

**Figure 32-13.** Install vinyl trim, base, and moldings with a vinyl adhesive. *(Franklin International)*

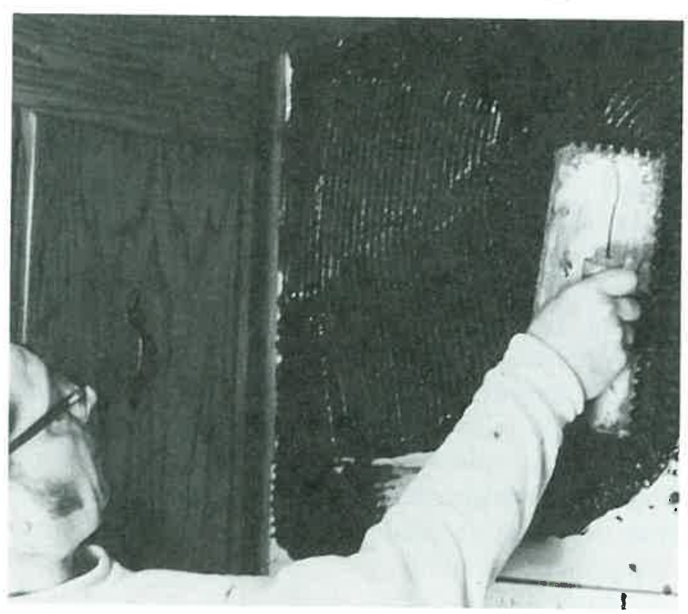


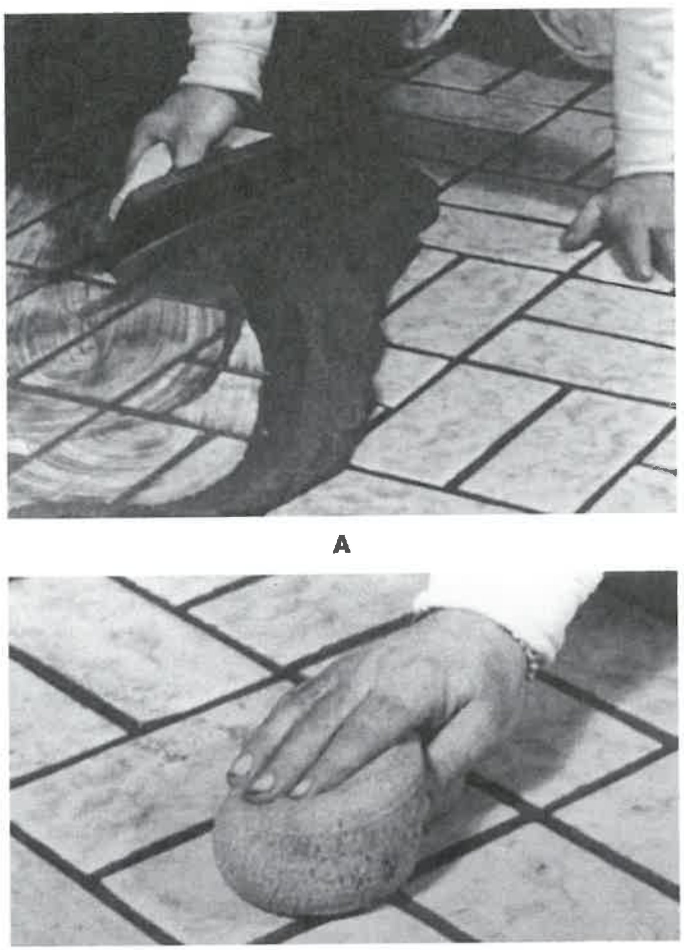
**Figure 32-14.** Apply tile adhesives with a notched trowel. *(Franklin International)*

## Grout

*Grout* is a cement or resin based powder that is mixed with water or solvents. Press grout into the joints between ceramic and slate tile. See **Figure 32-15.** It is also applied between the glass and came of leaded glass panels. Grout is sealed to protect it from wear and moisture absorption. Use an appropriate grout sealer.

# Selecting Specialty Adhesives

Specialty adhesives include a wide range of cements, glues, adhesives, and mastics. Most are made for specific purposes such as bonding different plastics. When the product fails to make a permanent bond, it is often due to two factors: improper material or applications. Read and follow the manufacturer's instructions carefully. Two of the more commonly used specialty adhesives are cyanoacrylate and epoxy.



A

B

**Figure 32-15.** Steps in applying grout. A—Spread grout into spaces between tiles with a grout float. B—Wiping off excess grout with a wet sponge. *(Franklin International)*

## Cyanoacrylate adhesives

***Cyanoacrylate adhesives*** are known as *super, instant,* and *miracle* glues. They bond only nonporous materials in as little as 10 seconds. Cyanoacrylate adhesives dry even without oxygen to evaporate solvents. While setting time is only 10 to 30 seconds, the glued assembly should be left to cure for three to six hours. Acetone (fingernail polish remover) is used for cleanup.

These adhesives bond similar and dissimilar materials, such as ceramics, metal, rubber, and plastic. Almost a 100% joint surface contact is necessary. Also, cyanoacrylics do not withstand heat over 160°F (71° C), continuous immersion in water, and many chemicals.

**Caution**

Cyanoacrylate will bond skin to skin almost immediately. Seek medical assistance if you experience this problem. There have been cases where surgical separation was necessary. Acetone (fingernail polish remover) will separate some cyanoacrylic bonds. However, follow the manufacturer's instructions on the packaging.

## Epoxy adhesives

Epoxy adhesives are used for both porous and nonporous materials. Like cyanoacrylics, they dry chemically. They are available in liquid or stick putty form.

### Liquid epoxy

***Liquid epoxy*** is a two-part adhesive. A resin and hardener are mixed in a 50:50 or 60:40 ratio. See **Figure 32-16.** A 60% hardener mix adds flexibility to the bond. This increases resistance to impact. A 60% resin mix is stronger, but more brittle.

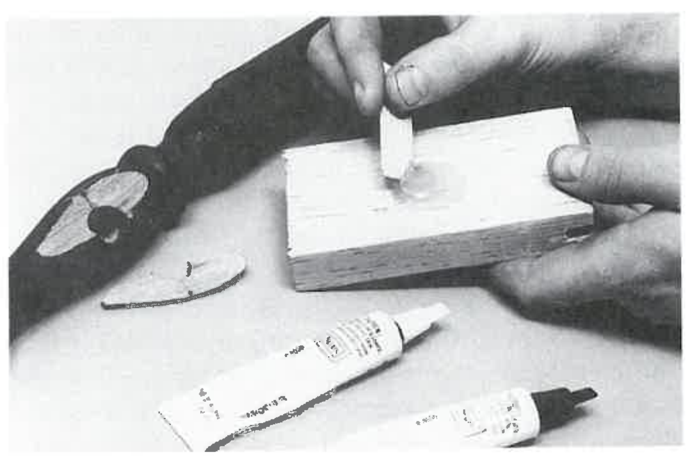


**Figure 32-16.** Mix resin and hardener thoroughly with a small stick. *(Franklin International)*

Mix liquid epoxies in small amounts due to the short assembly time. Once the resin and hardener are combined, they cannot be stored.

### Stick epoxy

***Stick epoxy*** will fill gaps in materials. Apply it as you would putty. You cut off and knead together equal parts of a stick of resin and stick of hardener. Knead them with a putty knife or place them in a plastic bag and knead with your fingers. Spread the mixture with a putty knife or stick. Seal unused epoxy sticks in separate, air-tight containers.

**Caution**

Epoxy adhesives, like cyanoacrylates, may cause irritations if they contact the skin. Follow the manufacturer's instructions on the packaging if problems occur.

## Applying Adhesives

There are several procedures for applying adhesives. Glues that have a creamy consistency at room temperature can be brushed or rolled. Many can also be sprayed if thinned with solvent or water. Some are applied with heat.

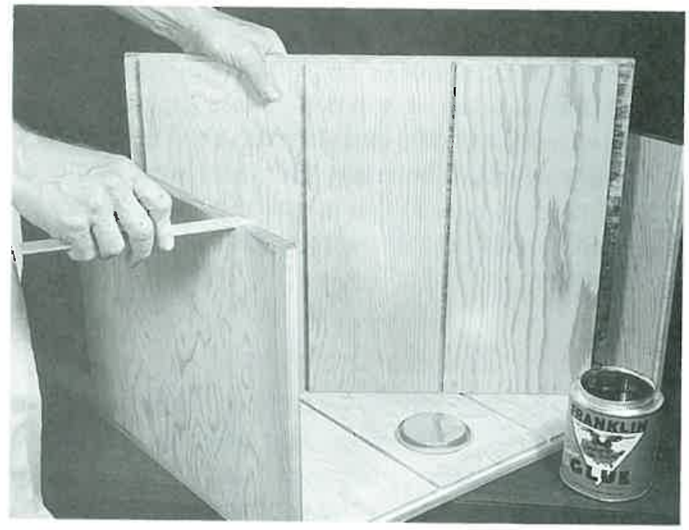
Before gluing workpieces together, make sure they are at the equilibrium moisture content. This will range from 6% to 10%. If the wood is too moist or too dry, the glue joint will be weak.

### Traditional gluing

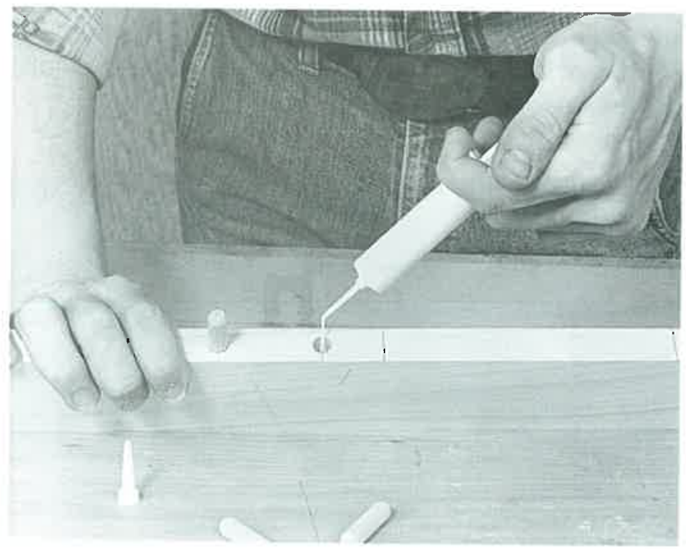
***Traditional gluing*** refers to applying liquid adhesive and clamping the assembly while the adhesive sets and cures at room temperature. Fit your assembly together before applying glue. This is referred to as a dry run. Clamp the entire assembly. Check to see that all the workpieces fit properly. Then wipe any dust or debris off each workpiece.

Glue is spread on surfaces by a number of means. See **Figure 32-17.** It is recommended that you cover the entire surface to be joined. You cannot be sure that a thin line of glue will spread to fill the joint when the assembly is clamped. When applying glue in a plate joining kerf, spread glue on both sides of the kerf where the plate meets the workpiece.

Once you have applied glue, clamp the assembly. See **Figure 32-18.** Small beads should ooze from the joint. This tells the cabinetmaker that sufficient glue was used. If no glue oozes, take the assembly apart immediately and reglue. If there are drips or runs, too much glue was used. In this case, wipe off the excess glue with a wet cloth. Adjust the amount you apply next time.




A



B

**Figure 32-17.** A—Apply adhesive with a stick. *(Franklin International)* B—In holes, use a glue syringe. *(Shopsmith)* C—In plate kerfs use a plate glue bottle and base. *(Chuck Davis Cabinets)*

**Figure 32-18.** Clamps hold the assembly together while the glue sets. *(American Tool Companies)*

## Hot melt gluing

*Hot melt gluing* is an efficient method of bonding many materials. It is done with an electric glue gun. See **Figure 32-19.** You place a small cylinder of solid adhesive in the gun. As you pull the trigger (electric switch) the adhesive warms and liquefies. It then flows onto the workpiece surfaces being bonded. With larger guns, pulling the trigger feeds the adhesive automatically. On small guns, feeding the adhesive stick is done by hand.

Workpieces must be assembled quickly after the melted glue is applied. The glue cools and sets in approximately 15 seconds. Coat only an area that can be covered in about 10 seconds. Then hold the components together for 10 seconds. In 60 seconds the bond is at 90% of its strength.

Hot melt glue has many uses. Select the proper type of adhesive for wood, wood products, plastic, fabric, paper, and some rubber products.

## Radio frequency gluing

*Radio frequency (RF) gluing* is a method of using high frequency radio waves to heat and cure the glue joint. RF gluing is also called *high-frequency heating* and *dielectric heating*. It is similar to microwave cooking.

RF gluing equipment consists of a generator and pair of electrodes. The generator creates radio waves and sends them to electrodes placed on each side of the glue joint. See **Figure 32-20.** The radio waves cycle through the wood and glue causing molecular friction. This generates heat. However, the heat is concentrated on the glue joint. This causes the glue joint to set and dry much quicker. You are able to remove the clamps in a few minutes, rather than wait hours.

**Figure 32-19.** This electric glue gun ejects hot melt adhesive through the small nozzle tip. *(Chuck Davis Cabinets)*

An RF glue gun has both electrodes mounted on the bottom. The electrodes are shaped for flat surfaces and corner joints. See **Figure 32-21.**

Larger RF gluing systems have a pair of electrode plates. One is positioned on top of the assembly. Another is positioned on the bottom. Clamping is generally done automatically by the RF machine. See **Figure 32-22.**

### Adhesive selection

Adhesives that cure chemically, not by a loss of water, are the best for RF gluing. Examples are:

* *Urea formaldehyde resin.* This is one of the least expensive and best-suited adhesives for RF.
* *Cross-linking polyvinyl acetate resin.* This is the most widely used adhesive for RF gluing. It differs from polyvinyl acetate (white glue) in that it is set by an acidic salt chemical reaction, not by water loss.
* *Resorcinol.* This is a less used adhesive because it can become too hot during the RF cycle. Excess heat produces burnt glue lines.
* *Aliphatic resin.* These resins cure slower because they are set by water evaporation.

Other readily available adhesives are not adaptable to RF gluing. Polyvinyl acetate (PVA), or *white glue*, is not used because it is apt to melt uncontrollably during RF curing. Hide glues and caseins cannot by used for RF gluing. Hide glues are softened and weakened by heat. Caseins cannot be set or cured by this process. The adhesive will foam and leave a weak joint.

### Setup

To prepare to use the RF gluing equipment, first read the manufacturer's manual. It contains information on what material types and thicknesses you can bond.

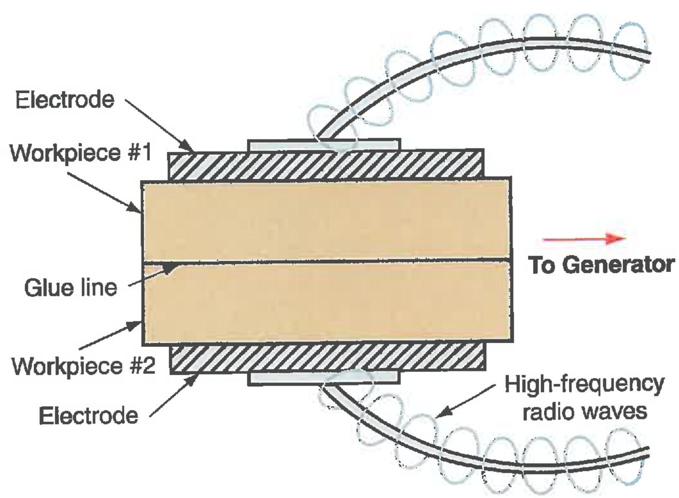



**Figure 32-20.** RF gluing sends high frequency waves through the glue and workpieces. The glue heats and sets quickly. The wood stays relatively cool.

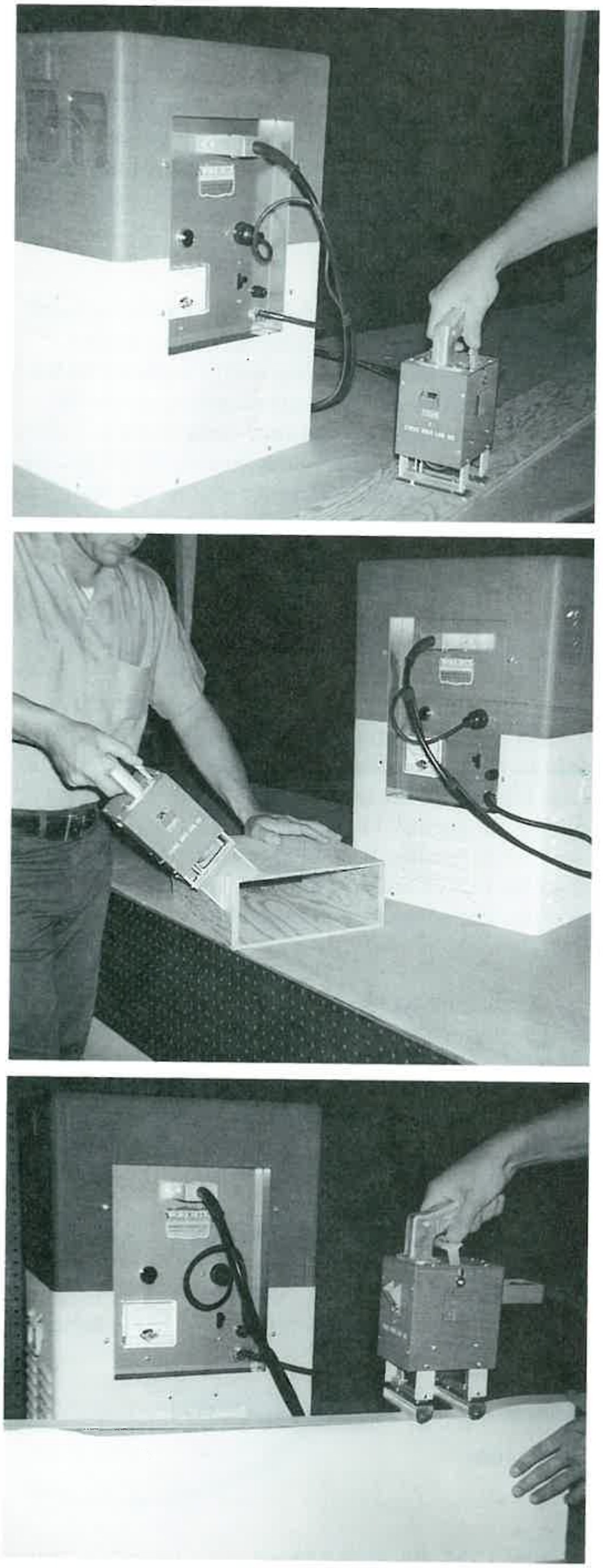


Figure 32-21. The electrodes on RF gluing guns are shaped according to the joint you are bonding. *(Workrite)*

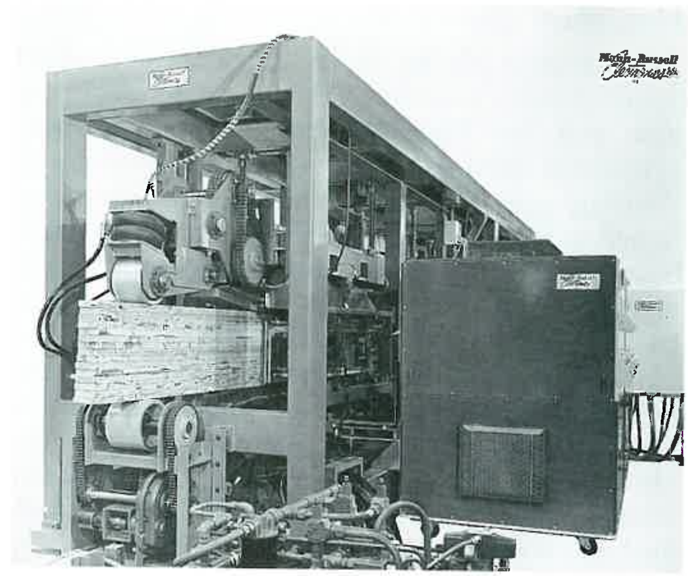


**Figure 32-22.** Large scale RF gluing machines clamp the stock. Here, a 15 piece face-to-face lamination is being RF glued. *(Mann-Russell Electronics)*

Clamp your assembly together as described in *Chapter 33*. Be sure the metal clamps do not interfere with moving the RF gun across the glue line. Touching the electrodes of the gun to the clamps could cause permanent damage to the RF equipment. After clamping, wipe off any excess adhesive.

## System operation

Always follow the manufacturer's procedure when operating the RF equipment. Each machine has specific features that affect its use. If recommended cure times (cycles) are not given, you can determine them for the piece you are gluing.

## RF gluing gun procedure

Most RF gluing guns work as follows:

1. Glue and clamp your assembly.
2. Turn on the welder switch.
3. Keep your free hand at least 12" (305 mm) from the gun electrodes.
4. Position the gun over the joint, one electrode on each side of the glue line.
5. Squeeze the trigger on the gun handle to begin the frequency curing.
6. The glue should heat and bubble from the glue line. You should not hold the trigger for more than 15 seconds per position. Longer time can damage the equipment.
7. Move to another position over the joint.
8. Repeat steps 5 through 7 at about 4" (101.6 mm) intervals.
9. Remove clamps.

## Summary

Adhesives serve the cabinetmaker in many ways. Choosing the right adhesive affects the strength, durability, and appearance of your product. When selecting the adhesive, carefully consider the following questions:

* What is the adhesive's shelf life?
* How quickly will the adhesive begin to set? This determines the time you have to clamp.
* What joint strength and durability is required?
* Must the adhesive resist heat and/or moisture?
* Must the adhesive resist solvents (paint or lacquer thinner)?
* Will the adhesive have to fill gaps of poorly fit joints?
* Should the adhesive have a good wet tack?
* Within what temperatures should the adhesive be applied?
* Once the adhesive dries, is the glue line visible?
* Can excess adhesive be removed with water or solvent, or must you remove it with a scraper or abrasive after it dries?
* Will you use RF, hot melt, or traditional means of gluing?

## Think Safety—Act Safely

A number of safety concerns are associated with adhesives. These are identified on container labels. They inform you of toxic, skin irritating, and flammable ingredients. When using adhesives, follow these precautions:

* Wear safety eyewear to protect yourself from splashing adhesives and solvents.
* Read all adhesive container labels and product instruction sheets. See **Figure 32-23.**
* Apply toxic adhesives in a well ventilated area. Forced air exhaust systems are best.
* Extinguish all flames while using flammable adhesives and solvents.
* Protect sensitive skin with rubber or plastic gloves.
* If you experience any adverse symptoms while applying adhesive, contact your physician immediately.
* Touch only the handles of hot glue or RF guns during use.
* Keep your free hand at least one foot from the RF gun while using it. Your moist skin near the gun could attract an arc from the gun similar to lightning. A serious third degree burn could result.



**Figure 32-23.** Read the adhesive container label for important information, such as flammability and toxicity. *(Franklin International)*

## Test Your Knowledge

*Do not write in this text. Answer the following questions on a separate sheet of paper.*

1. Explain the difference between adhesion and cohesion.

*Matching Test: Match the terms with the appropriate definition.*

2. ______ Shelf life.
3. ______ Assembly time.
4. ______ Drying time.
5. ______ Clamp time.
6. ______ Curing time.
7. ______ Wet tack.

   a. Time for glue joint to reach full strength.
   b. Length of time the adhesive is spreadable.
   c. Describes how well the adhesive sticks on the surface where it is applied.
   d. Length of time the adhesive can be stored before it is unusable.
   e. Chemical reaction time for the adhesive to reach full strength.
   f. Length of time from spreading the adhesive to the time when clamps can be removed.

*Matching Test: Match the adhesive with the appropriate category.*

8. ______ Casein.
9. ______ Hide.
10. ______ Plastic resin.
11. ______ Acrylic resin.
12. ______ Aliphatic resin.
13. ______ Resorcinol.
14. ______ Hide.

    a. Ready-to-use liquid.
    b. Powder mixed with water.
    c. Liquid mixed with a powdered catalyst.

15. Bond components together with contact cement _____.
    a. immediately after spreading the cement
    b. immediately after the cement sets
    c. immediately after the cement cures
    d. any time
16. The contact cement that is safest to use is _____.
17. Three construction adhesives are _____, _____, and _____.
18. Where is grout used?
19. *Super glue* refers to _____.
    a. contact cement
    b. epoxy adhesives
    c. cyanoacrylate adhesives
20. An adhesive in both liquid and solid stick forms is _____.
21. Adhesives can be applied by _____, _____, and _____.
22. Name three adhesives adaptable to radio frequency gluing.

# Gluing and Clamping

33

## Objectives

After studying this chapter, you will be able to:

- Identify types of clamping devices.
- Select clamps to assemble various joints.
- Protect workpieces from clamp damage.
- Explain the procedure for assembling your product with clamps.

## Important Terms

3-way edging clamp
backing blocks
band clamp
bar clamps
bed frame
C-clamp
cam clamp
edge clamp fixture
hand screws
hold-down clamp
locator board
maxi-clamp system
miter clamp
quick-release clamp
screw clamps
spring clamp
starved joint
veneer press
web clamp
wedge clamp

Clamps are like another pair of hands for the cabinetmaker. They may hold a workpiece while you are processing it. They can secure a jig in place. They might also hold featherboards or stop blocks so your hands stay away from the point of operation. Use clamps to reduce accident risks when you work with tools and machinery.

Clamping is most often associated with adhesive bonding when assembling a product. Here, clamping is a two-step procedure. To assure proper fit, position and secure workpieces without adhesive. This is called a trial assembly, or dry run. Now, remove the clamps, spread the adhesive, and clamp the final assembly.

Clamps come in many shapes and sizes. Some are designed for one specific purpose. Others hold glue joints as well as attach jigs and fixtures. With most, you can control the amount of clamp pressure. Clamp pressure is achieved with springs, screws, threads, levers, cams, and wedges. However, *spring clamp* pressure depends on the strength of the spring. Except for the spring clamp and vacuum press, the clamps discussed in this chapter are positioned and tightened by hand. Clamping machines are discussed in *Chapter 52.* These use hydraulic or pneumatic pressure.

## Spring Clamps

***Spring clamps*** have jaw lengths ranging in size from 4″ to 12″ (102 mm to 305 mm). See **Figure 33-1.** Jaw opening range is from 1″ to 4″ (25 mm to 102 mm). They may have vinyl coated jaws and handles to prevent marring the material. Dip clamp jaws in liquid plastic. The plastic, which cures to be a soft protective covering, is available in most hardware stores. The coated handles also improve your grip.

Spring clamps are easy to use. Pressure is constant depending on spring tension. However, you cannot control the pressure as with screw thread clamps. You might attach trim or inlays with spring clamps. See **Figure 33-2A.** You might also use vise grips. See **Figure 33-2B.** Place a protective piece of material between your workpiece and the jaws.

**Figure 33-1.** Clamps are placed on the workpiece after the adhesive is applied *(American Tool Companies)*

## Screw Clamps

*Screw clamps* allow you to vary the amount of pressure. This is both an advantage and disadvantage. While screw clamps allow you to properly tighten the joint, you can also overtighten them. When bonding an assembly, too much pressure both crushes the wood cells and may cause a starved joint. A *starved joint* is one that does not have enough adhesive. The adhesive squeezes out or too little was applied in the first place. Another disadvantage of screw clamps is you can fail to give enough pressure to glue joints. The glue will not be forced into wood cells within the joint. The bond will be weak.

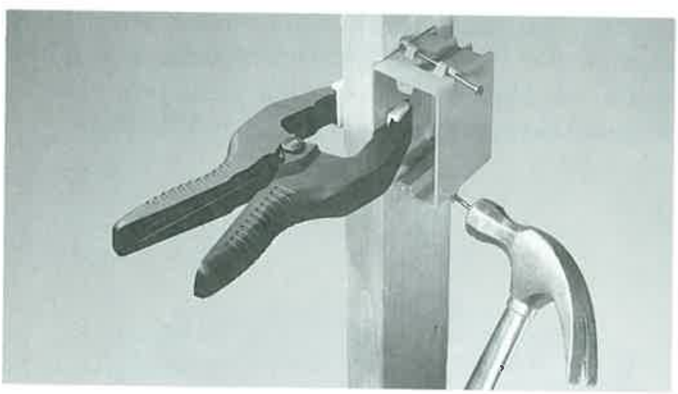
### Hand screws

*Hand screws* are one of the oldest woodworking clamps known. They range in size from a 4" (102 mm) jaw length and maximum opening of 2" (51 mm) to a 24" (610 mm) jaw length and a 17" (432 mm) opening. See **Figure 33-3A.**

People assume that screw clamps will not mar a workpiece because they are made of wood. This is not true. Marring will occur if the clamp is made of a harder wood than the material being held. Also, dried adhesive on the jaws is apt to dent the material.

You can adjust the jaw opening one handle at a time or by rotating both handles. For quick changes, swing the hand screw with both handles. This keeps the jaws parallel as the clamp opens. See **Figure 33-3B.**

When applying pressure, use the full surface of the jaws. Also make sure that the jaws are parallel. Otherwise, unequal pressure is applied and the workpieces are apt to separate.



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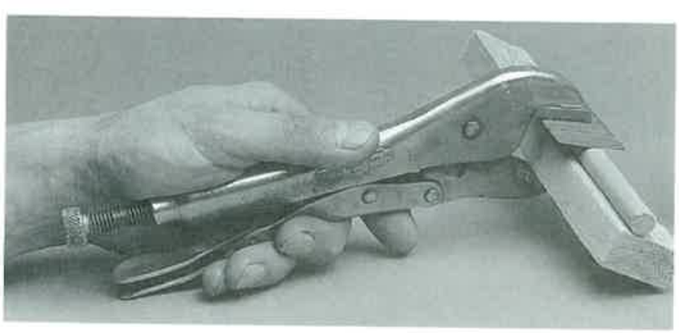

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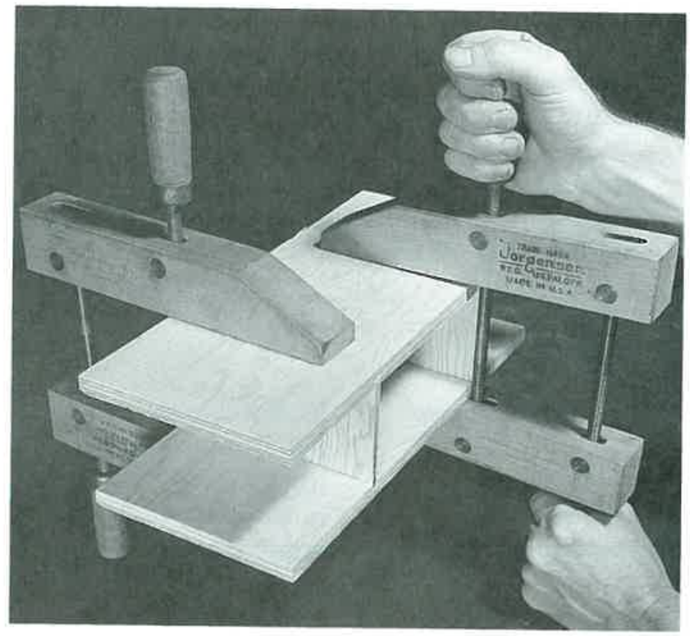
**Figure 33-2.** A—Using spring clamps. *(American Tool Companies)* B—Using vise grips. *(Franklin International)*



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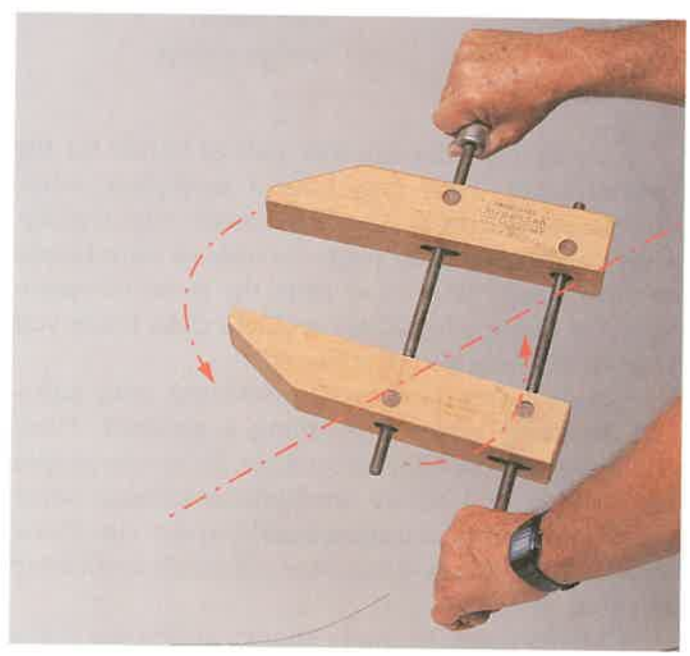


B

**Figure 33-3.** A—Hand screw jaws, when set parallel, will apply pressure evenly along the entire length. The jaws of the right clamp are not parallel. B—Swing clamp on centerline shown to keep jaws parallel as the clamp opens or closes. *(Chuck Davis Cabinets)*

## Bar clamps

*Bar clamps* can be used for short and long spans. They range from 6″ (152 mm) to 8′ (2438 mm), depending on the style. See **Figure 33-4.** They consist of a steel bar or pipe, fixed jaw (or head), movable jaw (or head), and screw handle.

To use a bar clamp, turn the screw handle counterclockwise as far as it will go. Slide removable jaw to the jaw's maximum opening. You may have to press a lever on the movable jaw or lift it from a notch in the bar. Place the fixed jaw against one side of the assembly. Place *backing blocks* (scrap wood) between the workpiece and the jaws. Then slide the movable jaw against the other side. Finally, tighten the screw handle to exert the correct amount of pressure on the assembly. For a glue joint, adhesive should ooze from the joint.

## Edge clamp fixture

An *edge clamp fixture* is a bar clamp accessory. It is often used to attach edging or trim, or hold some types of joints. See **Figure 33-5.** Slip the edge clamp between the bar clamp and the workpiece before tightening the bar clamp.

A

B

**Figure 33-4.** A—These sliding head bar clamps differ from the normal in that they exert pressure to spread the workpiece. B—Sliding bar clamps are available in a variety of sizes. *(American Tool Companies)*

## C-clamps

*C-clamps*, often called *carriage clamps*, are used quite often in the shop. See **Figure 33-6.** They can secure jigs to tabletops and machines as well as bond some types of joints.

The maximum opening (frame size) may range from 1″ to 18″ (25 mm to 457 mm). The throat depth from screw to frame can be 1″ to 4″ (25 mm to 102 mm). C-clamps may be further classified as light or industrial duty, depending on their strength. At the end of the screw jaw is a "foot" that swivels to prevent the screw from digging into the material. Again, it is best to place backing blocks between the jaws and the material.

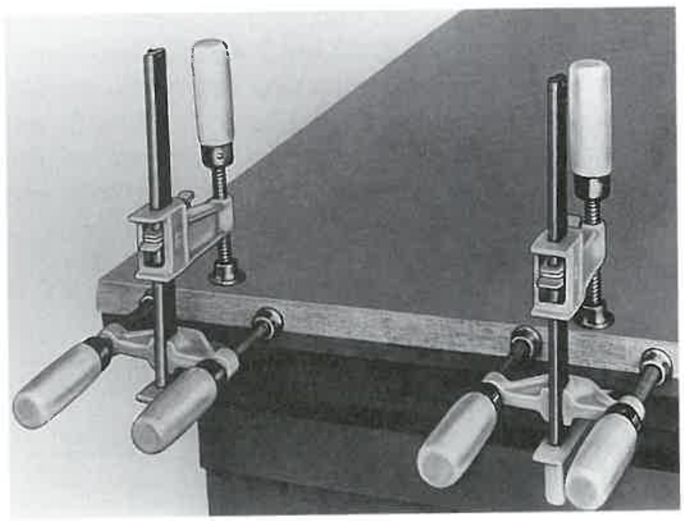


**Figure 33-5.** Use edge clamp fixtures to apply bonding pressure around the edge of tabletops. *(Franklin International)*

**Figure 33-6.** Clamps can secure mitered corners. *(American Tool Companies)*

## 3-way edging clamp

The *3-way edging clamp* is a combined C-clamp and an edge clamp fixture. See **Figure 33-7.** However, unlike the C-clamp, two screws hold the clamp.

## Web and band clamps

***Web*** and ***band clamps*** apply pressure in one direction—toward the center of the assembly. They are essential for irregular shapes. A cloth webbing, rubber strap, or steel band is pulled tight around the assembly. See **Figure 33-8.** A friction lock prevents the belt from loosening. A screw handle or steel hook allows you to apply the final pressure.

Light duty clamps are called ***web clamps.*** They have a 1" (25 mm) nylon web or belt about 12' to 15' (3.7 m to 4.6 m) long. Heavy duty clamps, called band clamps, have a 2" (51 mm) fabric or steel band.

One type of band clamp uses stretchable rubber straps and steel hooks. Place hooks on the strap at a distance slightly less than the perimeter of the assembly. Stretch the strap and slip the two hooks together. See **Figure 33-9A.**

Another band clamp includes 90° corner blocks. They can be moved to fit around frames. The band slides through them while tightening, **Figure 33-9B.** These clamps can increase efficiency. One band may replace four or more bar clamps, for example. Test the use of this clamp during your dry run.

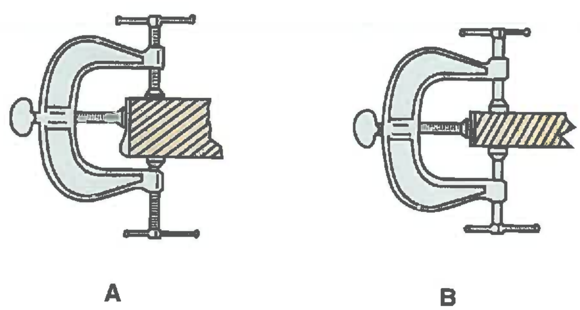



**Figure 33-7.** A—3-way edging clamps may be applied with the right angle screw off center. B—Right angle screw is centered. *(Shopsmith)*

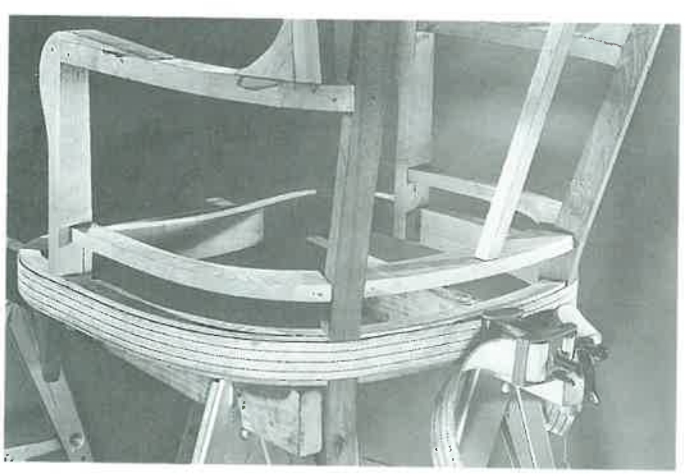


**Figure 33-8.** A web clamp holds this chair frame until the adhesive sets. *(Adjustable Clamp Co.)*

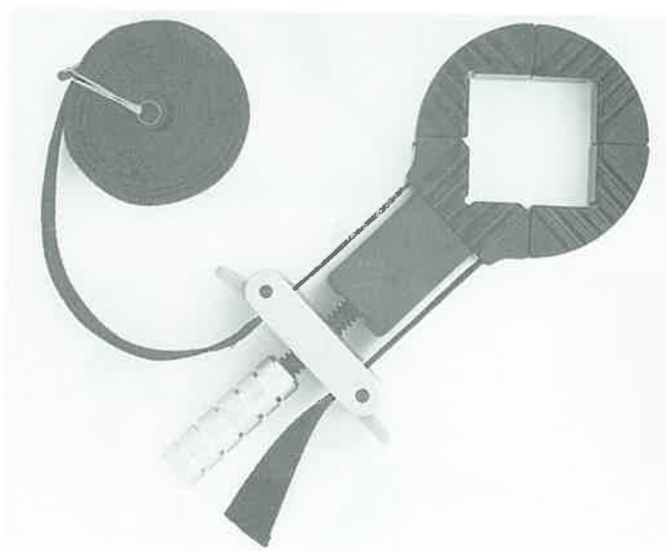




**Figure 33-9.** A—The rubber cord is looped through the metal hook to adjust the length of the band clamp. *(Brookstone Co.)* B—This clamp has 90° corner blocks for frames and other rectangular assemblies. *(Vermont American Tool Co.)*

## Miter clamps

*Miter clamps* are designed specifically for miter joints. Two screws hold the workpieces at the proper 90° angle. See **Figure 33-10A.** There is no direct pressure on the joint so it is important that you position and hold the workpieces while tightening.

Another miter clamp style can be used for workpieces which join at angles other than 90°. However, you must drill holes in the workpieces. See **Figure 33-10B.** Holes can be hidden later.

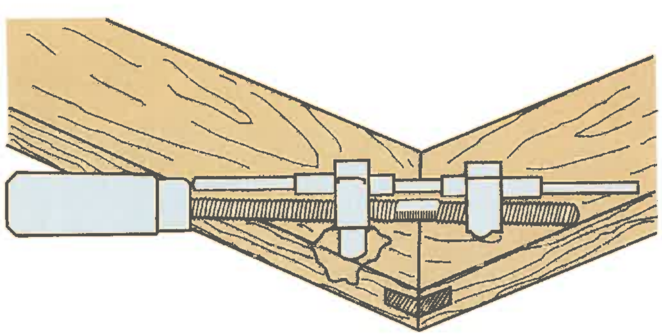
## Maxi-clamp system

The ***maxi-clamp system*** is a set of screws and fixtures that can be fastened many ways. See **Figure 33-11.** Arrange the clamp to fit your needs. Pressure can be applied in one, two, or three directions. Arrange the clamp setup during your trial assembly.

## Workbench vises

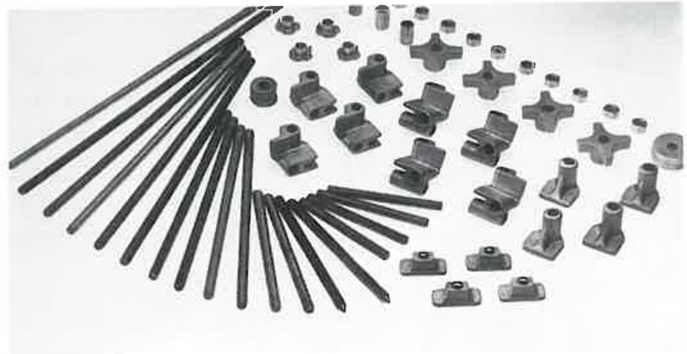
Many cabinetmakers find that their workbench vise occasionally meets a specific clamping need. The vise may be built in or attached to the bench. See **Figure 33-12.**


A

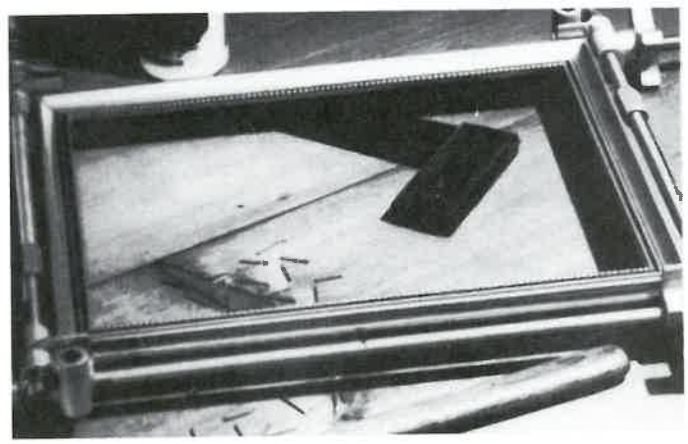


B

**Figure 33-10.** A—Miter clamps can apply pressure across corners. *(Record Ridgway Tools)* B—This clamp pulls workpieces together using holes drilled in the back of the frame. *(Shopsmith)*



A



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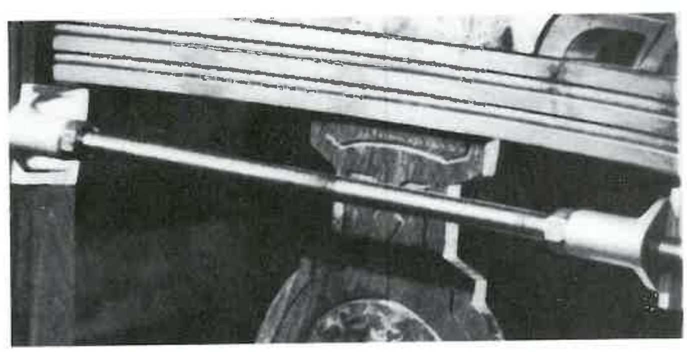
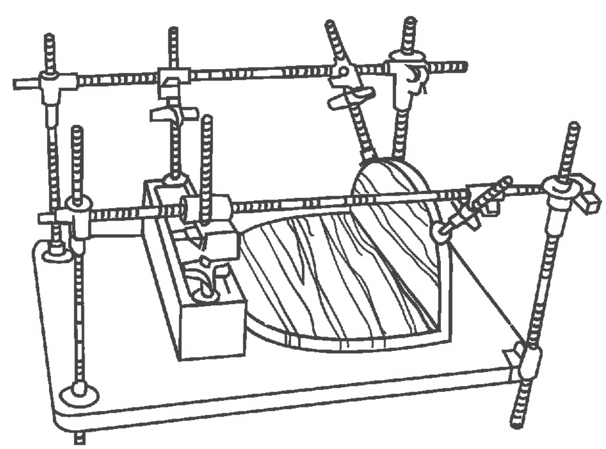


C



D

**Figure 33-11.** A—Maxi-clamp system parts. B—Clamping a frame. C—Attaching a chair back. D—Clamping in three directions. *(Shopsmith, Leichtung, Inc.)*

## Hold-down clamps

***Hold-down clamps*** temporarily secure an assembly to the table- or bench top. This keeps the components in the same plane. They may be used to clamp lap, miter, and other joints when installing fasteners. The clamp attaches through the bench stop hole with a bolt. See **Figure 33-13.** It may also fasten to the slot of a machine table.

## Veneer press

***Veneer presses*** are used to hold veneer to a wood substrate when gluing. This process is called veneering or overlaying. The practice has decreased since cabinetmakers can buy hardwood veneer plywood. However, many woodworkers still overlay rare and expensive hardwood veneers to lower priced, more stable materials such as particleboard and MDF.

A traditional veneer press has one or several rows of bolts mounted in a ***bed frame.*** See **Figure 33-14.** The bolts apply pressure on an ***upper caul.*** Sandwiched between the upper and ***lower cauls*** is your work. The size of the workpiece is limited due to structural requirements involved in provided the pressure required over large areas.

## Vacuum bag press

A vacuum bag press works on the principle that air above and around us has weight or exerts pressure. This pressure is about 15 pounds per square inch, or 29.9 inches of mercury at sea level. This pressure is equal in all directions. For example, by sucking on a straw to remove the air, a vacuum is created and the air pressure on the surface of the liquid in the glass pushes the liquid up the straw.

With vacuum bag presses, the air is removed from the bag and the air pressure on the outside presses inward. Air is removed from the bag, **Figure 33-15A,** to create the vacuum with either a rotary vane vacuum pump, **Figure 33-15B,** or Venturi vacuum generator. The time to evacuate one cubic foot of air to 24 inches of mercury varies from 6 to 34 seconds.

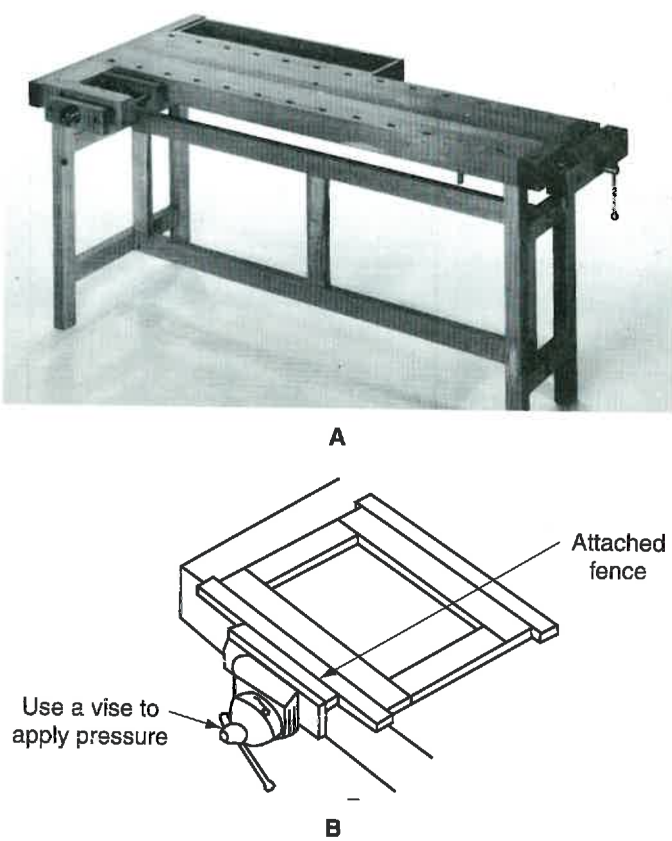



**Figure 33-12.** A—Vises may be built into the workbench. B—Using a fence and vise you can apply pressure to a frame.

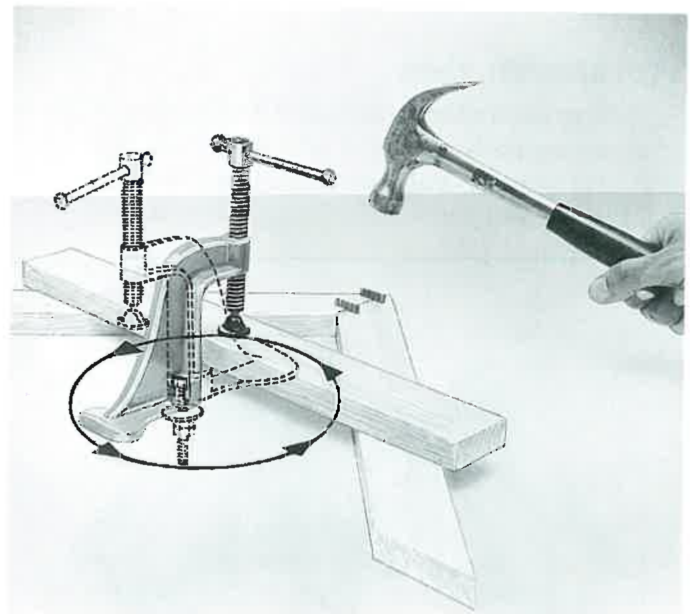


**Figure 33-13.** Position hold down clamps where needed. *(Adjustable Clamp Co.)*

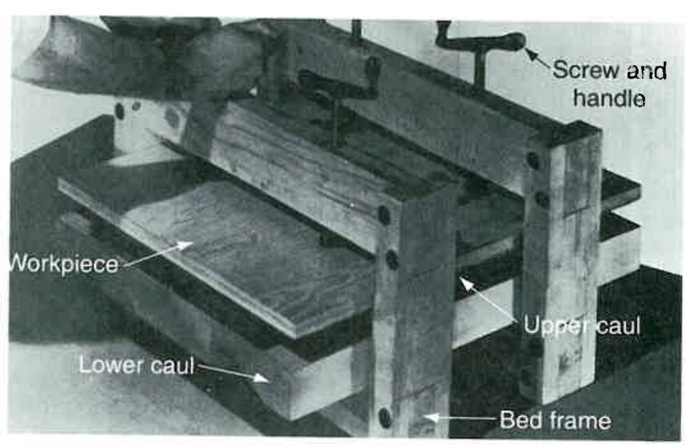


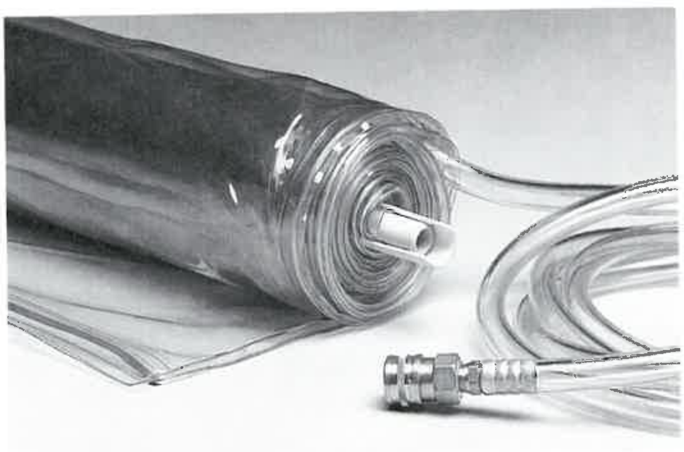

**Figure 33-14.** Parts of a veneer press. *(Franklin International)*

Working vacuum is 25 inches of mercury. Vacuum pumps maximum vacuum varies from 27 to 29.9 inches of mercury and Venturi vacuum generator's maximum is 28 inches of mercury.

To use vacuum bag presses, make a grooved platen from a sheet of thermofused melamine panel and insert it into the vacuum bag. The platen serves as a flat base for the workpieces and the grooves provide an escape route for the air. Prepare the substrate and laminate (veneer or HPDL) in the usual manner, apply a thin even layer of any woodworking glue to the substrate, and lay the laminate on top. Place a thin caul on top of the laminate. A scrap sheet of HPDL works well as a caul. Move the work to the platen. Snap on the double sided C-channel to close the bag. Turn on the pump and make final adjustments before applying full vacuum. Clamp time is about an hour.

Stock bag sizes are available that will accept material ranging from 49″ by 23″ (1245 mm by 584 mm) to 49″ by 169″ (1245 mm by 4292 mm). Custom bag sizes are available.

When making bent laminations, only a single concave or convex form need be made. See **Figure 33-16.** Form construction and set-up time are reduced. Place the glue coated laminates and a thin caul on the form. Use tape to temporarily hold them in position. Place the assembly in bag, close the bag with the C-channel, and turn on the pump. Clamp time is about three hours.



A


B

**Figure 33-15.** Vacuum bag press components. A—Vacuum bag, snap-on C-channel, and connecting tubing. The vacuum bag stores in a small space when not in use. B—Rotary vane pump. Hose connection manifolds allow connecting two or three bags to one pump. *(Mercury Vacuum Presses, Inc.)*

## Membrane press

Tabletop membrane presses provide pressing of veneers and other overlays on flat or contoured surfaces. See **Figure 33-17.** They also work well for making bent laminations with multiple glue lines. The membrane press uses a flexible silicone rubber membrane and a seal attached to an aluminum frame and platen. Capacity of different models are 39″ by 48″ (991 mm by 1220 mm), 39″ by 72″ (991 mm by 1829 mm), and 51″ by 97″ (1295 mm by 2464 mm). Counter-balance gas springs assist in opening and closing. A vacuum hose connects the frame to the vacuum pump.

To use the tabletop membrane press, lift the frame and place the glue coated assembly on the platen. Close the frame and turn on the vacuum pump. Atmospheric pressure instantly pushes the frame against the platen creating a seal. Full vacuum pressure is achieved in just a few seconds. The atmospheric pressure bears uniformly on the membrane, which is pressing the workpiece inside.

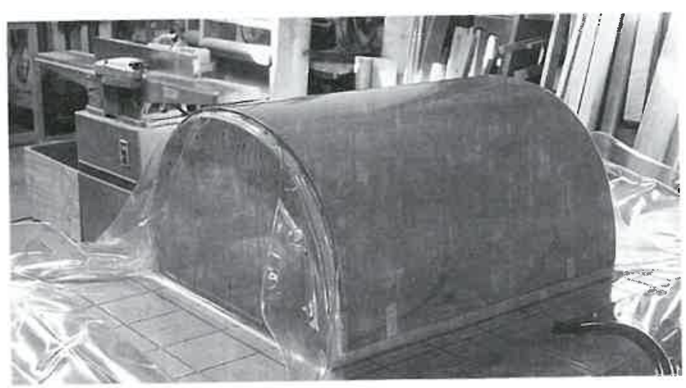


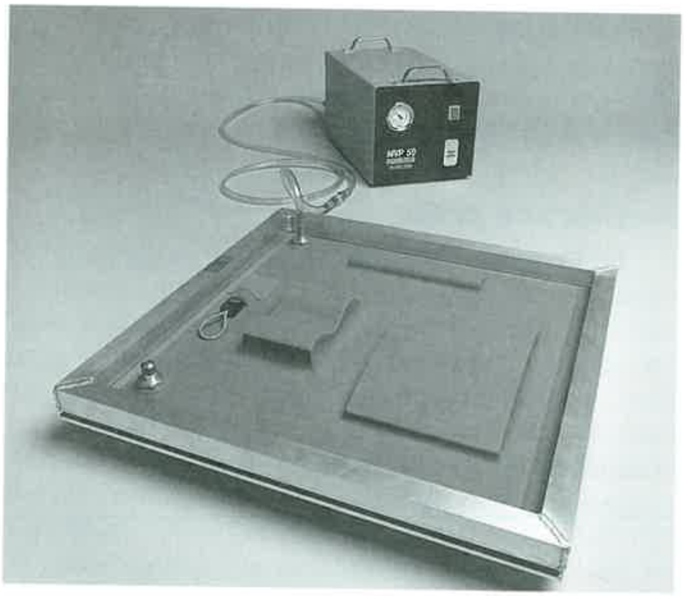
**Figure 33-16.** Half round forms can be used with vacuum bag presses. Provide holes for the air to escape from the inside of the form. The form must be strong internally to withstand the pressure. *(Mercury Vacuum Presses, Inc.)*

## Other Clamps

Several other common hand clamps are quick release clamps, cam clamps, and wedge clamps. These use neither screws nor springs to apply pressure.

### Quick-release clamps

*Quick-release clamps* can be used to quickly apply a preset, uniform pressure on an assembly. They may be lever or air pressure operated. You will often use them with a jig or fixture, to assemble multiple products. See **Figure 33-18.** The clamp is attached to the jig with screws or bolts. You might also attach them to a drill press table.



A

B

**Figure 33-17.** A—Atmospheric pressure at work with a tabletop membrane press. B—Press operation is complete. A variety of shapes and thicknesses up to 6" (152 mm) high can be laminated in this press. *(Mercury Vacuum Presses, Inc.)*

### Cam clamps

*Cam clamps* consist of a fence, locating pins, and cams. These are placed on a drilled hardwood locator board. See **Figure 33-19.** The board's holes are spaced for standard sizes.

Cam clamps are versatile. Many sizes of frames can be clamped quickly. Position a trial assembly to accurately arrange the pins and fences, then cams. Turn the hex head of the cam with a wrench to apply pressure. The simple action of the cam permits quick assembly.

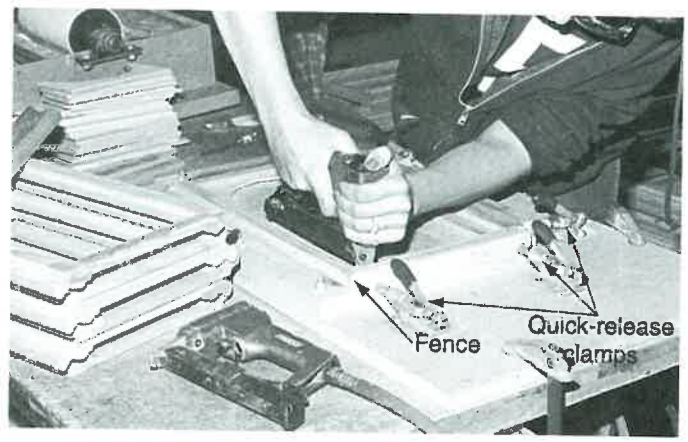



**Figure 33-18.** Quick-release clamps are often bolted to a jig. This jig, made of plywood with a fence and clamps, is for assembling picture frames. It is clamped to the workbench with a bar clamp. *(Craft Products)*

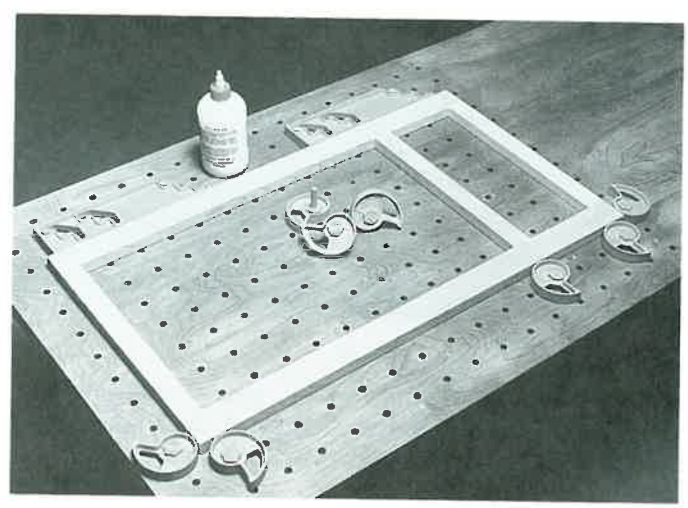


**Figure 33-19.** Cam clamps, positioned on the locator board, adjust to frame sizes. *(Meyer Vise Co.)*

### Wedge clamps

You can make ***wedge clamps*** to suit a variety of frame clamping purposes. The clamp consists of four fences attached to a metal covered bottom board. See **Figure 33-20.** The metal prevents excess adhesive from bonding the frame to the clamp. Pairs of wooden wedges slide past each other to apply pressure. Tap the wedges with a mallet to fully hold the assembly.

## Clamping Glue Joints

The quality of your product depends greatly on the care you take to process and assemble it. Clamps provide help for these purposes. Clamping helps you saw, drill, and process workpieces accurately. When you are ready to assemble the product, clamps provide the necessary pressure for good glue joints. Before clamping glue joints, make sure all workpieces are smooth and that the proper tools are available.

## Gathering Tools and Supplies

The following tools and supplies must be readily available when preparing to assemble a product:

- Select the proper adhesive. For water-base and two-part adhesives, have measuring devices handy. Mix the adhesive only when you are ready to spread it. Squeeze bottles, with nozzles, are best for ready-to-use adhesives. If you will be RF gluing the product, check that all equipment is present and in good working condition.
- Lay out the correct number and type of clamps preset to the approximate opening. Select clamps that will provide adequate pressure and clamp to workpiece contact.
- Make backing blocks or buy clamp pads to place between the clamp and wood to prevent marring the surface. See **Figure 33-21.**
- Acquire the proper adhesive applicator. For small areas, use a bottle, brush, or stick. For larger areas, consider a roller or sprayer.
- Obtain a sponge or rag and water or solvent to wipe off excess wet adhesive. Dried adhesive will not absorb stain during finishing. Therefore, that area will retain its natural color.
- Cut and place wax paper between clamps or backer blocks and the workpiece at a glue joint. This prevents clamps from being bonded to the assembly. It also retards stain marks caused by glue contact with metal clamps. See **Figure 33-22.** For wood handscrews, consider coating them with paste wax or silicone spray.
- Have a rubber mallet handy to tap joints into alignment once the assembly is glued and clamped.
- Select a framing and/or try square to check squareness of the assembly. When necessary, have a sliding T-bevel preset to check angles of your product.

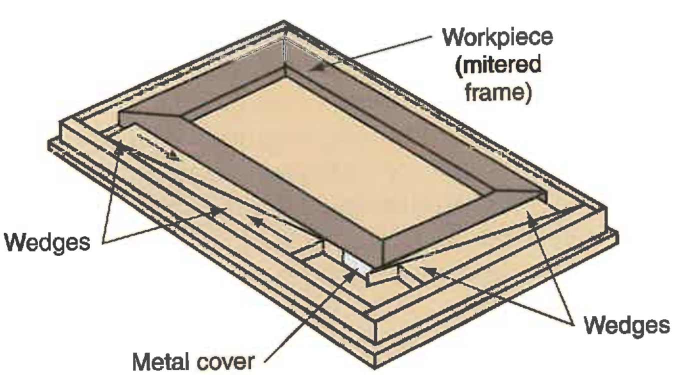
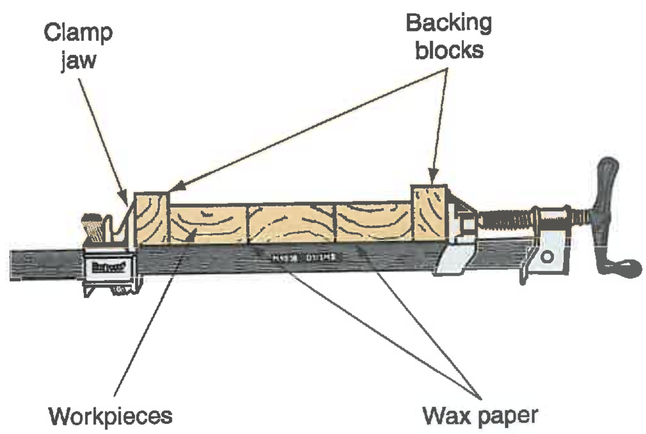



**Figure 33-20.** Make a simple wedge clamp to assemble small frames quickly.



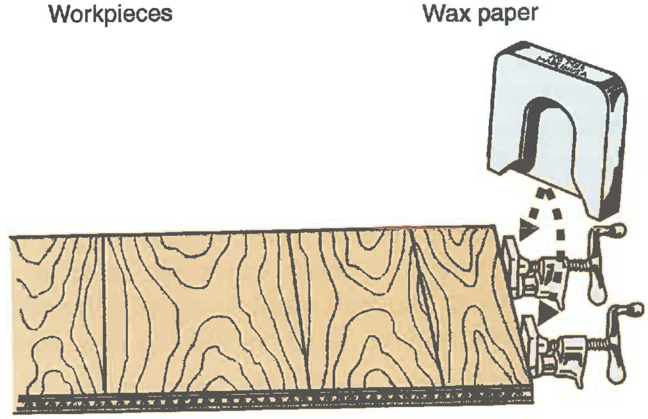



**Figure 33-21.** Backing blocks and clamp pads protect your product from damage caused by clamp jaws. *(Adjustable Clamp Co.)*

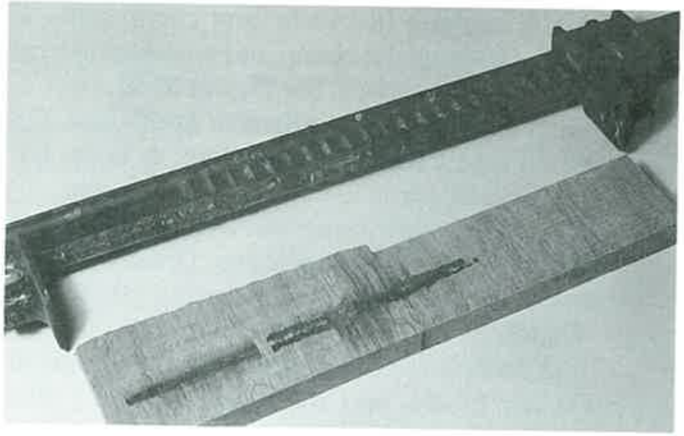


Figure 33-22. Typical wood stain caused by bar clamp.

* Use a straightedge to check the flatness of glued panels. For case assemblies, use it to see if excess pressure was applied which would cause cupping.

## Clamping Procedure

The procedure for clamping includes making a trial assembly (also called a dry run), applying adhesive, and clamping the assembly.

### Trial assembly

First, secure the components without adhesive. Use pads or backing blocks to protect the wood. Position clamps so that joints are given the necessary pressure. Have as much clamp surface in contact with the workpiece as possible. Place bar clamps alternately over and under the workpiece where possible. This evens out pressure and prevents cupping the wood. Also clamp workpieces with hand screws against bar clamps to prevent cupping. Whenever feasible, use clamps in pairs on both sides of the assembly. See **Figure 33-23.** This prevents one end from being separated while the other is being joined.

Inspect all joints, dimensions, and angles of the clamped assembly. The joints should fit well without excessive pressure. See that all dimensions are correct. Be sure that corners are square or at the angle shown on your shop drawings.

If the assembly fits properly, loosen the clamps just enough to remove them. Lay them aside in an orderly manner. You will want to reuse them after the adhesive is spread. They should not need to be adjusted again.

As you disassemble the workpieces, you may wish to mark them. With a pencil, lightly write letters or numbers on adjoining workpieces. These help identify mating parts during reassembly.

**Figure 33-23.** The same number of clamps have been placed on each side of this case assembly. Doing so balances clamp pressure. *(American Tool Companies)*

### Applying adhesive

Your next step will be to apply the adhesive. Lay all workpieces out in an orderly manner. This will make clamping more efficient. If you are using a two-part adhesive, mix the proper amount. Then spread the adhesive to all surfaces being bonded. Applying adhesive to both parts of a glue joint is better than a single spread. However, with hot melt glue, one surface is sufficient.

For glues with a short assembly time, layout and glue subassemblies first. Then glue these together later to complete the product assembly.

For liquid adhesives, once you have spread the glue, let it set for about a minute. This increases the wet tack. Then it is necessary to fit workpieces together quickly and accurately.

### Clamping the wet glue assembly

After the glue is spread, reassemble the components. Insert wax paper between joints and clamps.

At first, lightly tighten all the clamps. Use a square and T-bevel to check adjustment frequently. Have a rubber mallet handy to tap joints into alignment. Then tighten clamps evenly. Again check the squareness and alignment of components. If necessary, use a block of softwood and a mallet or hammer to move misaligned joints. Place a straightedge over flat surfaces to check whether components have bowed under pressure. If so, relieve pressure slightly.

Properly fit glue joints require little pressure. Overtightening the clamps will result in a starved joint. Properly clamped joints will have small beads of glue at intervals along the joint. See **Figure 33-24.**

When the assembly is securely clamped, wipe off all excess adhesive. Sprinkle sawdust over the oozing glue beads to make the adhesive easier to remove. Dried adhesive can be removed later with a cabinet scraper. Do not wet the product surface with water or solvent. This only spreads the glue. The glue film would have to later be removed by sanding.

Allow the glue to reach its set time before removing clamps. When possible, it is advised to leave clamps on during the curing time also. Material and environmental conditions affect the adhesive set and cure time.

## Edge-to-edge Bonding

Frequently, a cabinetmaker needs boards wider than can be readily bought. Also, exceptionally wide boards tend to warp. Make them by edge-gluing narrower stock. The component arrangement is most important when edge gluing. Alternate the end grain (curve of the annual rings) with each piece. See **Figure 33-25.** This reduces the amount of cup in the assembled board.

Some lumber will be wide enough, but cupped. Removing the cup by planing the surfaces will likely reduce the thickness too much. You can rip the board into narrow pieces and edge-glue them back together as shown in **Figure 33-25B.**

The procedure for edge-gluing stock to make wider boards is:

1. Rip and joint narrow stock.
2. Cut all workpieces 1/2" (12.7 mm) longer than the final length of the component.
3. Arrange the end grain pattern and mark mating joints. See **Figure 33-26.**
4. Place bar clamps on a flat surface and place the workpieces on it.
5. Position bar clamps every 10" to 20" (254 mm to 508 mm). Two clamps should be located near the ends.
6. Place wax paper over the clamps to prevent discoloring the wood.
7. Arrange workpieces on the clamps as marked.
8. Apply adhesive to the workpiece edges and press them together.
9. Lay wax paper over the glued joints.
10. Place bar clamps over the assembly, spaced between the bottom clamps. See **Figure 33-27.**

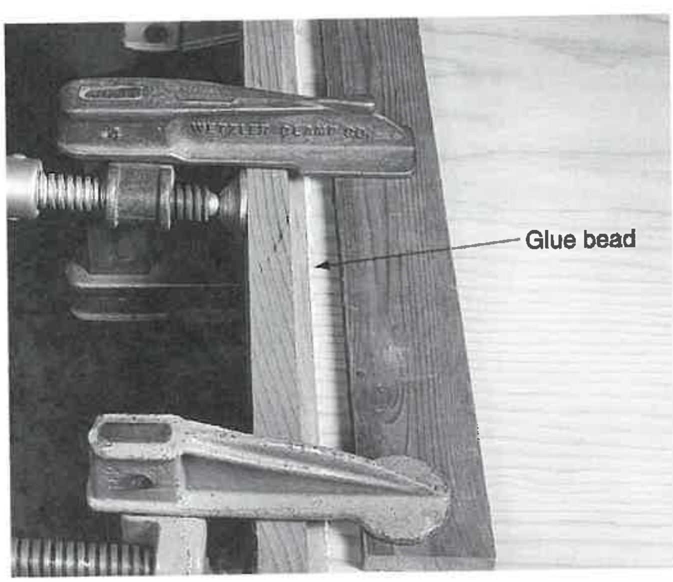



**Figure 33-24.** A properly clamped glue joint should have glue beads, but not runs. The absence of beads may indicate a *starved joint.*

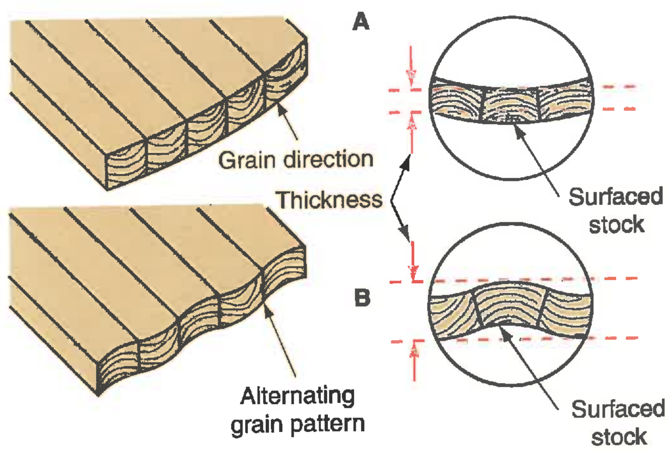



**Figure 33-25.** A—Edge-gluing workpieces without alternating grain pattern results in more warp and less surfaced thickness. B—Properly positioned workpieces results in less warp and greater surfaced thickness.

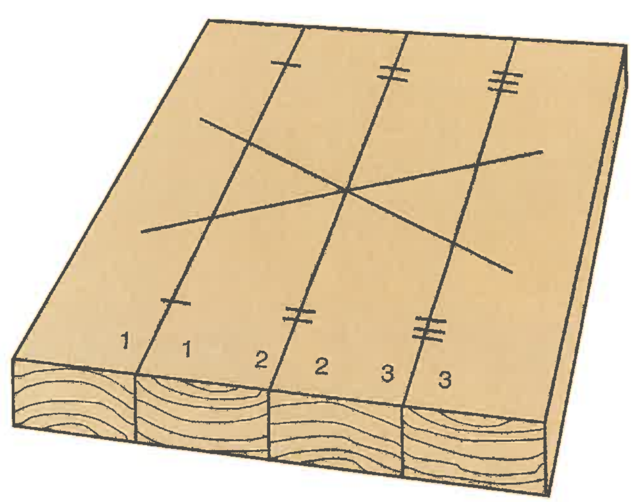



**Figure 33-26.** Lightly mark workpieces with a pencil to identify mating joints.

11. Tighten the bar clamps, making sure the workpieces lie flat on the bottom clamps. Also check that joints remain aligned; if not, strike them with a mallet.
12. If one or several pieces are cupped, clamp them to the bottom bars with hand screws. See **Figure 33-28.**

If you are edge-gluing boards of the same thickness, double clamps work well for alignment. See **Figure 33-29.** First, slide the lumber between the bars. Then set the clamps to the approximate width. Twist the double bar clamps as you tighten the screw. One bar will be flush above and the other will align the boards below.

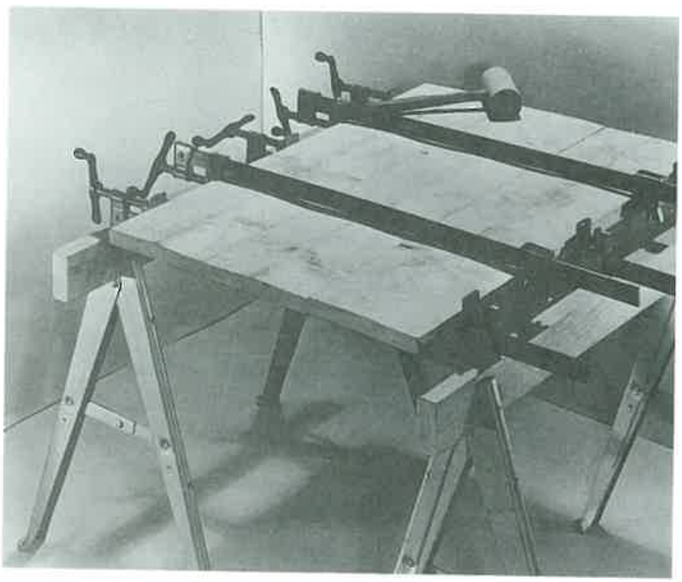


**Figure 33-27.** Alternate bar clamps on top and bottom of assembly. Use a mallet to position boards which slip out of place. *(Franklin International)*

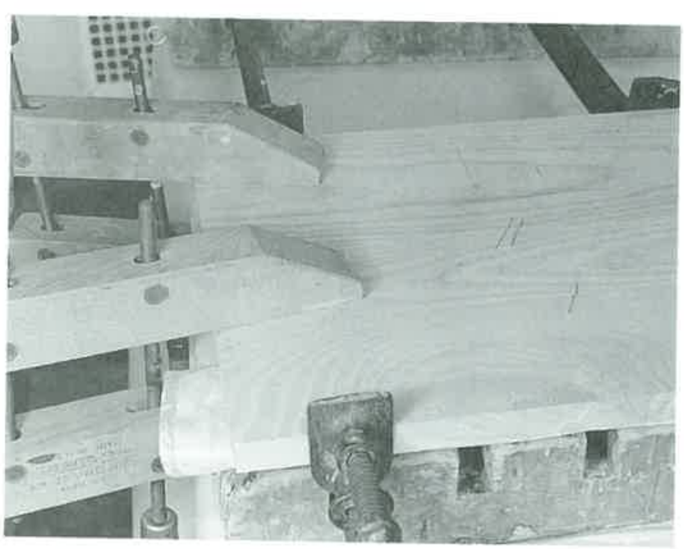


**Figure 33-28.** Hand screws hold boards against bar clamp for alignment.

## Face-to-face Bonding

For thicker components, bond workpieces face-to-face. By reversing the end grain pattern, a component made of two pieces is less apt to warp than solid lumber. Match grain patterns if possible. Straight grain patterns are less likely to warp than figured grain.

Use handscrews when clamping workpieces face-to-face. See **Figure 33-30.** This puts pressure in the center and at the edges. The procedure is as follows:

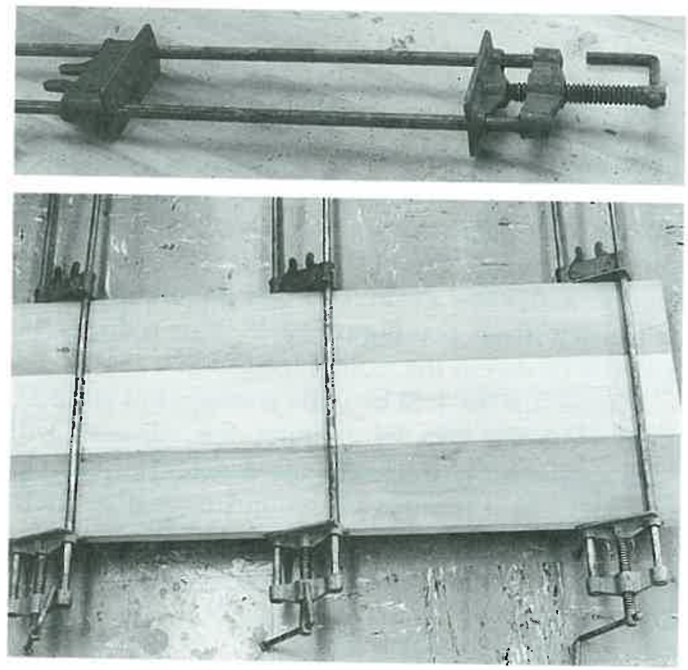


**Figure 33-29.** Double bar clamps align the boards while clamping.

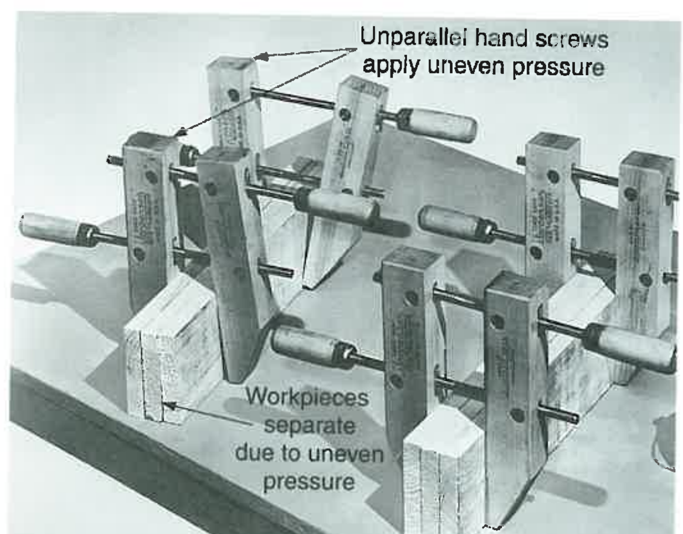



**Figure 33-30.** Hand screw jaws should be adjusted parallel with the surfaces. Notice how clamped assembly at left has separated because of uneven pressure. *(Adjustable Clamp Co.)*

1. Preset the clamp jaws parallel and to the approximate opening of the assembly.
2. Apply a double spread of adhesive.
3. Place the workpieces together with the end grain (annual rings) opposite each other.
4. Position and tighten the first handscrew at one end of the assembly.
5. Set additional clamps working toward the other end. Space them about 10″ to 20″ (254 mm to 508 mm) apart. If the glue doesn't ooze from the joint, add more clamps.

## Clamping Frames

When clamping frames, it is important that you work on a flat surface. This helps align the frame. **Figure 33-31** shows a typical frame clamping arrangement. If the frame becomes out of square, shift one or two bar clamps at a slight angle. This diagonal force pulls the frame into alignment. Then look across the frame to be sure it is not twisted.

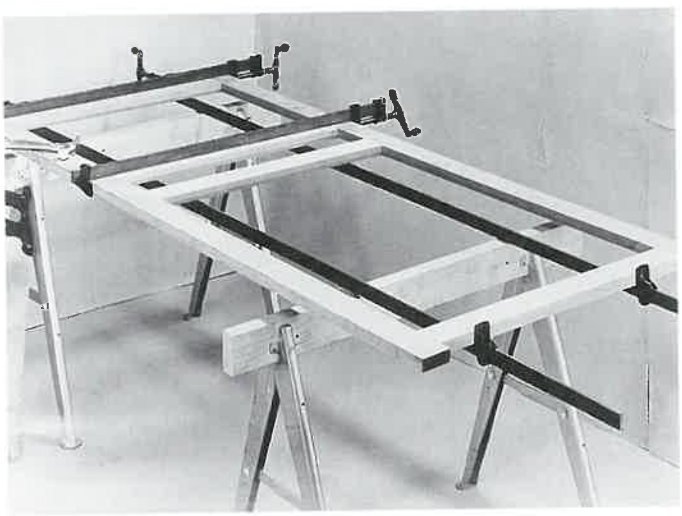


**Figure 33-31.** Clamping a frame with 8′ (2438 mm) and 3′ (914 mm) bar clamps. *(Adjustable Clamp Co.)*

## Summary

Clamps are used to position and hold assemblies They also serve as extra hands while you are processing materials. They can hold jigs and fixtures in place during production.

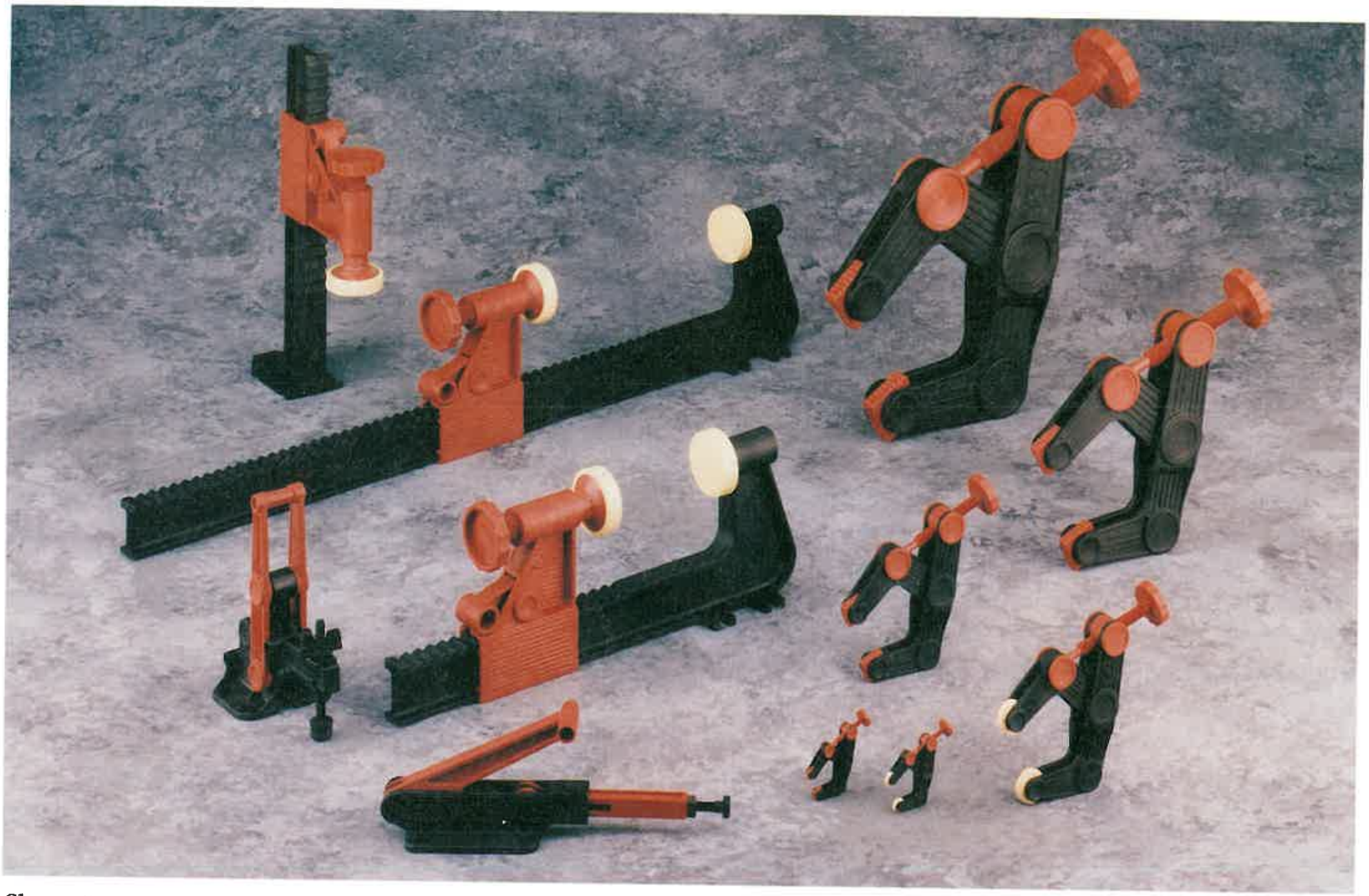
Clamp pressure is achieved with springs, screw threads, levers, cams, and wedges. Hand clamp pressure is adequate for most cabinetmaking purposes. Hand clamps include spring clamps, hand screws, bar clamps, edging clamps, band clamps, and miter clamps. Quick-release, cam, and wedge clamps are also common. Machine clamps are used for high production operations. Clamp pressure is supplied by pneumatic or hydraulic rams.

The bonding procedure involves a trial assembly, spreading the adhesive, and clamping the glued assembly. The trial assembly is made to check the fit of joints. It also lets you experiment with positioning clamps for proper pressure. Then adhesive is spread on the components, after which they are reassembled and clamped.

## Test Your Knowledge

*Do not write in this text. Answer the following questions on a separate sheet of paper.*

1. Clamps are used for both _____ and _____.
2. With a spring clamp you cannot adjust the _____.
3. List an advantage and a disadvantage of using screw clamps.
4. The position of hand screw jaws when clamped should apply pressure _____.
   a. at the tip of the jaws
   b. at the back end of the jaws
   c. the entire length of the jaws
   d. only with the top jaw to prevent workpiece damage
5. Two styles of bar clamps are _____ and _____.
6. An edge clamp fixture is used with a(n) _____ clamp.
7. A light duty band clamp is called a(n) _____.
8. Quick-release clamps are often part of a(n) _____ or _____.
9. Cam clamps are most used to assemble _____.
10. List eight tools or supplies you should have on hand before clamping.
11. You assemble your product without adhesive during a(n) _____.
12. Explain four considerations when positioning clamps.
13. Diagram the direction of the annual rings when gluing stock edge-to-edge.



Shown are various styles and sizes of clamps. *(De-Sta-Co Industries)*

# Bending and Laminating

34

## Objectives

After studying this chapter, you will be able to:
- Identify methods of dry bending wood.
- Describe the procedures for wet bending wood.
- Follow the procedures for laminating flat and curved components.

## Important Terms

elasticity
free bending
full surface, one direction lamination
kerf bending
partial surface lamination
plasticizing
segment lamination
straight laminations
wet bending
wood bending
wood laminating

Many furniture designs require processes beyond cutting and assembling solid wood components. Thicker and stronger cabinet parts are made by bonding two or more pieces of wood together. This is laminating. Curved pieces, such as drawer fronts, chairbacks, and table aprons are made by bending and/or laminating.

## Wood Bending

***Wood bending*** is the process of forming a piece of solid lumber into a curve. See **Figure 34-1.** Under pressure, wood fibers compress on the inside of the curve and stretch on the outside.

All wood species will bend to some radius. See **Figure 34-2.** This is called ***elasticity***. However, the grain pattern and the amount of defects in the wood are more important than the species. Select straight grain wood for bending. Samples with figured grain are more likely to split. There should be few defects in wood. Use wood free of knots, checks, splits, and other separations of the grain. Blue stain or other surface blemishes do not affect bendability.

Moisture content in the wood also affects the radius of the bend. Moistening increases bendability. This is why most lumber is steamed before being bent.

**Figure 34-1.** These chair backs and arms were steam bent to form gentle curves. *(Thomasville)*

Plywood and fiberboard can also be bent. However, the bending radius is limited. Plywood limits are shown in **Figure 34-3A,** and fiberboard limits are shown in **Figure 34-3B.** This is due to cross grain fibers and adhesive.

Bending requires pressure. The sharper the curve's radius, the greater the required pressure. The pressure is usually supplied by a mold and clamps. The mold is the shape of the desired curve. Clamps or a press hold the wood to the mold. Gentle curves form with the aid of clamps or wedges. Sharp bends may require a hydraulic press and several tons of pressure.

Listen to and watch the material during the bending process. If a cracking noise can be heard, the bend radius is too sharp. You may have to plane the lumber thinner.

Wood and manufactured wood products bent while dry must be held in place permanently by glue, joints, or mechanical fasteners. Stress is produced when wood is bent without moisture.

| Species | Minimum Bend Radius | | | | | |
|---|---|---|---|---|---|---|
| | Dry 1/8" (3 mm) | | Steam 1" (25 mm) w/mold | | Steam 1" (25 mm) wo/mold | |
| | (inch) | (mm) | (inch) | (mm) | (inch) | (mm) |
| Ash | 4.8 | 122 | 4.5 | 110 | 13 | 330 |
| Beech | 4.5 | 114 | 1.5 | 38 | 13 | 330 |
| Birch | * | * | 3 | 76 | 17 | 430 |
| Cherry | 5.9 | 150 | 2 | 51 | 17 | 430 |
| Chestnut | 7.5 | 191 | 18 | 460 | 33 | 840 |
| Douglas Fir | 7.8 | 198 | 14 | 360 | 27 | 690 |
| Elm | 4.6 | 117 | 1.7 | 43 | 12.5 | 320 |
| Hemlock | 8.8 | 223 | 19 | 480 | 36 | 910 |
| Hickory | 5.8 | 147 | 1.8 | 46 | 15 | 380 |
| Mahogany | 8.5 | 216 | 36 | 910 | 32 | 810 |
| Maple | 6.4 | 163 | * | * | * | * |
| Oak | 5.4 | 137 | 1 | 25 | 11.5 | 290 |
| Pine | 5.9 | 150 | 34 | 860 | 29 | 740 |
| Poplar | 6.3 | 160 | 32 | 810 | 26 | 660 |
| Sitka Spruce | 5.4 | 137 | 36 | 910 | 32 | 810 |
| Sycamore | 4 | 102 | 1.5 | 38 | 14.5 | 370 |
| Walnut | 6 | 152 | 1 | 25 | 11 | 280 |
| Western Red Cedar | 8 | 203 | 35 | 390 | 37 | 940 |

*Data not available

**Figure 34-2.** This table shows the approximate radius for bending selected wood samples. Numbers indicate the smallest radius that should be attempted. This may vary according to what type of machines or pressure are used. Dry bending samples were tested at 12 % moisture content. Steam bends were tested at 25% M.C.

This method of holding the wood should be designed into the product. See **Figure 34-4.** The illustrated kitchen island features a ¼" (6 mm) veneered MDF panel with a 42" (1067 mm) radius. The panel is fastened with glue to twelve ¾" by ¾" (19 mm by 19 mm) vertical stringers let into four curved horizontal ribs. Screws into the top and bottom rib reinforce the glue. The screws are then covered by the steam-bent half-round moldings.

Moisture, heat, and chemicals make wood easier to bend. This is called ***plasticizing***. Heat speeds up absorption of moisture by the wood fibers. After the wood is formed and left to cool and dry, it will closely hold the formed shape. Some springback is likely to occur. This is the wood's attempt to return to its original straight shape.

## Dry bending

There are two ways to bend lumber dry. One is to bend the workpiece by hand and hold it in place with fasteners. The other process is kerf bending.

### Plain bending

Workpieces to be bent dry should pass a stress test. A sample is bent to the desired shape. If it cracks or splinters, plane the workpiece thinner and try again. Secure the bent wood with adhesive, trim, screws, or other fasteners.

### Kerf bending

In ***kerf bending***, you cut saw kerfs in one face of the wood. This allows sharper and easier bends than solid dry lumber. However, a kerf-bent curve is weak. It should be attached to another component, much as an apron is attached to a tabletop.

#### *Bending with saw kerfs*

Three measurements control the bending radius. One is the width of the kerfs. This is determined by the saw blade. The second is the depth of the kerfs. Generally, these are cut to about 1/16" (2 mm) from the opposite surface. The third is the distance between kerfs. Making the kerfs too deep or too far apart is seen as a fold when the piece is bent. Cut kerfs in a scrap piece to test the bending characteristics of the wood you are using.

You can kerf bend convex as well as concave curves. See **Figure 34-5.** In both cases, cut kerfs in back (hidden side) of the workpiece. If both sides are visible, kerf the concave side. Bend the workpiece to the desired shape (when the kerfs close). Then overlay the kerf side with veneer.

When kerf bending, you must find three distances.

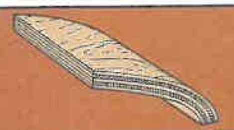
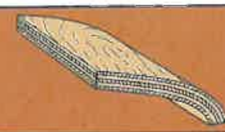
- The circumference of the desired curve.
- The length of lumber needed.
- The distance between kerfs.

To demonstrate the kerfing procedure, let's make an apron for a round table. The table is 25" (635 mm) in diameter and has a 22" (584 mm) apron. First, calculate the circumference of the apron:

*Circumference = Pi × diameter*

*Circumference = 3.14 × 22*

*Circumference = **69***

| Plywood Bending |  | |  | |
|---|---|---|---|---|
| **Plywood Thickness** | **Parallel to Face Grain** | | **Perpendicular Face Grain** | |
| (in) / (mm) | (in) | (mm) | (in) | (mm) |
| 1/4 / 6.0 | 64 | 1626 | 20 | 508 |
| 3/8 / 9.5 | 88 | 2235 | 40 | 1016 |
| 1/2 / 12.5 | 112 | 2845 | 80 | 2032 |
| 5/8 / 16.0 | 152 | 3860 | 100 | 2540 |
| 3/4 / 19.0 | 216 | 5486 | 164 | 4166 |

A

| Minimum Bending Radius | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thickness | | Cold Wet Bends | | | | Cold Dry Bends | | | | Heated Bends | | | |
| | | Out# | | In# | | Out# | | In# | | Out# | | In# | |
| (In) | (mm) | (In) | (mm) | (In) | (mm) | (In) | (mm) | (In) | (mm) | (In) | (mm) | (In) | (mm) |
| 1/8 | 3.0 | 7 | 175 | 5 | 125 | 12 | 300 | 10 | 250 | 2.5 | 62.5 | 2 | 50 |
| 3/16 | 4.5 | 10 | 250 | 8 | 200 | 18 | 450 | 16 | 400 | 3.5 | 87.5 | 3 | 75 |
| 1/4 | 6.0 | 15 | 375 | 12 | 300 | 27 | 675 | 24 | 600 | 5 | 125 | 4 | 100 |
| 5/16 | 7.5 | 22 | 550 | 18 | 450 | 35 | 875 | 30 | 750 | 7 | 175 | 6 | 150 |

B

**Figure 34-3.** A—This table shows the dry bending radius for plywood. Wet bending could soften the adhesive and separate the layers. *(Forest Products Laboratory)* B—Both untempered and tempered high density fiberboard (hardboard) can be bent. The radius varies on whether the smooth side of the board is outside or inside the bend. Heat bending was done between 300°F and 400°F (149°C and 204° C). *(Forest Products Laboratories)*

**Figure 34-4.** Large radius dry bend using 1/4" MDF panel with mahogany face veneers. The top and bottom half-round molding were steam bent and glued to the assembly. *(Chuck Davis Cabinets)*

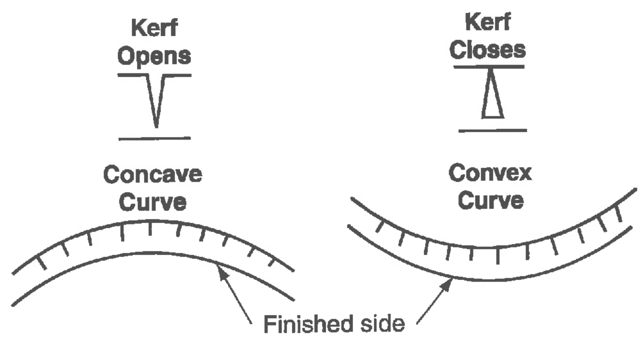


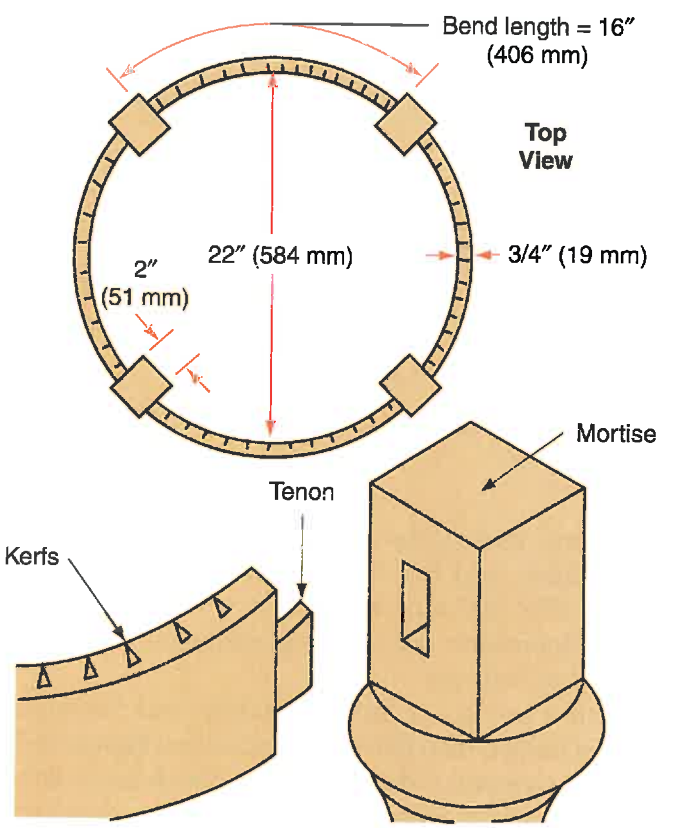

**Figure 34-5.** Kerfs can be made for both concave and convex curves.

You need to bend four individual pieces to make the entire curve. This means that each one will be ¼ of the circumference, or 18" (457 mm). However, ¾" (19 mm) tenons will be cut in the apron pieces to insert into the table leg mortises. Subtract the width of the table legs to determine how much of the apron piece is to be kerfed for bending. Each table leg is 2" (51 mm), making the bend length 16" (406 mm). See **Figure 34-6.** Add two ¾" (19 mm) tenons and each piece is 17½" (445 mm) long.

To determine the spacing between saw kerfs, proceed as follows:

1. Cut a test board the exact width and thickness, but longer, than the apron pieces. See **Figure 34-7.**
2. From one end of the board, mark the distance of the radius of the curve (11" [279 mm] in this example).
3. Make a saw kerf at this point to a depth of 1 /16" (2 mm) from the other face of the board. A radial arm saw works best.
4. Securely clamp the board with the kerf up. Place the free end of the board even with the table edge.


A




B

**Figure 34-6.** A—This round lamp table has an apron attached underneath. *(Bassett)* B—The apron is made of four kerf bent pieces attached to the legs with mortise and tenon joints.

5. Lift the board until the kerf closes.
6. Measure the distance between the end of the board and the table. (Suppose it is 1".) This is the distance between kerfs.

Kerfs are easily cut using a radial arm saw. Set the saw blade 1/16" (2 mm) above the table. Cut the workpieces as follows:

1. Evenly space kerfs along the bent length. For our example of 16" (406 mm) bending length, the distance will be 1" (25 mm) from the end of the tenons and 1" (25 mm) between kerfs centers. See **Figure 34-8.** Mark kerf centers.
2. Set the saw 1/16" (2 mm) above the saw table.
3. Cut the kerfs.

Once the cuts are made, bend the workpiece to the proper radius and hold it in place with glue or fasteners.

### *Bending with particleboard*

KerfKore® is a substrate with individual, evenly spaced ribs of particleboard. The ribs of particleboard are laminated between layers of phenolic impregnated and latex impregnated papers. See **Figure 34-9.**

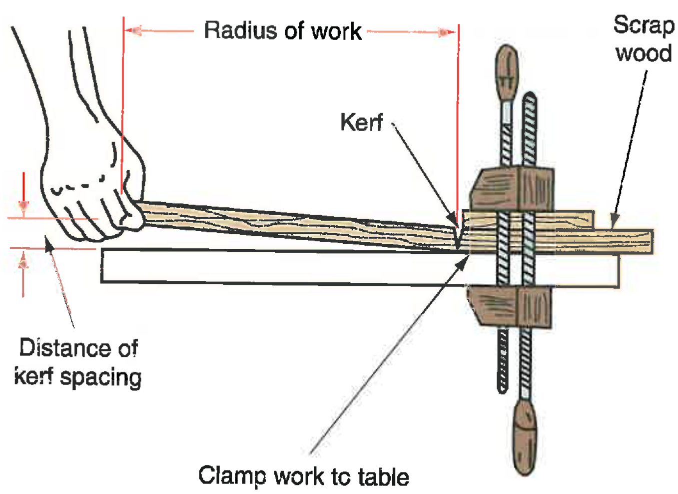



**Figure 34-7.** The distance between kerfs is found by bending a sample piece of material.

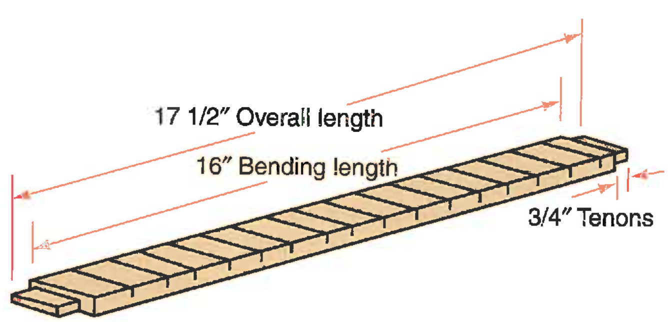



**Figure 34-8.** This is one of the four kerfed apron pieces for the table in Figure 34-6A.

**Figure 34-9.** KerfKore® substrate was used for these lazy Susan shields. HPDL was laminated to both the inside and outside radius. It is an attractive means of protecting little fingers from the Susan in this busy travel agency. *(Chuck Davis Cabinets)*

HPDL and phenolic backed veneers are laminated flat to the latex impregnated paper side using contact cement. The phenolic impregnated paper on the other side is sliced or cut away between selected ribs to allow for the bend. Bending the KerfKore causes the applied decorative facing material to compress the latex impregnated paper at the rib corners. Bending also causes the applied decorative facing material to stretch the paper and glue line in the rib centers. The result is a smooth radius. The reverse is true on an inside radius.

With this composite construction, difficult to bend materials such as HPDL, Colorcore®, Vitricor®, Solicor®, *etc.* are able to be bent further than normal without cracking. For instance, Vitricor 1/16" (2 mm), HPDL general purpose grade GP50, Colorcore, and Solicor can be bent to an outside radius of 3½" (89 mm) and 3" (76 mm) on an inside radius. Vitricor 1/8" (3 mm) can be bent to an outside or inside radius of 12" (305 mm).

KerfKore can be used in many applications, including radiused side panels, column covers and wraps, free-form tables, two sided structures, curved doors, and flexible pocket doors.

Some of the techniques of using this material are presented in *Chapter 36*.

## Wet bending

***Wet bending*** involves softening, or plasticizing, the lumber. The workpieces may be:

- Soaked in water at room temperature.
- Soaked in boiling water.
- Placed in a steam chamber. See **Figure 34-10.**
- Wrapped in wet towels and placed in a 200°F (93°C) oven.

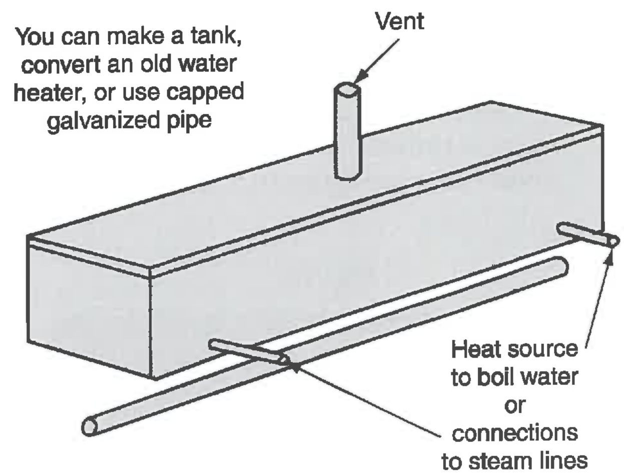



**Figure 34-10.** For soaking or steaming wood, use a nonrusting container that holds water. If you will be using a direct heat source, make sure the container is nonflammable.

It is advisable to seal the ends of the wood before wetting. This limits moisture absorption into the cells and prevents checking while drying. Seal with varnish.

Separate workpieces with strips of wood while they are being softened. This lets moisture surround each piece of wood. The final moisture content (M.C.) of the wood should be between 20% and 30% for good bendability. The higher the M.C., the easier any species of wood will bend. Allow about one hour of steaming or boiling for every inch of thickness.

Several kinds of molds (forms) can be used to shape the moistened wood. Molds can be one-piece or two-piece. Wood is clamped to one-piece molds with clamps, blocks, or wedges. See **Figure 34-11.** This is called **free bending.** The curve can also be maintained with a form and a band clamp to hold the wood to the form. See **Figure 34-12.** In a two-piece mold, the wood is held between male and female forms. See **Figure 34-16.** Mold surfaces that will touch the workpiece should be covered, generally with plastic or sheet rubber. No nails or screws should penetrate the mold surfaces. They could rust and stain the wood.

Pressure should be kept on bent wood until it dries. This may take several days. Removing the pressure too soon results in springback. Drying time will vary for each kind of wood and the thickness of the workpiece.

## Wood Laminating

***Wood laminating*** is the process of bonding two or more layers of lumber or veneer. The layers may be clamped flat or molded into contours.

Laminating is done for several reasons.

- A laminated component is typically stronger than the same size piece of solid lumber.
- By alternating grain patterns, laminating helps stabilize dimensional changes. Solid wood has a tendency to warp.

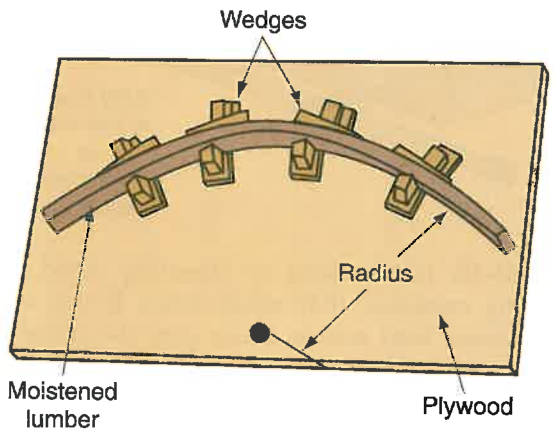



**Figure 34-11.** The wood must be held in place until it is thoroughly dry. Here, wedge clamps and blocks are attached in a curve on a plywood base.

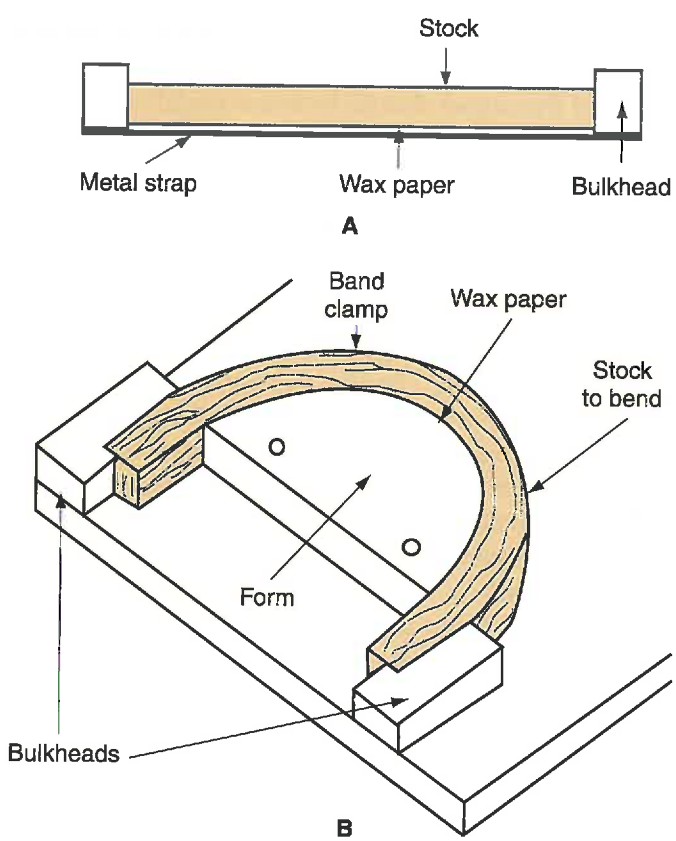



**Figure 34-12.** A—When free bending, the ends are not contained. This allows the back of the wood to stretch. B—With end pressure supplied by bulkheads, the wood cannot stretch, only compress. The metal strap withstands the tensile force.

- Layers of wood can be bonded into curved shapes. These are stronger than the same shape cut from lumber.

Some of the more common laminations are tennis rackets, skis, and chairbacks or seats. Most of these products could be cut from solid wood. However, because they must endure stress, bonded layers of wood are used. A wood beam is another example of a lamination. See **Figure 34-13.** A laminated wood beam may be stronger than the same size steel beam.

Most curved product laminating is done with successive layers having the same grain direction. Thinner layers allow the wood to bend more easily. Some products, such as molded plywood, are two dimensional laminations. Here, each layer of wood is turned 90° from the previous layer. Although more difficult to form, two dimensional laminations are exceptionally strong.

## Selecting wood

Both softwoods and hardwoods can be laminated. Hardwoods have somewhat better bending characteristics. Softwoods are used primarily for structural laminations, such as beams and plywood.

For curved laminations, the amount of bend is affected by the defects and elasticity of the wood species. This was discussed earlier in the chapter. Rigid woods tend to split, and would be poor choices for curved laminations.

Try to select straight-grained lumber without structural defects (knots, splits, and checks). These may split under pressure and weaken the strength of the lamination. If possible, identify the radial and tangential faces of the lumber. See **Figure 34-14.** It is better to use tangential faces for straight

**Figure 34-13.** This lamination will be an arch for a cathedral ceiling. *(Forest Products Laboratory)*

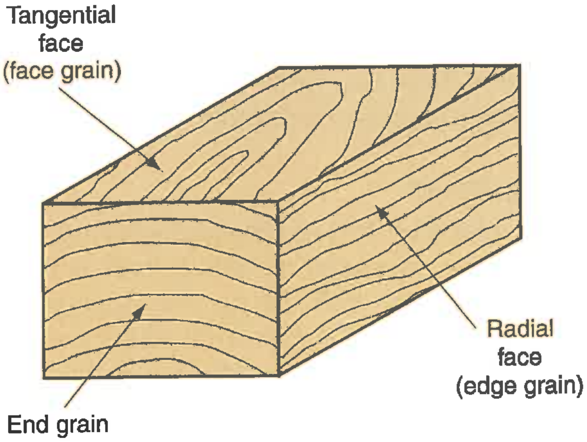



**Figure 34-14.** It is important that you identify the three grain directions for proper laminating.

laminations because of wood's tendency to cup across that face. You will encourage the wood to warp when making curved laminations. For curves use either radial or tangential faces.

## Selecting adhesives

Adhesives for laminating should have a long set time. Resin-type adhesives, such as urea resin glue, are the best. They have a lengthy assembly time, which gives you more time to position the wood layers. Casein glues are often used in industry for beams and other structural laminations. However, casein has a tendency to stain the wood.

## Laminating straight components

With ***straight laminations,*** you increase strength and/or increase thickness. The more layers used, the less the lamination will warp. A common straight lamination is to make thick workpieces for turning spindles. See **Figure 34-15.** You might use two or more layers to build up the thickness. Follow this procedure:

1. Resaw or rip the material across the tangential face.
2. Cut workpieces slightly oversize, then plane them to size.
3. Reverse the direction of the annual rings (seen in the end grain) as shown in **Figure 34-15B.**
4. Select the proper size and type of clamps.
5. Double spread the adhesive.
6. Follow the proper clamping procedure found in *Chapter 33.*

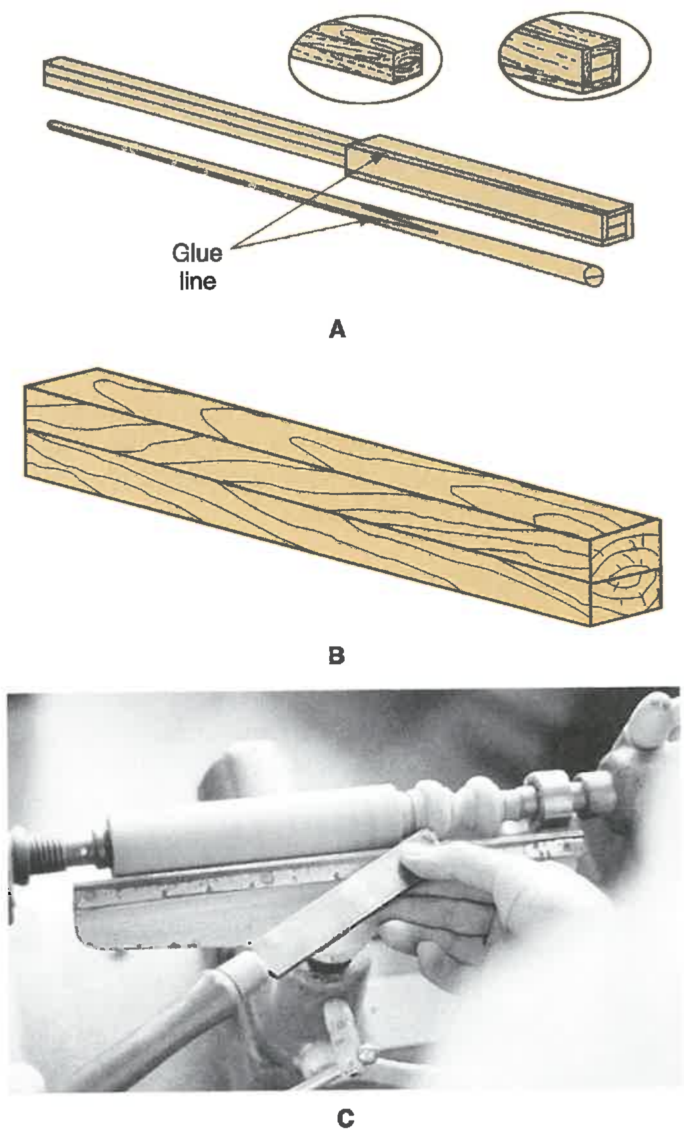



**Figure 34-15.** A—A billiards cue is a lamination of several pieces of wood. The proper direction of the wood grain limits the amount the cue will warp. B—Two pieces to be turned into a spindle. Notice how the annual rings of the end grain oppose each other. This balances the warp of each piece of wood. C—Turning the laminated part. The guard has been removed to show the operation.

## Laminating curved components

Curved workpieces can be made by sawing. This is adequate for slight curves. However, with sharper curves, there is more crossgrain material, resulting in a weaker product. As a result, it will break more easily. Laminating several layers of wood to obtain the curve will result in a much stronger product. Curved laminations are made one of three ways: full surface, partial surface, or segment.

### Full surface, one direction, curved laminations

When straight laminating, you alternated the grain pattern to prevent warpage. With ***full surface, one direction laminations*** you do just the opposite. Grain direction is not reversed so curving the wood is easier.

### Cutting veneer

Curved laminations are made with veneer or thin strips. Most bending can be done with 1/8″ (3 mm) thick layers. Generally, for one direction laminations, you cut material so it will be bent along its length. Flexible veneer can be cut with scissors. (Before cutting, wet the veneer to prevent splitting.) Flat veneer is cut with a jig saw or band saw. Thin stock can be ripped or resawn with a table saw. Check the minimum bending radius to determine how thin the stock can be and still bend properly. Refer to **Figure 34-2.**

Sawed stock can be used but must be surfaced. This is a time-consuming task and wastes a great deal of wood. It may be more economical of both time and money to use veneer.

### Preparing the mold

A mold is used to control the contour. It must keep pressure on the laminates until the adhesive cures. A one-piece mold with a web clamp may be adequate. You might also make an adjustable form out of plywood and wedge clamps. A two-piece mold works well for thin and thick laminations. See **Figure 34-16.**

Molds should have rubber or plastic faces. This prevents damage to the wood and evens pressure across the surface. Lining the mold with wax paper or silicone spray prevents the adhesive from sticking.

### Stacking layers

The method of stacking the layers is very important. For across-the-grain bending, look at the end grain. Stack layers with the growth rings parallel. See **Figure 34-17.** The curve of the rings should be opposite the curve of the mold. This is the natural

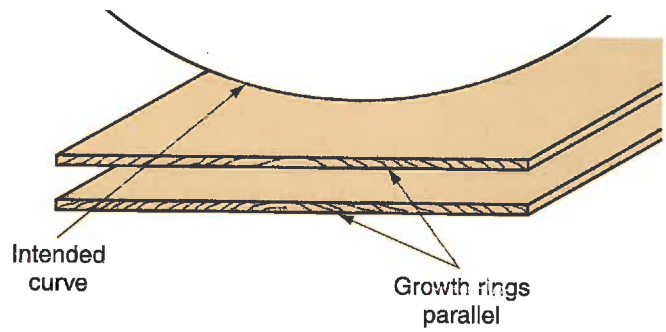



**Figure 34-17.** Make sure the growth rings are parallel for curved laminations of veneer. The direction of the rings should be opposite the intended curve.

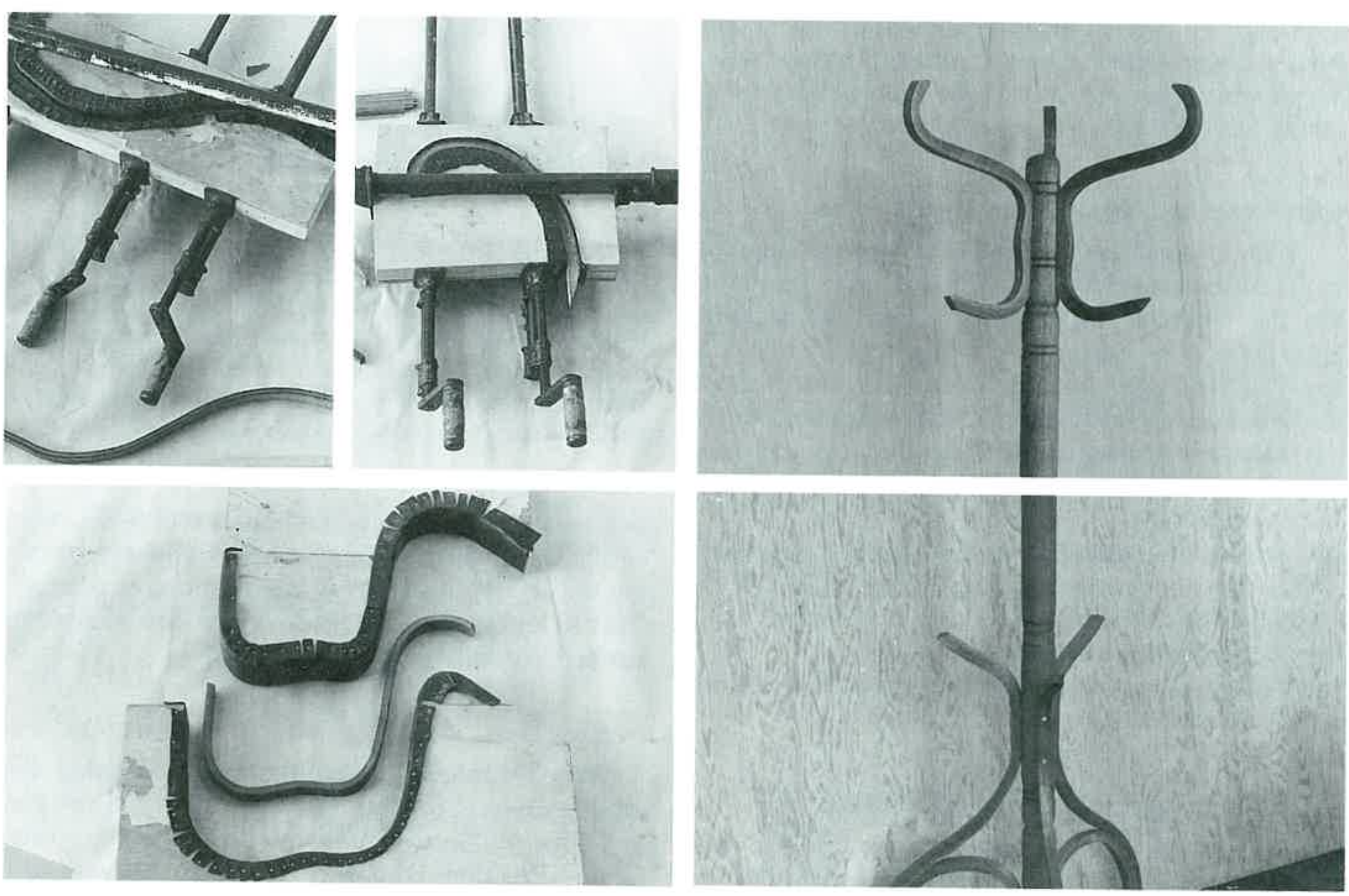


**Figure 34-16.** Three two-piece molds were required to make the bent parts of the hall tree.

cupping direction for lumber. To bend along the grain, look at the edge (radial) grain. Stack all layers with parallel radial grain.

### *Laminating procedure*

The steps to follow when making curved, one direction laminations are:

1. Cut material oversize. Allow ½" (12 mm) extra across the curve and 2" (51 mm) or more extra with the curve. This allows material to form the curve and compensates for slippage when clamping.
2. Stack the components, without adhesive, and properly align the grain of each layer.
3. Clamp and bend the laminates against the mold without an adhesive. If the wood cracks or splinters when bent, release the clamps. You must either reduce the thickness of each layer, or preform the components by wet bending.
4. Line the mold with wax paper or mold release.
5. Apply a thin, even layer of glue to each matched surface.
6. Reassemble the layers.
7. Slowly tighten the clamps. Begin at the middle of the mold, then tighten outer clamps.
8. Allow the assembly to set and cure for at least 24 hours or the time given on the adhesive container.
9. Remove the lamination and scrape excess paper and glue from the surface.
10. Mark and cut the final shape using a band saw. Then sand and finish.

## Full surface, two direction, curved laminations

You can laminate gentle, two-directional curves using layers of veneer. See **Figure 34-18.** Each layer is turned 90° to the previous one. The two halves of the mold should be well matched. Otherwise, air pockets may remain between layers after the adhesive dries. A veneer press or hydraulic press will provide ample clamping power.

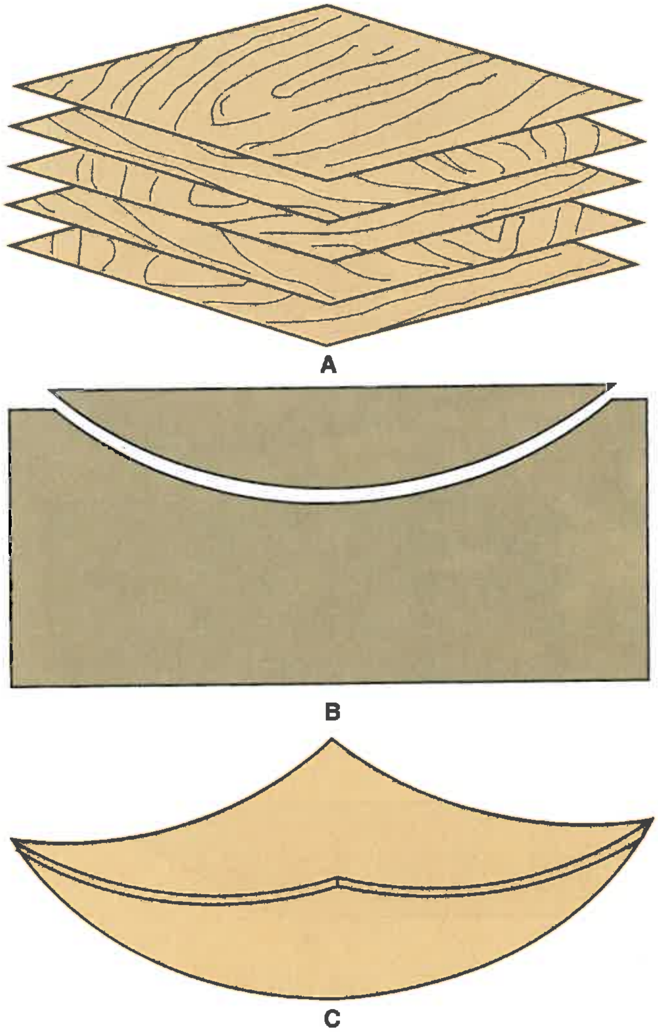



**Figure 34-18.** Molded plywood. A—Successive layers of veneer should alternate grain pattern 90°. B—The two mold halves should match perfectly. C—The molded plywood will retain its shape without springback.

## Partial surface laminations

A ***partial surface lamination*** is done when you want to curve only the ends or edges of a workpiece. An example is the tips of water skis. The procedure is as follows:

1. Make a series of resawing kerfs parallel with the face surface. See **Figure 34-19A.** At least two are needed, depending on the wood thickness.
2. Clamp the workpiece, without adhesive, in a mold. It should bend without excessive stress or splintering.
3. Remove the clamps.
4. Fit pieces of veneer into the saw kerfs. See **Figure 34-19B.** They can fit snugly but not tightly.
5. Remove the veneer.
6. Apply adhesive to all surfaces being bonded. Wet a cloth with adhesive. Pull it through the saw kerfs to coat them.
7. Slide the veneer into the kerfs.
8. Reset the clamps and tighten. See **Figure 34-19C.**
9. Allow the assembly to set and cure. See **Figure 34-19D.**

## Segment laminations

***Segment laminations*** are curves built of rows of solid wood pieces. Each layer is staggered, much like brick laying, with a minimum of three layers. See **Figure 34-20A.** This way, there is no continuous joint from layer to layer. The procedure for segment laminating is as follows:

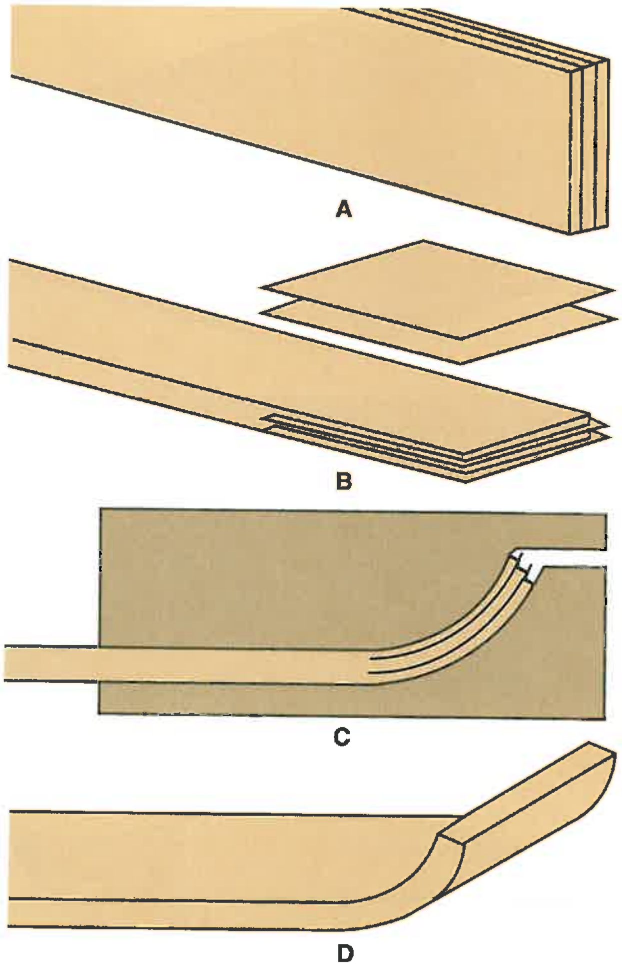



Figure 34-19. Partial curved laminations. A—Kerfing. B—Inserting veneer in the kerfs. C—Gluing and clamping the lamination. D—Finished product.

1. Lay out a full-size pattern of the curve.
2. Establish the length of each segment. Select a length that covers both inside and outside layout lines.
3. Determine the angle for segment ends.
4. Saw all the segments. Use a miter saw or table saw with a miter gauge.
5. Apply adhesive and assemble the segments on the layout.
6. Apply pressure until the adhesive sets and cures. (Use hold-down clamps or place weight on the top layer.)
7. Saw the outer and/or inner segment curves on the band saw. You may not wish to saw a hidden side.

Another method is to curve the edge of each segment before assembling them. Make a template of one segment. Then saw all segments using a scroll or saber saw and the template. Assemble the components as you did in steps 5 and 6 above.

After the segment curve has dried, you should smooth it with a plane, scraper, and/or abrasives. Veneer may be applied to hide the segment joints.

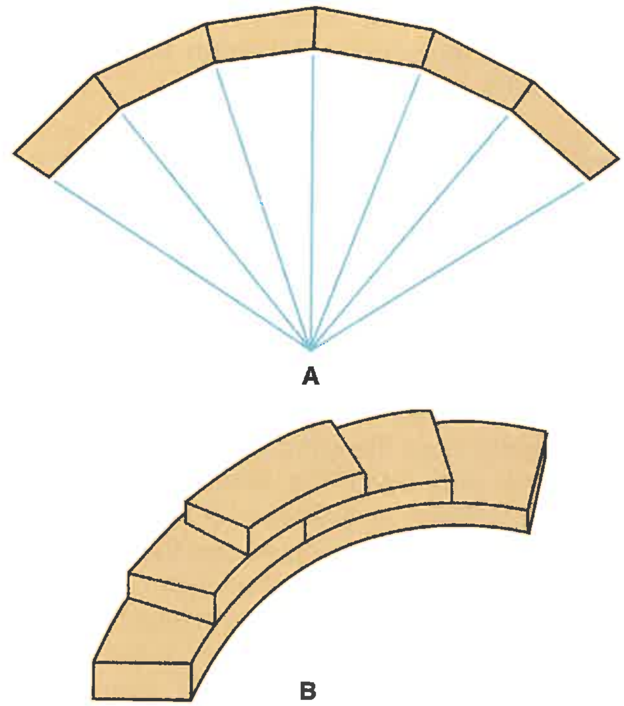



Figure 34-20. A—Segment laminations made of bonded short wood pieces. B—The assembly is band sawed to the final curve.

## Think Safety—Act Safely When Bending Wood

Wood is bent using pressures that vary according to wood species. Machine pressure may exceed 100,000 pounds. There is always a danger of the wood snapping or you becoming caught in a press. When bending wood:

* Wear eye and face protection.
* Wear heavy gloves.
* Use care around heat and steam sources to avoid burns.
* Stay clear of presses in operation.

## Summary

Bending and laminating are processes used to make curved components and thicker or stronger straight workpieces. These are involved processes and require skill in many areas of woodworking.

Bends can be made dry or with moisture and heat. Gentle curves can be made with relative ease. Sharp bends likely will require molds or forms and a source of pressure or vacuum.

Bends made by laminating are much easier than bending solid wood. Layers of veneer can be coated with adhesive and held in a form until dry. Straight laminations are made to increase the size and/or thickness of a part.

## Test Your Knowledge

*Do not write in this text. Answer the following questions on a separate sheet of paper.*

1. When bending wood, fibers on the inside of the curve are _____.
2. Bending wood dry is done by _____ or _____.
3. When kerfing, you must know the _____, _____, and _____.
4. Name three ways to plasticize wood.
5. _____ is a patented material that consists of individual ribs of particleboard that are evenly spaced apart and laminated between layers of phenolic impregnated and latex impregnated papers.
6. Wet bending is done at moisture contents around _____%.
   a. 50
   b. 25
   c. 15
   d. 10
7. To reach the proper moisture content for wet bending, you should steam or boil 2" (6 mm) lumber about _____ hour(s).
   a. 4
   b. 3
   c. 2
   d. 1
8. Resin-type adhesives are used for wood laminating because they _____.
   a. set slowly
   b. contain solvents
   c. are brittle
   d. cure very rapidly
9. Sketch the end grain patterns for laminating two pieces of wood when (a) you want the lamination to bend and (b) you want the lamination not to warp.
10. Segment laminating involves the use of _____.
    a. long narrow strips of lumber
    b. rigid lengths of particleboard
    c. short lengths of lumber
    d. veneer

Shown here are laminate sheets and edgebanding of three different wood species.

# Overlaying and Inlaying Veneer

35

## Objectives

After studying this chapter, you will be able to:

- Overlay surfaces with veneer.
- Edgeband panels.
- Assemble decorative surfaces using parquetry.
- Inlay designs using marquetry and intarsia.
- Inlay bandings to create borders and geometric shapes.
- Prevent inlays from being discolored during finishing.

## Important Terms

| | |
|---|---|
| bandings | overlaying |
| carvings | parquetry |
| core | stencil |
| edgebanding | tape lamination machine |
| flitch | veneering |
| gummed veneer tape | veneer pins |
| inlaying | veneer roller |
| intarsia | veneer saw |
| marquetry | |
| overlapping method | |

Overlaying and inlaying are methods of applying thin materials to enhance the appearance of a wood product. See **Figure 35-1.** While many other materials may be used, this chapter will concentrate on veneer or thin wood, except when discussing edgebanding. The veneer or thin wood may be cut into decorative patterns, shapes, picture mosaics, and strips.

Overlaying includes veneering and parquetry. When veneering, you bond flat or flexible veneer to a substrate, or core material. Parquetry is the art of arranging a geometric pattern of thin wood blocks, then bonding them to a substrate.

Inlaying involves making a recess in a wood surface and bonding veneer or thin wood in the recess. Like overlaying, there are two practices, marquetry and intarsia. Marquetry is inlaying veneer patterns. Intarsia is inlaying thin wood patterns. See **Figure 35-2.**

Bandings are strips of veneer on thin wood inlayed in the surface. They may be very decorative or simply a different wood species.

The surface to be decorated by overlaying is called a substrate. For overlaying, the material may be fiberboard, particleboard, MDF, or plywood. You cover the substrate completely.

Surfaced solid lumber may be the workpiece to receive inlay materials. The lumber will remain visible around the inlay. Other materials, such as plywood, veneered particleboard, or MDF may be used. However, due to the thin face veneers used on these products, extreme care must be taken when abrading the workpiece after completing the inlay.

**Figure 35-1.** Mahogany and prima vera veneers make these doors very attractive. *(Lane Accents)*

## Materials, Tools, and Supplies

Overlaying or inlaying a surface involves cutting, assembling, bonding, and pressing the veneer or thin wood to the workpiece. Select the proper materials, cutting tools, adhesives, and clamps.

### Materials

The materials you need for inlaying and overlaying include a suitable workpiece and veneer (for marquetry and veneering) or thin wood strips (for parquetry and intarsia). The workpiece is usually cut to size before being decorated. It may be a single board or, in some cases, a completely assembled cabinet.

Veneer types were discussed in *Chapter 14*. For a quick review, there are two types of veneer. Flat veneer is usually 1/28″ (0.9 mm) thick. Flexible veneer is typically 1/60″ (0.4 mm). Veneer may be bought as dimensioned sheets or random sizes (you must splice these together). How the veneer was cut determines the grain pattern. Generally, rotary and flat slicing methods produce figured grain. Quartered and rift cut veneers have straight grain.

Veneer warps and distorts during storage due to moisture changes. To correct this, prepare a glycerin solution. Mix 2 oz. of glycerin to 1 qt. water. Apply the solution with a damp sponge. Immediately place the veneer between a sandwich of kraft paper (brown wrapping paper) and plywood. Clamp this setup for a few days. Change the paper daily. The glycerin makes the veneer flat, stronger, and more flexible. It does not affect the finishing characteristics.

### Cutting Tools

Veneer may be sheared or sawed. Shearing means to cut the veneer with a single-edge razor, scissors, or knife. Specialty veneer strippers and trimmers are also available. Sawing is done with a ***veneer saw*** or coping saw. See **Figure 35-3.** Veneer saws cut on both the push and pull strokes. For coping saws, use a fine-tooth blade and a pull stroke.

### Assembling Supplies

A few supplies will be needed when assembling veneers. ***Gummed veneer tape*** or masking tape will hold veneer pieces together. ***Veneer pins*** help align and hold materials in place. They are much like plastic head push tacks, however, they have very sharp points.

### Adhesives

Choose adhesives depending on assembly time. Resin-based, water solvent adhesives have a long tack time. They are used when you will need time to align the veneer. They also contain a slight amount of moisture that flattens wavy, dry veneer. Contact

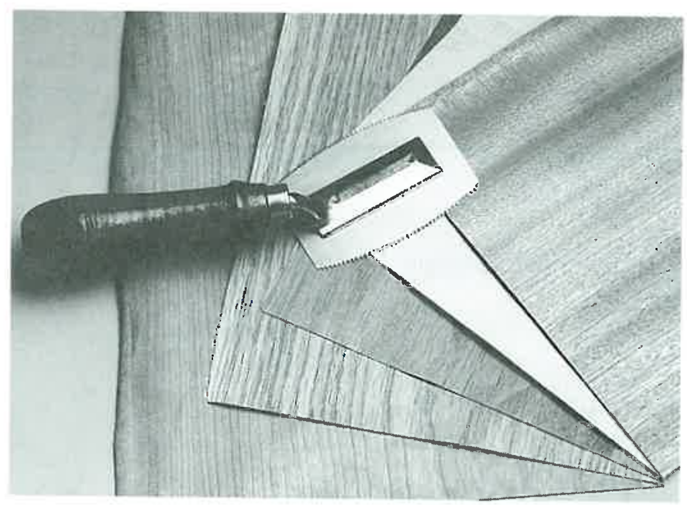


**Figure 35-3.** A veneer saw is used for thick veneers. *(Woodcraft Supply Corp.)*

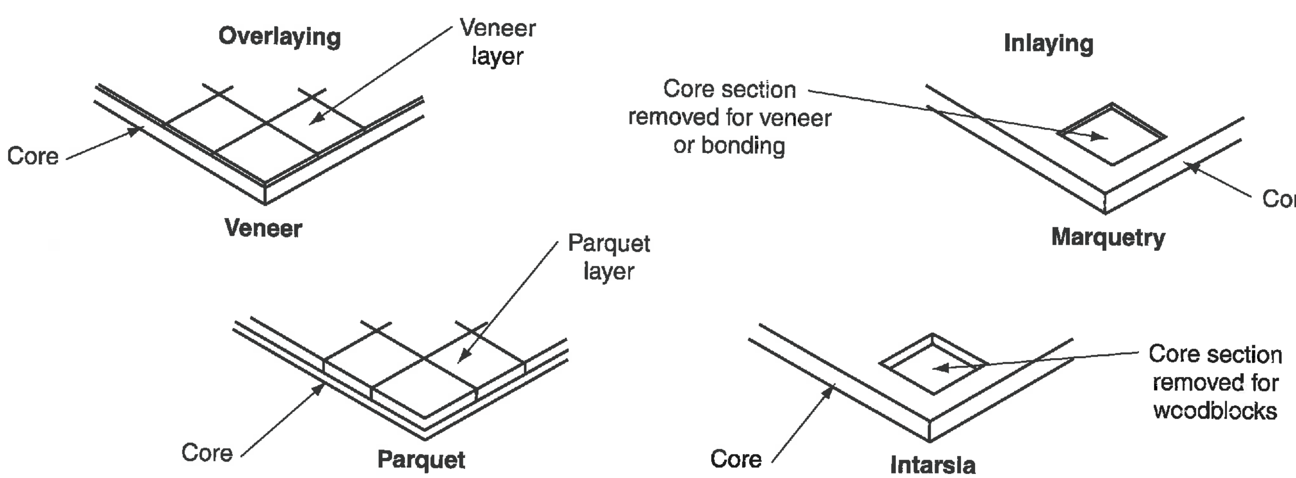



**Figure 35-2.** Overlaying or inlaying processes vary according to the thickness of the material.

adhesives provide an instant bond. No clamps are necessary. Adjustments cannot be made after the decorative surface touches the substrate.

Contact cement tends to lose its bond when oil finish is applied to the veneer. To avoid this problem, coat the veneer with a glue size or buy veneer with a suitable backing. This is a mixture of one part aliphatic resin or PVA glue to three parts water. Place the coated veneer between wax paper and plywood. Let the veneer dry a couple of days. The glue size strengthens the veneer, but does not affect the finish.

Hot melt glue is an alternative to liquid adhesives. Some dimensioned veneer has the glue already applied to the back. Glue sheets with glue on one side of a peel-off paper are also available. The veneer is aligned, then heated to melt the glue.

As a rule, when applying veneer, use only a thin coat of adhesive. It may be applied by brush or roller. A thin adhesive coat should not penetrate the veneer's wood cells. If it fills cells, it reduces stain and filler penetration. Hide glue does this and is, thus, not appropriate for veneering.

## Pressing Tools

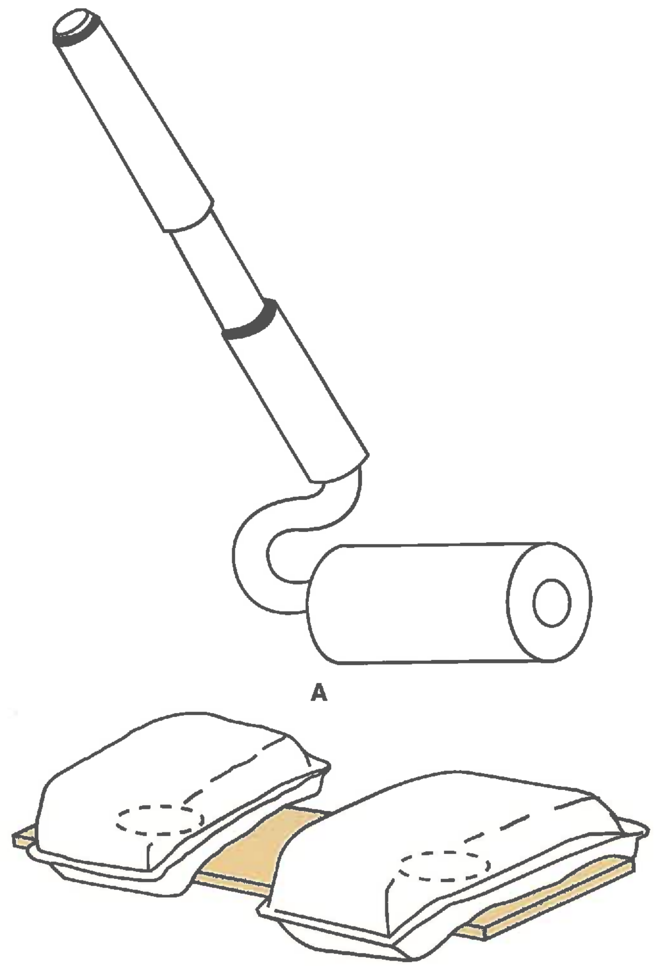
Pressure must be applied to the adhesive coated veneer to create a permanent bond. The pressure may be short-term for contact cement or long-term for other adhesives. Light, even pressure is all that is required. It must be maintained until the adhesive sets.

For contact cements, a ***veneer roller***, or rolling pin works well to bond the veneer. See **Figure 35-4.** For contours, place a sandbag over the veneer and strike it with a mallet.

Resin adhesives require clamping or pressure until the adhesive cures. Hand screws, C-clamps, and bar clamps are used for small areas. Use a veneer press for clamping large areas. Use a vacuum bag press to clamp large surfaces, either flat or curved. Some vacuum bag sizes range up to 49″ by 169″ (1245 mm by 4292 mm). For decorative overlays (parquetry), sandbags are sufficient. Place wax paper between clamps, core, and veneer. Otherwise, you might bond your work to the clamps.

## Overlaying

Overlaying, including veneering and parquetry, adds thickness to the core material. By fitting pieces of veneer or thin wood together, you can create decorative patterns. Adding molding or trim to the veneered product gives contour and protects the edges of the overlay.



B

**Figure 35-4.** A—This veneer roller works well for pressing veneer bonded with contact cement. B—Sandbags are applied for continuous pressure.

## Veneering

***Veneering*** is the process of covering a substrate with wood veneer. The finished workpiece looks like solid lumber. Typically, the veneer is standard 1/28″ (0.9 mm) flat veneer or 1/64″ (0.4 mm) flexible veneer. Mostly, you will use hardwood species for veneering.

Veneering typically involves covering the entire surface. Groups of ***flitches*** (veneer pieces) may be fitted together to form matches. Various matches were shown in *Chapter 14.* You can also create geometric shapes or designs. Preassembled veneer pictures or designs are available from many woodworking suppliers.

Producing a veneered surface requires artistic ability, patience, and skill. Your artistic talents show when selecting flitches and laying out patterns. Patience and skill are necessary when cutting, trimming, and assembling the veneers.

## Selecting flitches

Select flitch based on the grain pattern, defects, and overall appearance. For some surfaces, you will want matched grain forms. Try to obtain flitches in the order they were sliced from the log. The grain pattern will almost be identical. Sometimes, you might choose veneers of contrasting colors. They may be heart and sapwood of the same wood species or flitches from different species.

## Laying out patterns

Pattern layout depends on whether you will be using one or several flitches of veneer. If you are using one dimensioned sheet, there is little to lay out. Only mark the size to fit over the substrate. If you will be matching several flitches, lay out grain direction. You must determine the angle and size to cut the veneer. See **Figure 35-5.**

## Cutting veneer

When cutting veneer, always use a sharp tool and some kind of guide. Freehand cutting is discouraged. With a saw, use a wood straightedge as you do when backsawing. With a knife, use a metal straightedge, square, or metal template (for curves). Tape or pin the veneer to the table while cutting. Always cut veneers oversize to allow trimming.

Cutting should not be done in one pass. This tends to split or splinter the veneer. It also crushes the wood cells. Light pressure on a knife or forward and backward saw motion is best. Several passes with the knife are necessary.

When cutting veneers that will be laid side by side, cut both at one time. Overlap them slightly and cut on the overlap. See **Figure 35-6.** This assures that adjacent pieces will match. Cutting them separately means you will have to trim and fit each of them.

## Trimming

Place the veneers on a contrasting color surface. Surface color will show through where the veneers do not fit properly and need trimming.

Trimming straight edges is done with a sharp, small plane. The veneer is placed in a clamping jig to prevent it from bending. See **Figure 35-7.** Mark

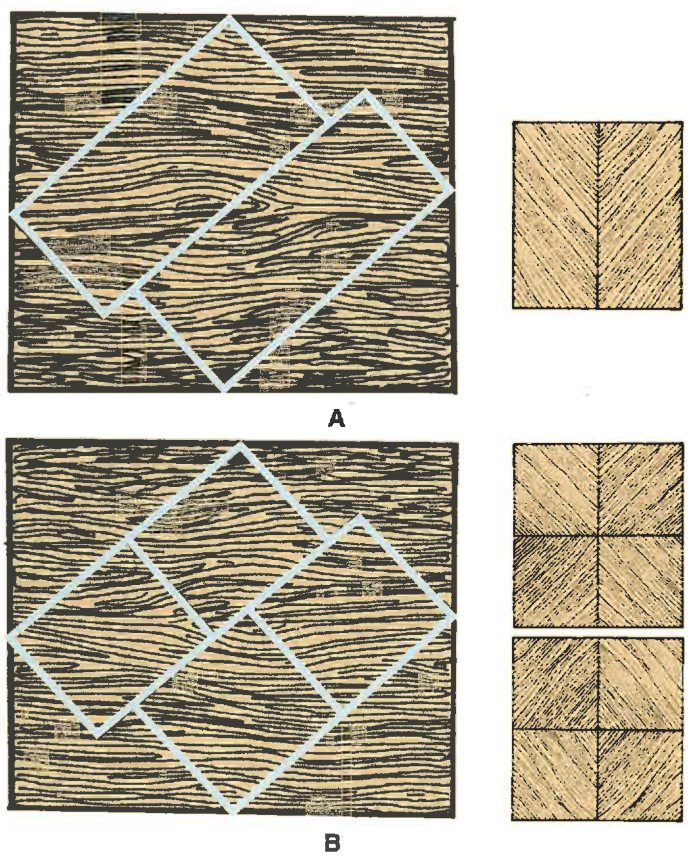



**Figure 35-5.** A—Layout for *V* match. B—Layout for reverse diamond and diamond matches.

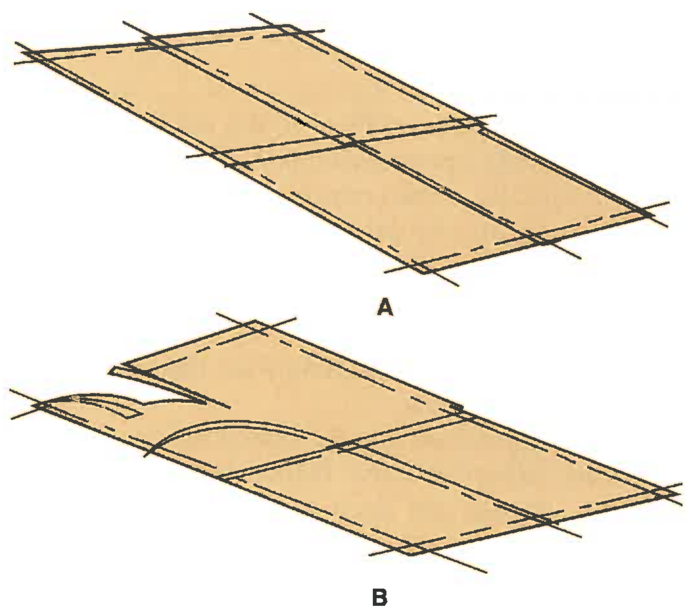



**Figure 35-6.** The overlapping method of fitting veneers. A—The four flitches are overlapped slightly at the ends and edges. B—Cuts are made on the overlap to assure a perfect fit.

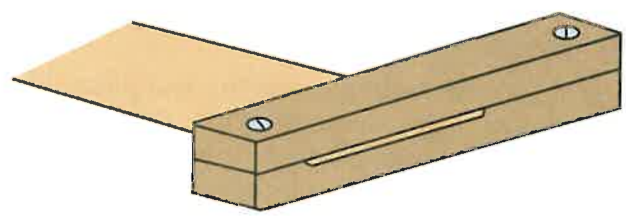


**Figure 35-7.** Place veneer in a clamping jig before trimming it with a plane.

the section where the fit is poor, then clamp the material. Trim the flitch edge to the correct shape. Curves can be trimmed with a sharp knife. Lay out the pieces as they will be assembled. Then trim them as necessary.

## Assembling

Once the pieces are trimmed, place them together. Make sure all the joints fit. Now, cover the joints (on the visible side) with masking or gummed veneer tape. See **Figure 35-8.** Press the tape firmly in place. Turn the panel over. Hold the assembled panel to a light and check for gaps between the flitches. Adjust or retrim the veneer as necessary.

If you will be using resin-type adhesive, make a trial run. Place the veneer panel on the substrate. (The substrate should have already been cut.) Position clamps to be used when bonding. Then release the pressure evenly and lay the clamps aside in an orderly fashion.

## Bonding

The bonding process involves first gluing the veneer edges, then applying the veneer to the substrate. Bonding to the substrate differs slightly for resin-type adhesives, contact cements, and hot glue.

Before bonding the veneer to the substrate, you should edge glue the veneer sections together. Lift the assembly at each taped joint. Apply a small amount of adhesive to the edges. See **Figure 35-9.** Lay the assembly flat on its good face and wipe off the excess glue. Then proceed to bond the veneer to the substrate.

### *Contact cement*

Before applying contact cement, it is advisable to glue size the sheet as discussed earlier. Then apply a layer of contact cement to both the substrate and the back of the veneer. Let it set until a piece of paper will not adhere to the surface (approximately 10 to 15 minutes, water-based cement will take a little longer). The cement coating should be glossy. Dull spots require an additional application of cement.

Place dowel rods or a sheet of kraft paper over the substrate. Then lay the veneer panel, cement side down, on the paper or dowels. Position the veneer carefully. See **Figure 35-10.** Then, while still holding

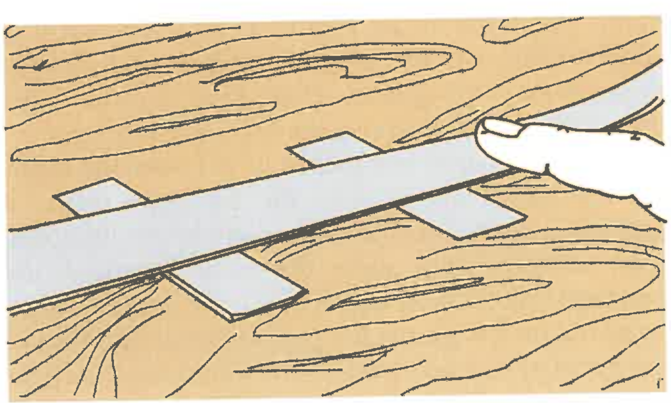
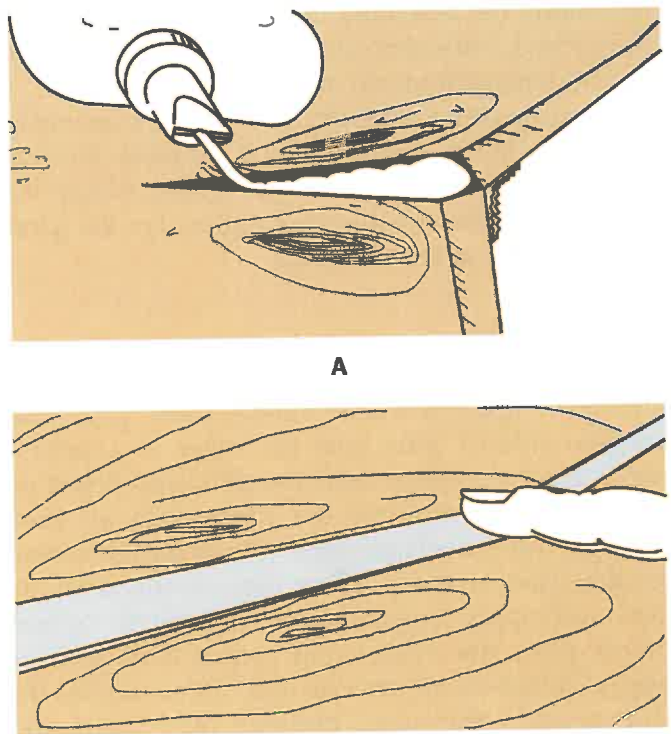


**Figure 35-8.** Press the veneers together and apply masking or gummed veneer tape. The first pieces should pull the flitches together. A longer piece covers the joint.



A

B

**Figure 35-9.** Bonding flitches together. A—Bend the joint and apply glue. B—Lay the veneer flat on its face, wipe off excess glue, and apply tape.

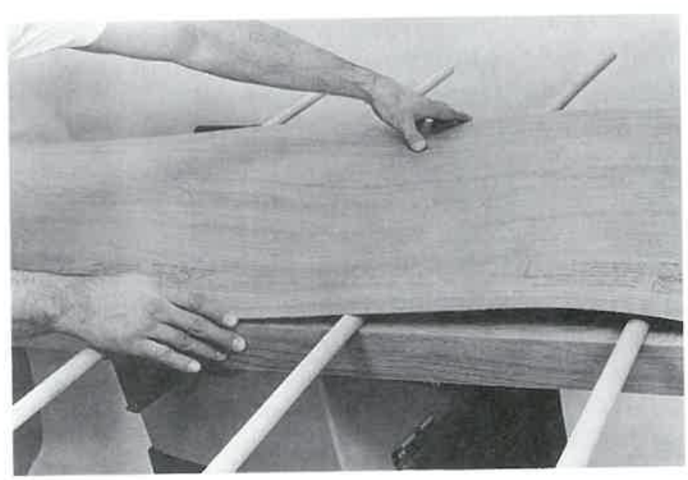


**Figure 35-10.** Using dowels to maintain separation between veneer and substrate until positioning is correct. *(Franklin International)*

the veneer, pull out the paper about 1" or remove to center the dowel. With a roller, press down on the exposed section of veneer to adhere it. Keep pulling out paper (or additional dowels) and rolling the veneer down until the entire surface is bonded. Then use extra pressure on the roller over the entire area.

### Resin glue

Coat both the substrate and the veneer panel back with adhesive. Place the panel on the substrate. Then clamp the assembly. Your assembly should be sandwiched between MDF, or particleboard, to prevent damage and provide a flat surface.

If you are using a veneer press, place the assembly, veneer side down, at the bottom of the press. Put wax paper between the press and the veneer. Clamp the panel snugly. Remove any excess glue. Let the panel set and cure for at least 24 hours.

### Hot melt glue

Hot melt glue comes in sheet form or may already be applied to the veneer back. The sheet has one side of glue and the other is a release paper. Place the sheet with the glue side down on the substrate, and heat the sheet with an iron. Then pull off the release paper and place the veneer on the glue coating. Heat the veneer with an iron and apply pressure. For preglued veneer, simply place the veneer and heat it with an iron. Apply pressure to the heated areas while the glue cools. Otherwise, bubbles may form and prevent good adhesion.

## Repairing

After removing any clamps, inspect the surface. You may see an obvious bubble or raised edge. Then tap on the surface with a fingernail. If you hear a dead or hollow sound, that area of veneer is loose. These locations need repairing.

There are two approaches to making repairs. Try pressing a 300°F to 350°F (149°C to 177°C) iron on a piece of cloth over the loose area. Then apply pressure without the iron. This should correct veneers bonded with contact cement or hot melt glue. For resin-glued veneers, raise the edge or corner with a knife point. Apply more glue with a scrap of paper or sliver of wood. For regluing bubbles, make a knife cut on each side of the loose area. Cuts should be along the grain. Insert adhesive with a glue injector or paper scrap. A small cut on each side of the bubble prevents air from being trapped behind the glue. Reclamp the loose area.

## Edge banding

***Edge banding*** is an overlaying process in which you cover the edges of manufactured panel products. *Edgebanding* is also the material that is applied in the process. Besides veneer and thin wood, other materials, such as PVC, melamine, polyester, and ABS, are used for edgebanding.

When applying edgebanding, the panel faces typically have already been laminated with veneer, thermofused melamine, or HPDL. Panel edges should be relatively smooth and without noticeable chipping. Generally, cutting the material on a stationary power saw (equipped with saw blade designed for the workpiece material) will produce an acceptable edge. If not, cut the workpiece slightly oversize, and use a straightedge and router fitted with a straight bit to trim the workpiece to size.

You can either cut veneer for edgebanding, or use a manufactured edgebanding. Strips of cut veneer are bonded to the edge with adhesive and an edge clamp. The process is similar to veneering. Using edgebanding is easier. Manufactured edgebanding is made of several different materials; wood veneer, PVC, melamine, polyester, and ABS.

For a 3/4" (19 mm) workpiece, the tape is typically 7/8" (22 mm) wide. Rolls can be bought from 1/2" to 10" (13 mm to 254 mm) wide, with or without a hot melt glue coating on the back. Veneer, melamine, and polyester edgebandings are applied to the edges of the panel with a hand iron, a household iron, or an edgebander. Contact cement may be used to apply veneer that has a suitable backing.

Due to relatively low melting properties, PVC edgebanding cannot be applied with an iron. You must use either an automatic edgebander that applies heated hot melt glue or an edgebander that blows heated air against preapplied glue and workpiece. You can apply PVC, melamine, polyester, ABS, and wood veneer edgebanding with the illustrated edgebander. See **Figure 35-11.** Place a roll of edgebanding on the dispensing pin and feed it through the tape guider. Then, pass it around the pressure roller and under the tape down holder.

Slide the panel from right to left over the table. As the panel approaches the pressure roller, it depresses the hot air blower switch. Pause for about two seconds and slide the panel against the pressure roller. Upon contact with the edgebanding, press the panel against the pressure roller and move the panel at a steady pace to the left. After the edgebanding is applied, the absence of the panel releases the blower switch and the hot airstream stops. Pull the knob in the front center of the machine to

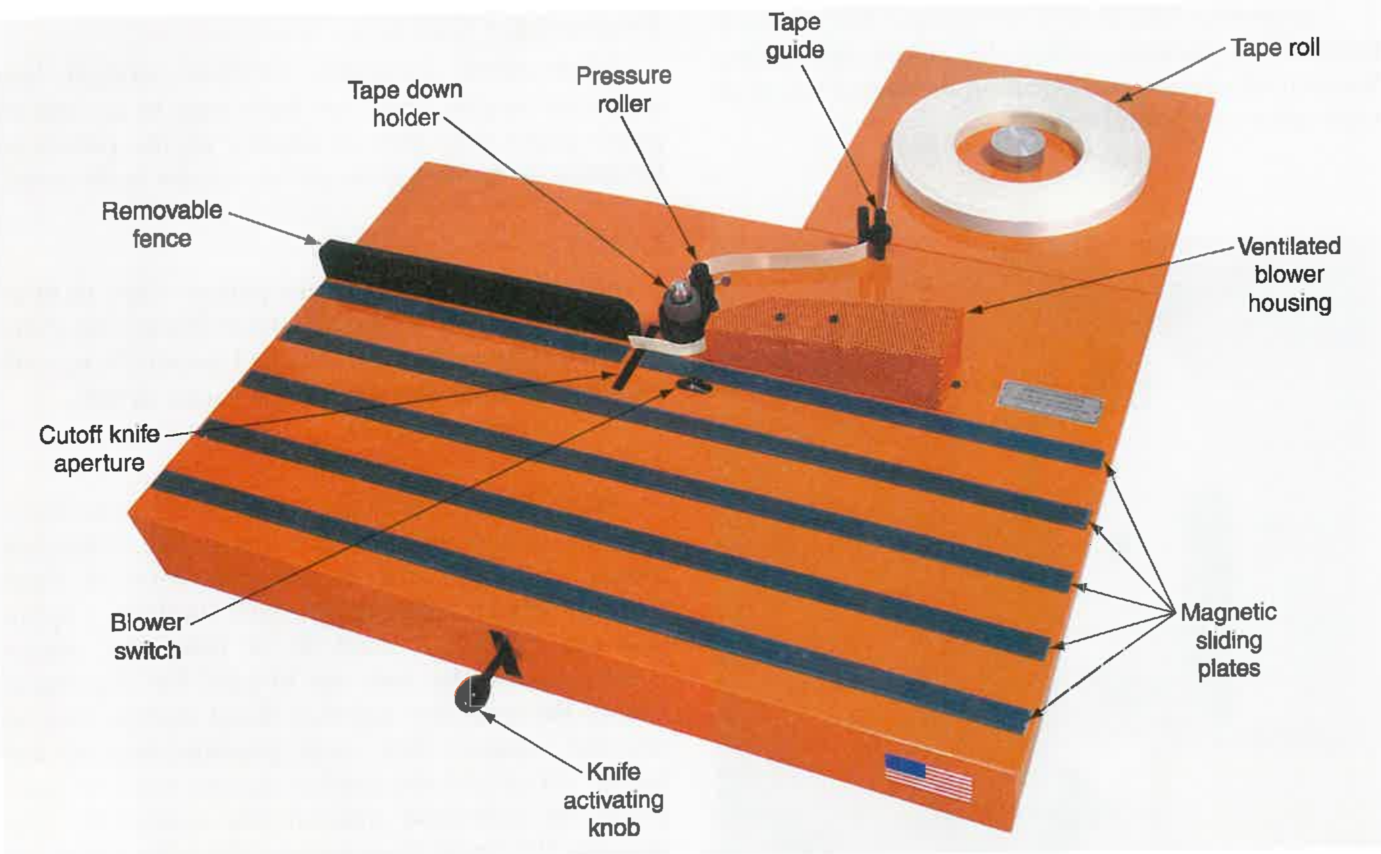



**Figure 35-11.** Important components of a tape lamination machine. Note direction of feed. To laminate tape to rounds and curves, remove the fence and magnetic sliding plates. *(Tapes & Tools)*

activate the cutoff knife, which will come up from beneath the table to cut the edgebanding. The cutoff knife retracts when the knob is released.

To apply polyester, melamine, or veneer edgebanding that has a hot melt glue coating, use an iron and clamp the panel with the edge facing up. Cut a strip of tape about 2" (51 mm) longer than the edge. When using a hand iron, set it to the highest temperature setting. For a household iron, set is to the wool setting. Start at one edge, while holding the iron on the tape. Then lift the iron and hold the tape down with a rag. This attaches one edge. Proceed toward the other edge, moving the iron along the edge. Follow with a rag to apply pressure while the glue cools. Use a single edge razor blade or sharp chisel to trim the excess tape from curved edges. See **Figure 35-12.**

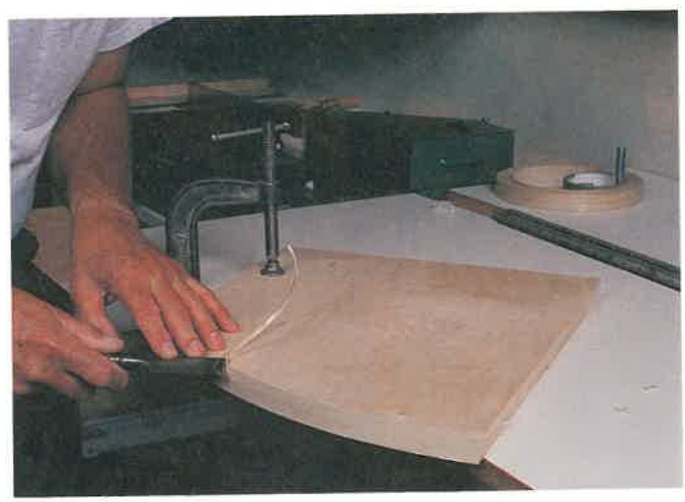


**Figure 35-12.** Trim tape on curved edges with a sharp chisel. *(Chuck Davis Cabinets)*

Trim overhanging ends of the tape with an end trim tool. See **Figure 35-13.** For straight edges, use an edge trimmer. See **Figure 35-14.** Squeeze the sides together and slide forward along the panel edge.

## Parquetry

***Parquetry*** is the process of bonding geometric wood blocks to a core. The blocks are attached to each other and to the core. They may be assembled independently or preassembled into components. See **Figure 35-15.** Parquetry differs from veneering because the material is thicker. Wood about 1/8" (3 mm) thick is recommended. (Parquet flooring will be even thicker.)

Decorative designs can be made two ways. One is by assembling woodblocks in different grain directions. The other is using contrasting colors of wood.

Parqueting involves several steps. They include preparing a pattern, cutting the pieces, assembling the shaped pieces, and bonding the wood pieces to each other and to the core.

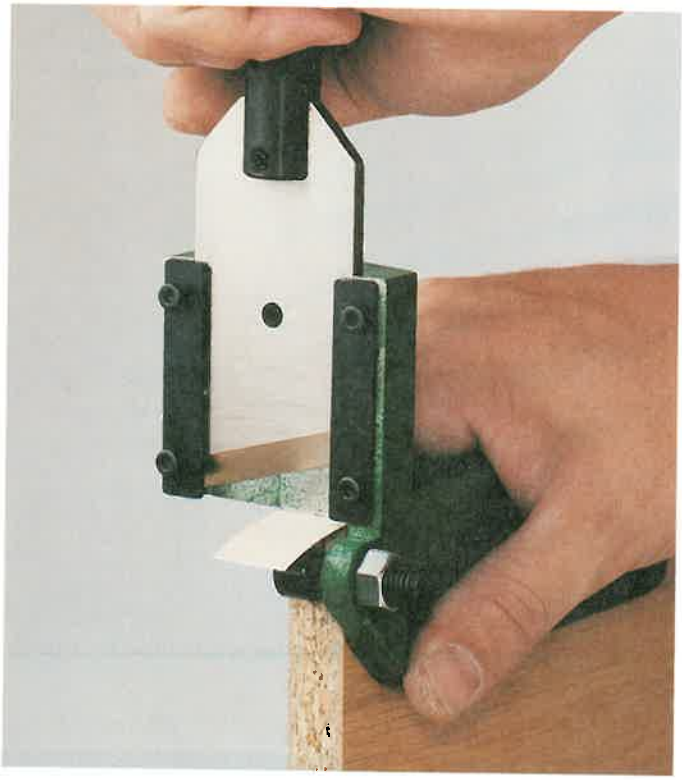


**Figure 35-13.** End trim tool, or cutoff knife for end flush cuts of edge banding. *(Tapes & Tools)*

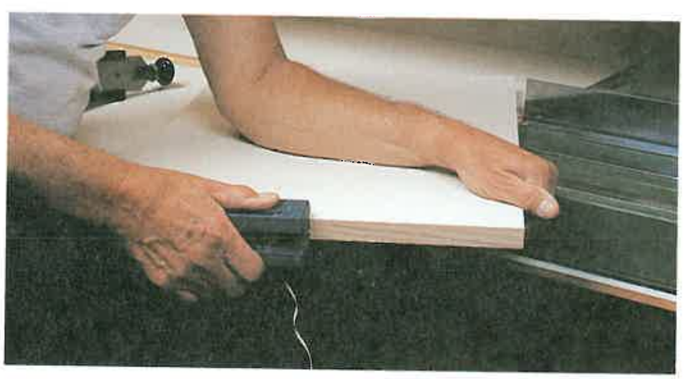


**Figure 35-14.** Trim tape on straight panel edges with an edge trimmer. *(Chuck Davis Cabinets)*

## Preparing a pattern

Most often, parquetry involves straight line geometric shapes. These are fairly easy to lay out on graph paper. Add lines or shading on the pattern to designate contrasting grain pattern or color in the wood.

## Cutting

Saw blocks according to the pattern. They must be cut very accurately with a fine tooth blade. Cut about 25% more pieces than you require. Use only those with the most accurate dimensions and fewest defects.

## Assembling

Small blocks, difficult to assemble separately, may be preassembled. Then bond the individual pieces or components to the core. First fit them without adhesive. Be sure even the smallest splinters are removed. Start at or near the center. Guidelines on the core are helpful for alignment. Clamp the assembly together. Band clamps may be selected because they exert pressure toward the center. You might also use bar clamps, but first place pieces of softwood around the assembly. This prevents the clamp from marring the sides and evens out pressure along the assembly. Once the clamps are preset, release and set them aside. You will also need sandbags, a veneer press, vacuum bag press, or other pressure to bond the blocks to the core.

## Bonding

Much time is required to apply adhesive to each joining surface. Therefore, coat only part of the core at a time. Then glue and fit that section of the blocks together. Remove excess adhesive from the section after the adhesive has set. Allow 10 to 15 minutes to assemble each section. Use slow setting adhesives when parqueting larger surfaces. Because of the time involved, preassembled parquet sections are recommended.

Select clamps for the surface, large or small, that you are parqueting. You might use a band clamp. However, it may need to be removed when the adhesive sets. Otherwise, the band could interfere with the block-to-core pressure. Cover the parquet with wax paper to prevent it from bonding to the clamps.

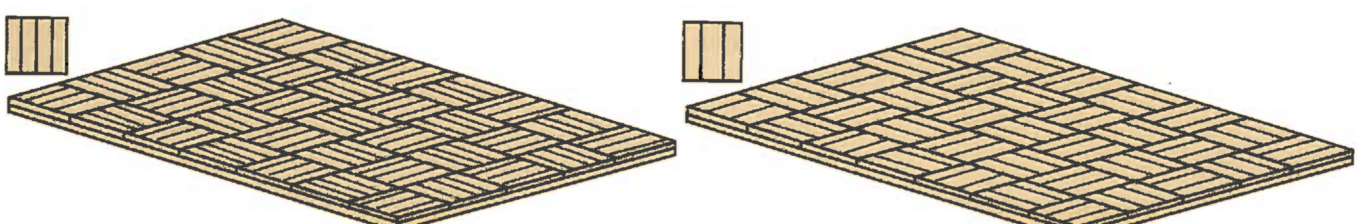


**Figure 35-15.** Components consist of pre-assembled woodblocks. The components are then laid as a parquetry design.

## Moldings

Most parqueted surfaces have a protective molding surrounding the edge. This covers the end and edge grain of the parquet material. It also covers the edge of the core. (Styles of molding were discussed in *Chapter 11*.) Miter cut the molding and place it in position around the parqueted core. Check the fit at corners where two pieces meet. Apply adhesive on both the molding and the parquet design, then apply clamp pressure.

### Attaching carvings

Carvings are precut, decorative overlays. They can provide an accent to surfaces. You might put a carving on a cabinet door, or in the corners of a dresser. Many of the traditional styles use carvings on the cabinet surface. Queen Anne furniture is an example.

Carvings may be sculptured wood or molded wood fiber. Both may have the same shape and take stain and finish. However, sculptured wood carvings also have a grain pattern. This may be desirable to match the grain of the wood core.

To attach carvings, you must make a stencil. This allows adhesive to be applied only where the carving will be located. Trace around the overlay on a piece of thin poster board or heavy paper. Then cut out the interior slightly smaller than the overlay itself. Tape the stencil where the carving will be located. Apply a thin coat of adhesive on the core through the stencil. Then lightly coat the back of the carving. Remove the stencil and attach the carving. Apply pressure with a sandbag or clamp. If contact cement was applied, you need only to press the carving in place.

## Inlaying Practices

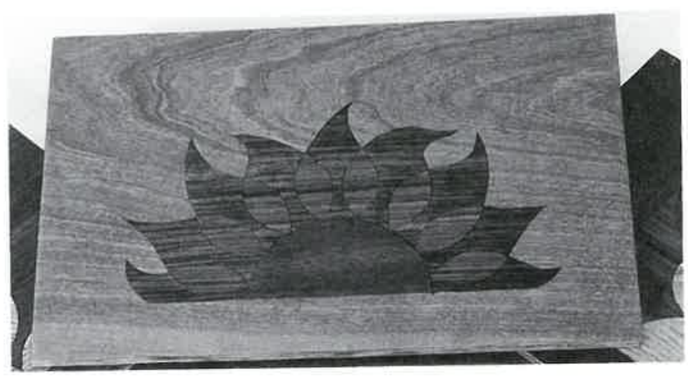
Inlaying is a method of decorating a surface without adding thickness. The inlayed veneer or wood is placed in a routed recess (or inlet) in the core material. When veneer is used, this process is called ***marquetry***. Setting thicker materials into the surface is called ***intarsia***. The inlaying process includes selecting designs and veneers, laying out the pattern, cutting the wood, assembling the design, inletting, and bonding the design to the core.

### Marquetry

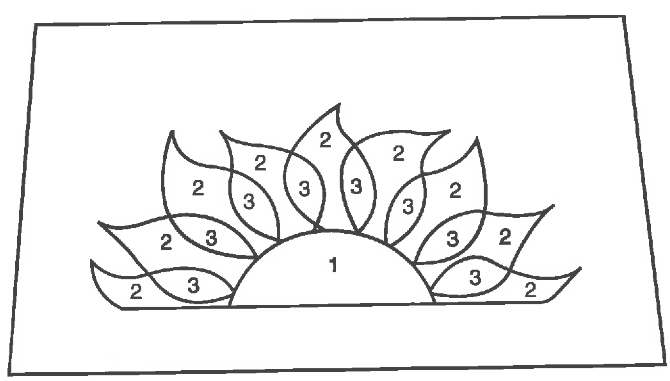
***Marquetry*** is the art of fitting together pieces of veneer to make a design. You can make marquetry patterns or buy the veneer pieces precut. Designs can be created by changing the grain directions of different veneer sections. Also, you may produce contrasting color designs by using several species of veneer. See **Figure 35-16A.** Prepare a sketch that shows grain direction and/or colors. See **Figure 35-16B.** Make as many copies of the sketch as you will use veneer types.

Marquetry pieces can be cut one of two ways: cutting each piece separately or by overlapping. The overlapping method is the easiest. One full size sheet of veneer is needed for each different grain pattern or color used in the design. You cut all the different pieces at one time. This assures that they will fit together. For example, suppose you wish to inlay three different veneers in a jewelry box lid. Cut each veneer sheet 1" (25 mm) larger in each direction than the design. The excess holds the material together until cutting is complete. Flatten the veneer if it is wrinkled. (Use water or the glycerin solution discussed earlier.) Stack the three sheets and tape them to a bottom layer of poster board the same size. Tape your sketch on the top layer of veneer. See **Figure 35-17.**

Make cuts using several passes with a sharp knife. Do not try to cut the entire stack with one pass. It may split or rip the veneer. Hold the knife vertical at all times. Cutting at an angle will make the pieces different sizes. Begin with the center piece. As you cut out the first shape, remove the three layers of veneer. Place them on the copied sketches. Continue to cut components from the center outward.



A




B

**Figure 35-16.** A—This design was made by using different species of veneer. *(Shopsmith)* B—Pattern made to produce the design.

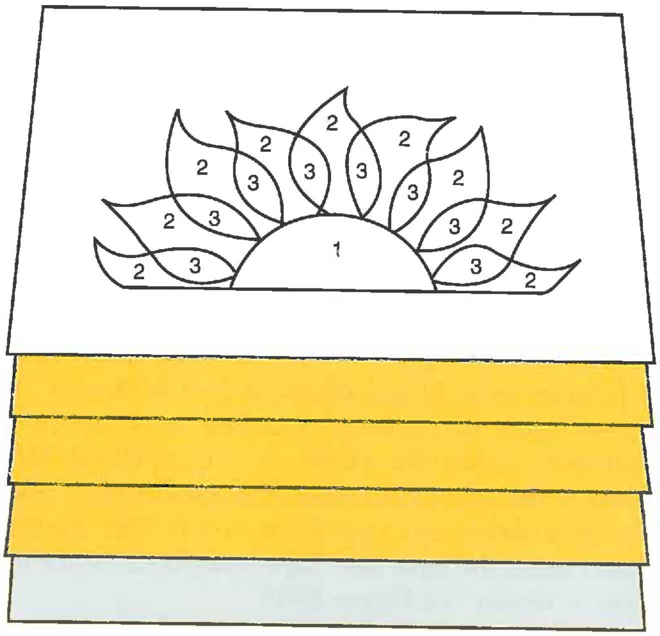



Figure 35-17. Place the veneer between the pattern and a poster-board base. Tape the edges.

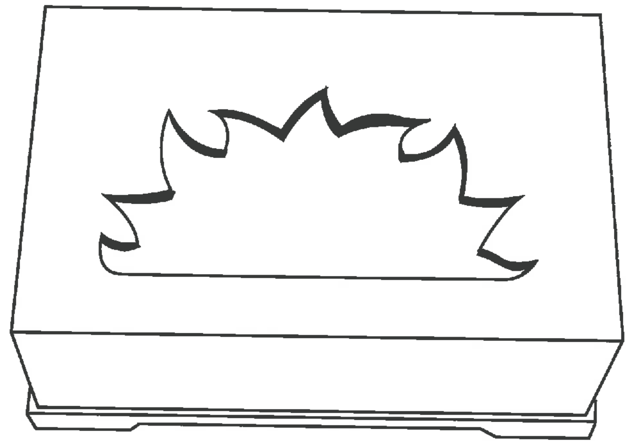


Figure 35-18. Carve or rout an inlet to accept the inlay.

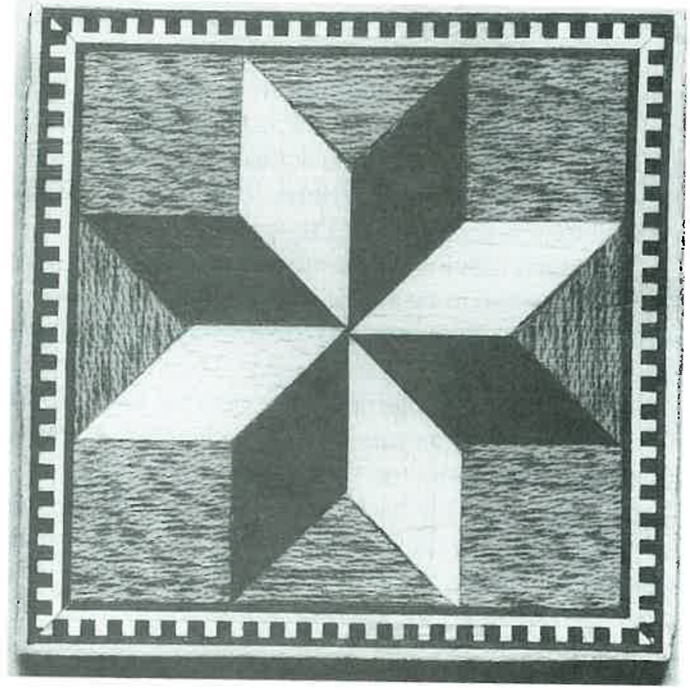


Figure 35-19. The center shapes of this design show intarsia. The outer design consists of inlaid bandings. *(The Woodworker's Store)*

After cutting through the veneers, you will have enough components for as many designs as you have layers of veneer. (Three in this example.) To assemble the shapes, fit them together and place masking tape over the joints. Inspect the back side to see if components fit.

Place the inlay in an inlet in the core. See **Figure 35-18.** The inlet (or recess) will be as deep as the veneer. To cut the inlet, first position one piece of the excess (outer part of cut veneer sheet) on the core. Secure the edges with tape. Make knife cuts around the inside of the excess to the needed depth. Lift off the excess and router or chisel away the space the inlay will occupy.

Place the inlay in position. Be sure it is flat and even with the core surface. If it is above the surface, you must remove more material from the inlet. If it is below the surface, you must build up the low area. Spread wood putty or a white glue and sanding dust mix in the low area. Let this set before proceeding.

To bond the inlay in place, coat the inlay's back and edges and the inlet of the core with adhesive. Press the inlay in place and remove excess adhesive.

Put a sheet of waxed paper over the inlay and apply pressure with clamps or sandbags. When the adhesive dries, remove the masking tape. Smooth and finish the surface.

## Intarsia

***Intarsia*** is much like inlaying a parquet pattern. See **Figure 35-19.** Thin blocks of wood are preassembled and placed in a routed or chiseled inlet in core material. Like marquetry, you can cut stacked wood layers. However, because of the thickness, you must use a band, saber, or scroll saw. Use the thinnest blade possible. The thickness of the blade determines how much space will be left between pieces. You might lay out and cut them slightly larger to compensate for the kerf. This means you must leave about 1/16" (1 mm) between the shapes on the design.

When cutting, start from one corner, not the center as you did with marquetry. Make cuts through all layers. As each shape is cut, place the layers on separate design sketches. Remember, you will have as many designs as you have layers of wood.

To assemble, hold all the components together on a contrasting color surface. Inspect them to see if trimming can reduce any spaces between workpieces. (You might spread filler in the spaces when finishing the product.) Tape the tops of each assembly. As you tape shapes together, brush adhesive on the edges. When finished, apply pressure to hold the assembled design together. (Consider using a band clamp, rubber band, or tied string.) After the assembly cures, trim and shape the outer edges.

Position the inlay on the core material and mark around it. Rout or chisel away the space the inlay will occupy. All sides of the inlet should be vertical or undercut.

To adhere the inlay, coat the inlay's bottom surface, edges, and the core inlet with adhesive. Position the inlay and apply pressure for the adhesive's set time.

### Inlaying bandings

***Bandings*** are narrow strips of wood or assembled veneer pieces. They may be overlaid or inlaid into an inlet to form borders or geometric designs. See **Figure 35-20.** Some contain metal and plastic for added color. Most are 1/28" (0.9 mm) thick and come in strips 36" (914 mm) long.

Applying bandings is a simple operation. First, rout out an inlet to the desired width and slightly shallower than the banding. See **Figure 35-21.** Position the bandings without adhesive. Overlap the bandings at corners and miter cut them with a knife. Glue the bandings in place. When the adhesive sets, lightly sand them until they are flush with the surface. Try not to make heavy cross grain scratches as you sand the inlay. Finish smoothing with a very fine grit.

**Figure 35-20.** Bandings are inlaid around the outside of the game case. *(The Woodworker's Store)*

## Special Practices for Finishing Overlaid and Inlaid Surfaces

Finishing a decorated surface may be a special problem. Grain may run in several directions. There will likely be contrasting colors. For example, suppose you have a maple veneer banding to be inlaid in a walnut surface. The walnut will be stained and filled. However, you do not want the maple discolored. There are several approaches to solving this problem:

- You can stain and fill the walnut surface without the banding. However, be sure not to get stain or filler in the banding's inlet. Stain and filler can fill the pores and add oil to the wood. Adhesives might not bond to such a surface.
- You can seal the banding with shellac to prevent it from absorbing the color of the stain. Tape outside the banding to keep shellac off the walnut.
- A third approach is to tape the banding when applying filler and stain to the walnut surface.

Another point to consider is sanding the surface before applying finish. Bandings and inlays often have grain running opposite to that of the core material. How do you keep from scratching the inlay? The easiest solution is to use a very fine grit (220 to 360 grit) abrasive with a finishing sander. The scratches made are so small that they are hardly visible. However, you could also tape the inlay to prevent sanding it. You could sand the pieces before adhering the banding. Simply hold the banding in its groove and sand it flush with the core. Then remove the banding and finish it and the core material separately.

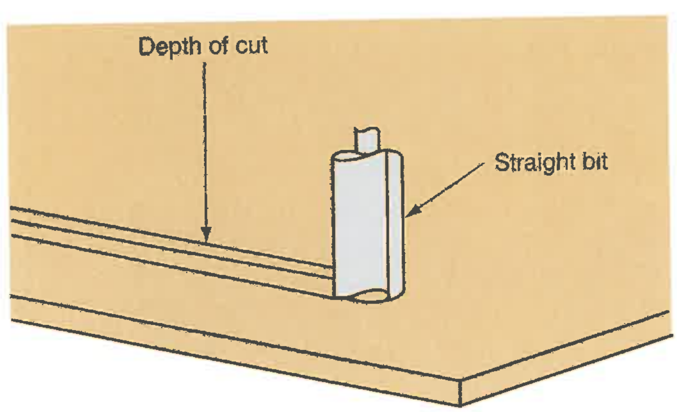



**Figure 35-21.** Use a router bit the width of the banding to create a groove.

## Summary

Overlaying and inlaying are surface decorating processes. For full surface veneering and marquetry, use 1/28" (0.9 mm) veneer. Thicker material of up to ¼" (6 mm) is used for parquetry and intarsia. Veneer tape covers the edges of panel products. Bandings provide decorative borders.

A few special tools and supplies are needed. They include a veneer saw, sharp knife, and possibly an iron or tape lamination machine. Supplies include veneer pins, masking tape, and adhesives.

Applying an overlay involves selecting the veneer, laying out the pattern, cutting, assembling, bonding, and pressing. Using this procedure, you can apply a decorative surface to an inexpensive core material. Applying an inlay requires many of the same processes, but includes inletting. Inletting is routing or chiseling a recess or groove in a solid hardwood core. Then, the assembled design is bonded into the recess.

Maintaining the color contrast from core to inlay can be a special problem. Some open grain woods may need staining and filling, while the inlay needs none. Where you do not want discoloration, apply shellac or tape to the surface.

## Test Your Knowledge

*Do not write in this text. Answer the following questions on a separate sheet of paper.*

1. Parquetry and intarsia are similar in that they both use _____.
2. Veneer flitches are held together during assembly with _____.
3. Why is hide glue not suitable for veneering?
4. Before bonding veneer with contact cement, you might apply a(n) _____ to prevent the veneer from separating when oil-based finishes are applied.
5. List several uses for sandbags when overlaying and inlaying veneer.
6. How do you hold veneer when trimming it with a plane?
7. Even though you may not see a raised edge or bubble, you can check for loose bonds by _____.
   a. peeling off the veneer
   b. slipping a knife under the edge of the veneer
   c. tapping the veneer with your fingernail
   d. cutting through the veneer surface
8. Describe two procedures to repair loose veneer bonds.
9. Edgebanding is most commonly applied to _____.
10. Why must you make a stencil when attaching carvings with contact cement?
11. When using the overlapping method of cutting marquetry patterns, you will have as many complete designs as you have _____.
12. Two methods making an inlet (recess) in a core material are _____ and _____.
13. List several considerations you must make when sanding and finishing bandings, overlays, and inlays.

36

# Installing Plastic Laminates

## Objectives

After studying this chapter, you will be able to:

* Describe steps taken to prepare the surface for plastic laminate.
* Identify tools to cut rigid and flexible laminates.
* Select appropriate adhesives for applying plastic laminates.
* Follow the appropriate procedure to bond laminate to edges and surfaces.
* List the steps used to form materials around curves.

## Important Terms

| | |
|---|---|
| core material | pressure sensitive backing |
| delamination | self-edge |
| laminate trimmer | substrate |
| manufactured moldings | warpage |
| postforming | |

Plastic laminates cover many styles of cabinetry. They provide a colorful, decorative surface resistant to water, chemicals, abrasion, impact, and normal household wear and tear. See **Figure 36-1.** These features make plastic laminates an alternative to solid wood or veneer. They are used for countertops, tables, and cabinetry in both residential and commercial settings. See **Figure 36-2.** Complementary colors add to the pleasing design. The 90° and 180° postformed high-pressure decorative laminates (HPDL) clad panels, drawer fronts, and doors may be used. They created a softer, longer lasting product.

Plastic laminates are either rigid or flexible. The most popular rigid laminate is HPDL. This term is derived from the manufacturing process. HPDL is manufactured by pressing melamine impregnated overlay and decorative paper over kraft paper impregnated with phenolic resin. Bonding occurs at pressures of approximately 1400 pounds per square inch and at temperatures more than 275°F (135°C). Many manufacturers produce HPDL with brand names such as Nevamar®, Formica®, Micarta®, Pionite®, and Wilsonart®.

**Figure 36-1.** Plastic laminates provide a clean, contemporary atmosphere to this bathroom.

A second rigid laminate has several variations of composition and appearance, but all have the decorative color throughout the thickness of the sheet. Most of these are thicker than the thickest HPDL. Examples of brand names of these products are Colorcore® and Solicor®. Other rigid laminates are acrylics, Nevamar Impressions™ and Vitricor®. These laminates are processed by the cabinetmaker in much the same manner as HPDL. However, there are precautions that need to be observed. Review the manufacturer's specification sheets for each product.

All plastic laminates must be bonded to a ***core material***, such as MDF, fiberboard, or particleboard. The core material is referred to as ***substrate***. Recommended substrates, that have the same expansion and contraction rates as HPDL, are medium-density fiberboard and 45# industrial particleboard. Solid lumber is not recommended for use as a substrate, because with changes in humidity it expands and contracts at a different rate and magnitude than the laminates. Conversely, because of its cross ply construction, plywood expands and shrinks less than the laminates. You should avoid using plywood with rigid laminates and never use it with other plastic laminates.

Most cabinet and countertop laminations are done with HPDL because of their wear resistance. There are several grades of HPDL. Refer to *Chapter 14.*

## Preparing the Surface for Laminates

For a laminate to stay bonded, the substrate must be stable. It cannot expand or contract at a different rate than the laminate. Likewise, the surface must be smooth, and joints must be secure.

With the production and availability of large substrate panels, it is seldom necessary to join two or more components. The main exception is a corner miter. If you must join components before lay up, secure the substrate using one of the joints discussed in *Chapter 29.* An edge rabbet or tongue and groove is recommended. However, a butt joint may be used. It is also a good idea to reinforce the joint with plate joinery. The substrate's surface should remain smooth across the joint. The joints in the laminate must not align with the substrate joints.

The surface to be covered with laminate must be clean. Laminating adhesives, usually contact cements, will not bond to oily, moist, or dirty surfaces. When in doubt, wipe the surface with cement solvent. You may have to sand the surface if the dirty area will not come clean.

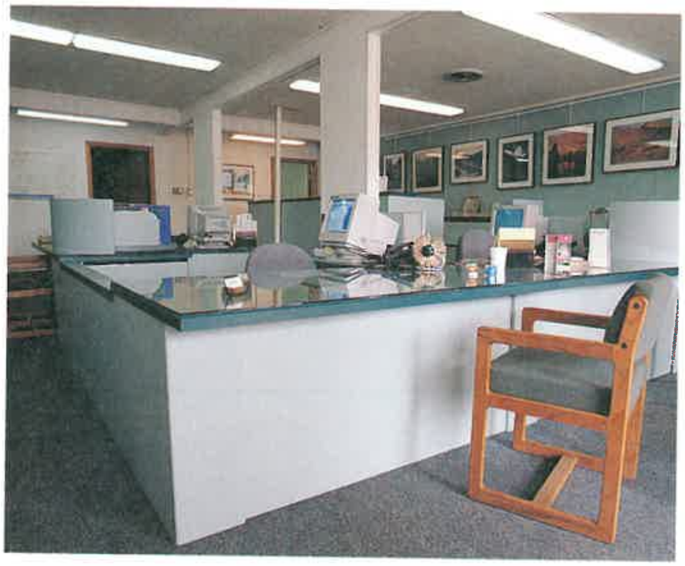


**Figure 36-2.** Surfaces of the countertops, furniture, and file cabinets in this modern travel agency are covered with HPDL. *(Chuck Davis Cabinets)*

## Cutting Laminates

Laminates are cut to approximate sizes before being adhered to the substrate. Both hand and power tools will cut rigid and flexible laminates. Rigid laminates can also be scored and fractured, much like glass is cut.

### Cutting rigid laminates

Tools that are used to cut HPDL include scoring knives, laminate trimmers, table saws, and vertical panel saws. Three common methods are illustrated. See **Figure 36-3.**

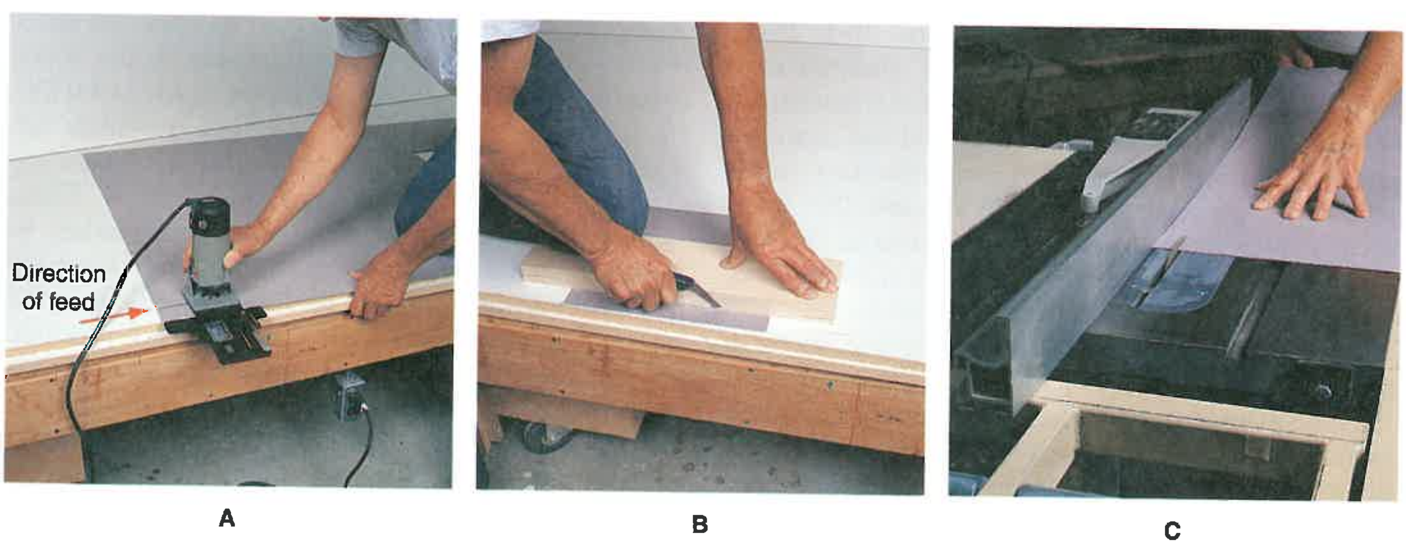



**Figure 36-3.** Laminate can be cut with a number of tools. The saw teeth must enter the decorative side of the laminate on the cutting stroke. A—Laminate slitter attachment mounted on laminate trimmer. B—Use a scoring knife and fracture HPDL as you would glass. C—The fence was repositioned to be flat to the table to prevent the laminate from sliding under the fence. *(Chuck Davis Cabinets)*

Make sure the cutting edge of the tool enters the decorative side of the HPDL. For most saws, the decorative side should be up. When the cutting edge exits, it has a tendency to chip the material. Chips on the back side of the laminate are not visible.

Select a sheet size larger than the entire surface. Cut the material oversized by ¼" to ½" (6 mm to 13 mm) or more. The excess is trimmed off later with a router or ***laminate trimmer*** to produce a smooth edge. However, when two pieces are butted against each other, an accurate cut is necessary. This may be done using a router with ¼" (6 mm) or smaller straight bit. The adjacent laminates are overlapped and clamped. Make the cut through the overlap using one of the clamp boards as a guide. See **Figure 36-4.** Any irregularities in the top layer will be matched in the bottom.

### Cutting flexible laminates

Flexible vinyl laminate is easier to cut than rigid laminates. Use scissors, shears, or a utility knife. Leave excess as you do with rigid laminate.

Flexible plastic laminates may have a hot-melt glue or ***pressure sensitive backing.*** Apply those with hot-melt glue by warming them with an iron. Install those with pressure-sensitive adhesives by removing the plastic backing. Then, press the laminate in place. This is similar to using contact cement. The substrate must be sealed with a shellac, varnish, or lacquer sealer coat before applying adhesive.

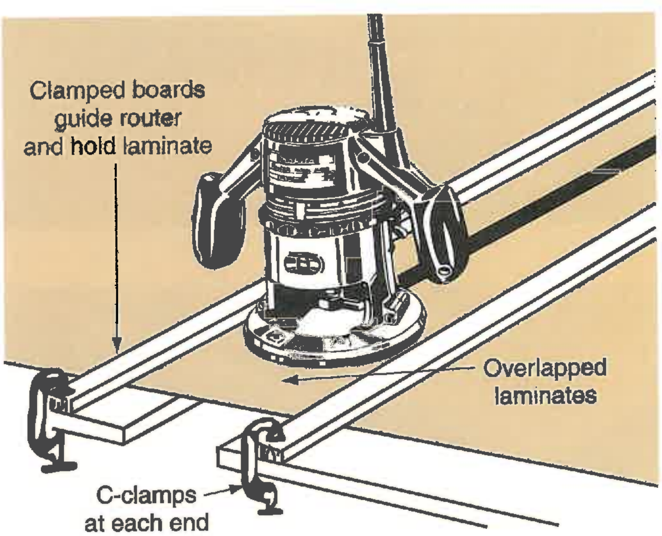



**Figure 36-4.** Laminate butt joints are made by overlapping the laminates. Cut through the overlap with a ¼" (6 mm) or smaller straight router bit. Keep the router base against only one guide board for a more true cut.

## Applying Adhesive

Contact cement is the primary adhesive for laminating. It bonds quickly and if the laminate and substrate are clean, will last many years without ***delamination.*** It is applied without an expensive press. Review the *Selecting Contact Cements* section in *Chapter 32.*

Before using any cement, read the label. It may contain safety information and application instructions. This information may have changed since your last experience with the product. Chlorinated and water-based cement can be brushed, sprayed, rolled on with a short nap roller, and troweled on with a fine notch spreader. Solvent-type cements can be applied the same way. However, spraying may require that you apply a spray grade cement.

The temperature and humidity of the room can affect bonding. The temperature should be no lower than 65°F (18°C). The relative humidity should be between 45% and 50%. These conditions apply to the laminate, substrate, and contact cement for a minimum of 24 hours before and after bonding; preferably 72 hours.

Stir the cement thoroughly, then apply an even coat to the substrate surface and laminate back. If you apply too little cement, or if a porous substrate material absorbs it, the dry adhesive film will appear dull. In this case, after the material dries, apply a second coat to the entire surface. When the cement sets, the surface should appear glossy and feel tacky.

A fine notch spreader is good for spreading cement over large areas. See **Figure 36-5.** It applies cement evenly and quickly. Excess cement can be removed from surfaces and tools with solvent.

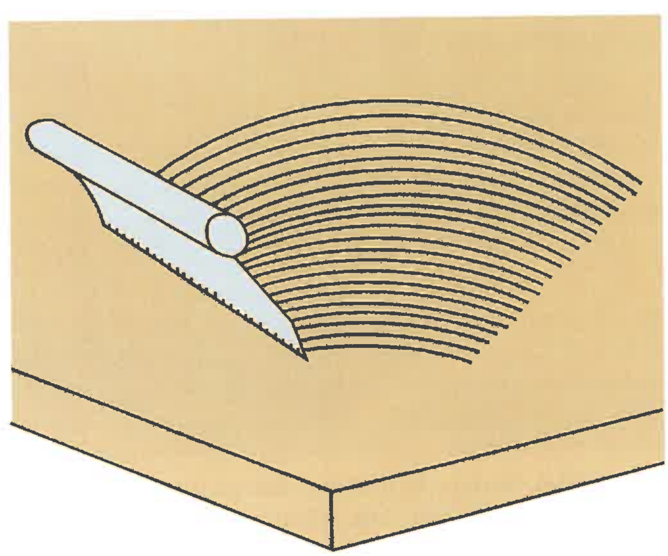


**Figure 36-5.** Spread cement evenly across the substrate and laminate back. *(Franklin International)*

## Installing Laminates on Flat Surfaces

The order in which you apply laminate to surfaces and edges depends on which face receives the most wear. Generally, you apply a laminate edge first. See **Figure 36-6.** When the edge is applied first, this type of application is referred to as ***self-edge.*** This is done if the top surface will receive the most wear. Cut edge strips 1/8" (3 mm) wider than the thickness of the substrate.

The edges of doors and drawers are also laminated before the surfaces. The front surface covers all the edges. When the door or drawer is closed, seams are not visible.

### Edges first

Follow this procedure to apply edges:

1. Cut the edge piece slightly oversize so it can be trimmed later. Butt joints between two strips can be made by overlapping them. Then cut through the overlap with a thin blade hacksaw. The ends should match well. If not, file them.
2. Coat both the laminate back and the substrate edge with contact cement. Keep them separated.
3. Allow the cement to set.
4. Test by touching the cemented laminate and substrate with a piece of kraft (brown wrapping) paper. The paper should not stick to the dry adhesive.
5. Position the laminate over the substrate. Make sure the laminate hangs over the substrate edges. See **Figure 36-7A.**
6. Press the laminate against the edge.
7. Apply pressure by rapping a hardwood block with a mallet or hammer. See **Figure 36-7B.**
8. Trim the excess laminate with a laminate trimmer, router, or mill file. The edge should be trimmed flush with the surface. See **Figure 36-8.**

There are times when you do not apply edges before surfaces. This is when a manufactured beveled laminate molding, veneer or plastic edge-banding, T-moldings, as well as metal or solid wood edge will be installed. In this case, the top (and possibly a bottom) laminate is applied to the surfaces. Then, the edge is placed over or flush with the laminate. See **Figure 36-9.**

### Manufactured moldings

***Manufactured moldings*** create an attractive, seamless look. Manufacturers offer many molding styles, such as solid wood bullnose and wood bevel, and a variety of thickness and colors of HPDL. Combinations of colors may be ordered on different faces of the beveled styles.

For best results with Perma-Edge® moldings, you may purchase a set of portable and bench-top power tools to complete the *task.* This set includes a router based straight cut planer, a ¼" (6 mm) dado cutting router with large base, a 10" disk sander, and an inside corner template and router. However, the basic tool required is the ¼" (6 mm) dado cutting router. The depth of cut has been set at the factory. The depth should not need adjusting until the bit

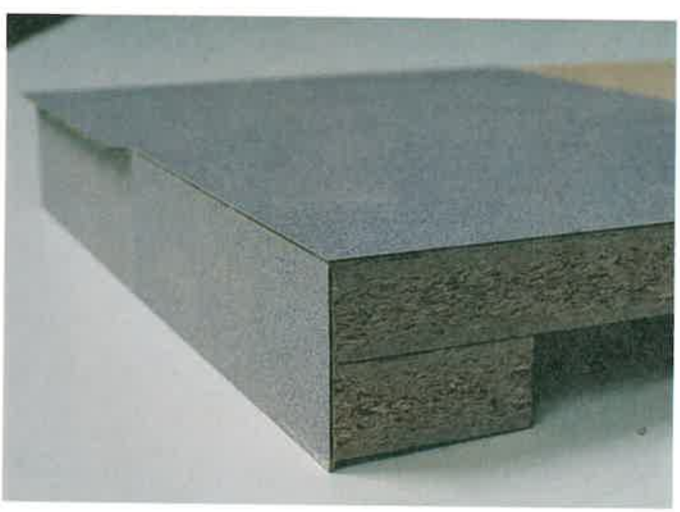
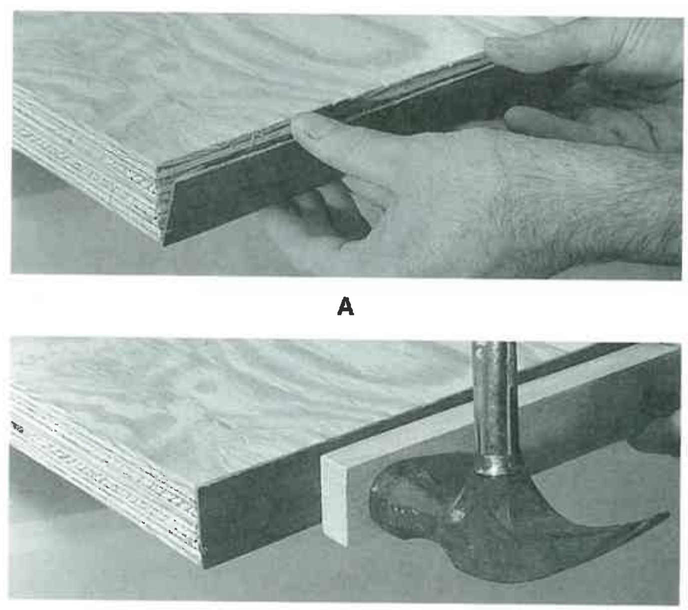


**Figure 36-6.** Surface laminate overlaps the edge banding that was applied first. The trimming is not complete to show the overlap. The 3/4" (19 mm) build down blocking is for appearance. It makes the tabletop look thicker. *(Chuck Davis Cabinets)*



A

B

**Figure 36-7.** A—Position the edge carefully. Make sure it covers the substrate thickness. B—Once positioned, rap the laminate to assure a good bond. *(Franklin International)* needs sharpening or replacing. See **Figure 36-10A.** Flat panels are required for these moldings. Buy laid-up panels from your supplier with the laminate glued to the substrate using PVA adhesives in presses. Cut the panels ¼″ (6 mm) oversize with a table or panel saw. Then, use a router and straight edge to trim panels to exact size required. The straight cut planer can be used for this operation. Then cut the slot using the dado cutting router. See **Figure 36-10B.** Move the router at a moderately fast rate. Too slow will tend to make the slot slightly oversize. Too fast will result in a very tight glue starved joint.

Trim moldings approximately 1″ (25 mm) longer than required. See **Figure 36-11.** Sand the trailing end (right end) of each molding piece using the disk sander. See **Figure 36-12.** Size a piece by placing it in the groove, aligning the right end. Mark the left end with a sharp soft (#2) pencil. Sand up to the mark, then slowly remove the mark. Dry fit to the top. Touch the next piece against the piece installed. Fit carefully and mark the left end and

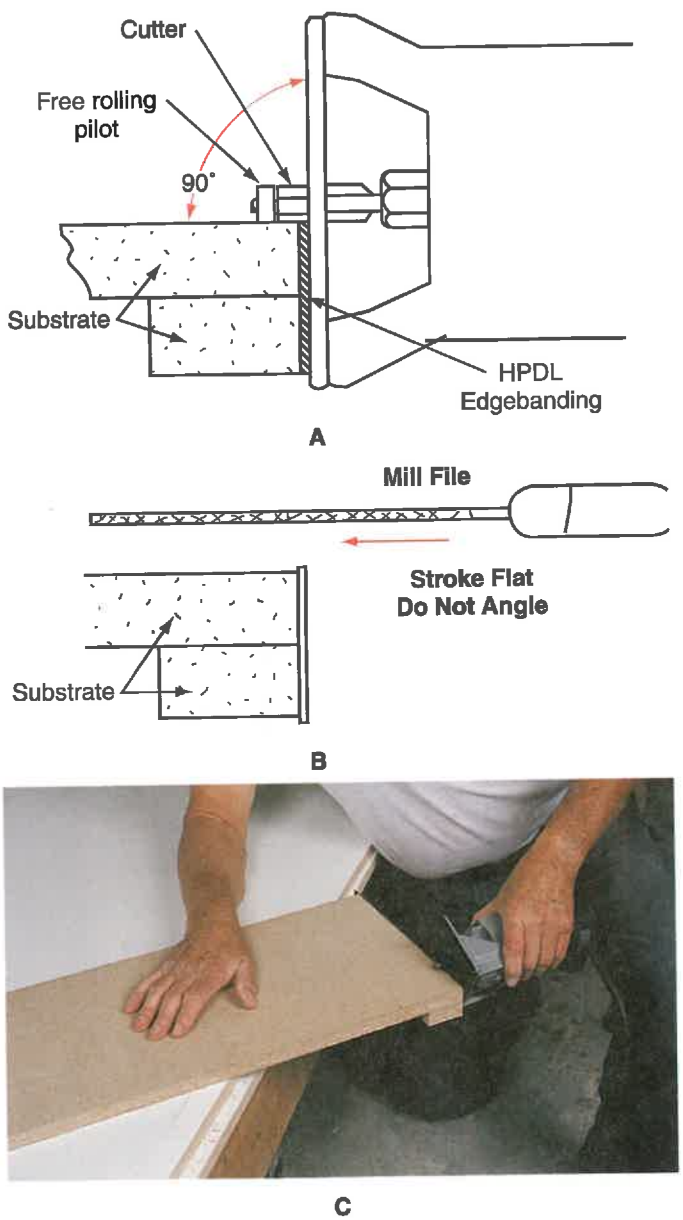



**Figure 36-8.** A—The pilot keeps the cutter flush with the surface as you move the router along the edge. B—Excess material can also be removed with a mill file. C—Using the router. *(Chuck Davis Cabinets)*

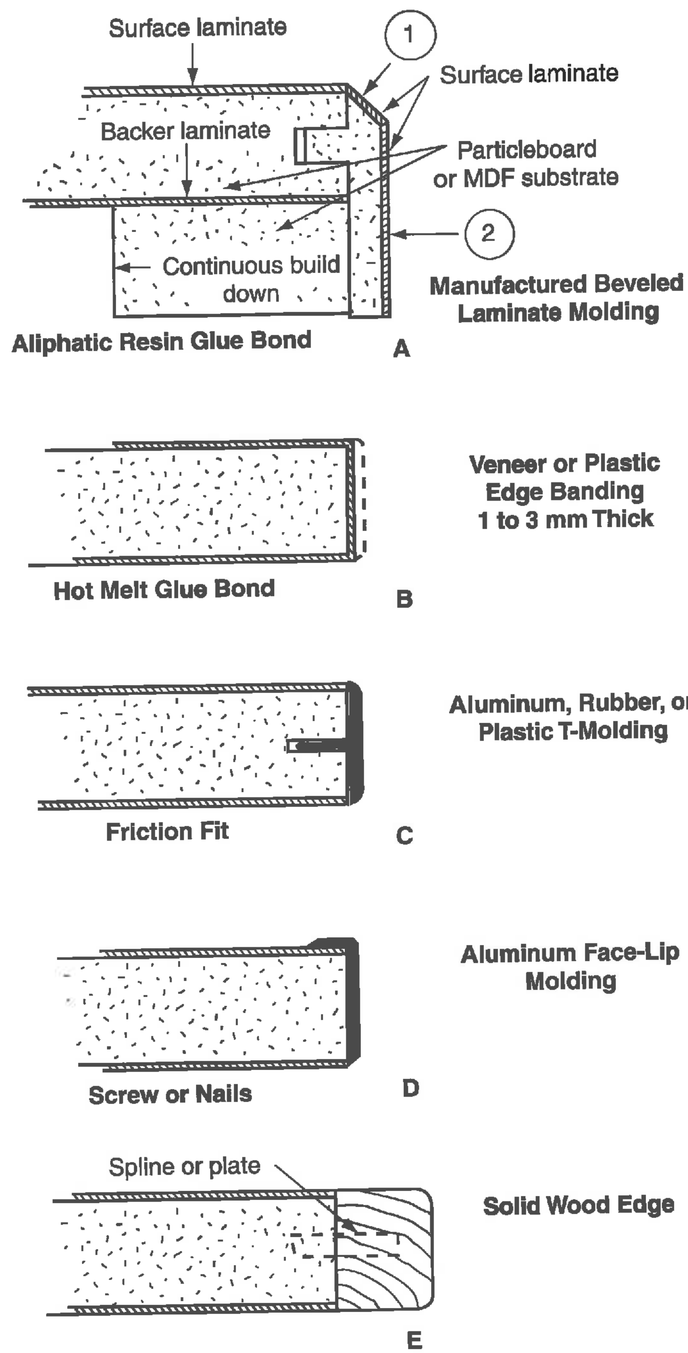
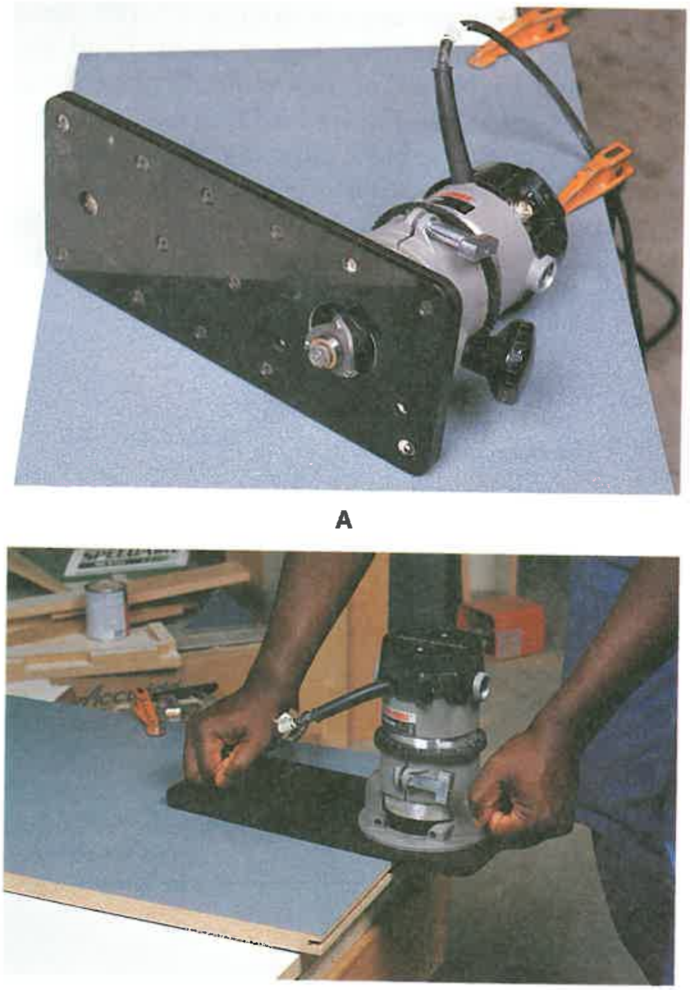



**Figure 36-9.** Surface laminates are bonded before applying manufactured beveled laminate molding, veneer or plastic edgebanding, T-moldings, as well as metal or solid wood edge. *(Chuck Davis Cabinets)*



A

B

Figure 36-10. A—This router is fitted with a wide base and 3-wing slot cutter. B—Hold the router steady, and firmly move it along the panel. *(Chuck Davis Cabinets)*

**Figure 36-11.** Trim the Perma-Edge® moldings about 1" (25.4 mm) longer than required. Note the groove in the temporary fence that is attached to the power miter saw. *(Wilsonart International)*

sand as before. Prepare all pieces in the same manner. Use a disk sander fitted with a 60 grit abrasive. Test fit with all pieces in place. Remove the pieces, one at a time and apply a bead of glue to the top of the tee. Apply a second bead of glue, twice as large as the first, to the bottom of the tee. See **Figure 36-13A.** Snap the molding in place with a rubber mallet. No clamps should be necessary. See **Figure 36-13B.** Turn the work piece over and glue and staple the build down in place.

**Figure 36-12.** This disk sander provides accurate sanding required of the miters. Accessories include 90°, 45°, and 22½° miter gauges. The outlet shown is switched to turn on the dust collector, if you plug it into the outlet. *(Wilsonart International)*

## Surfaces

Follow this procedure to laminate surfaces:

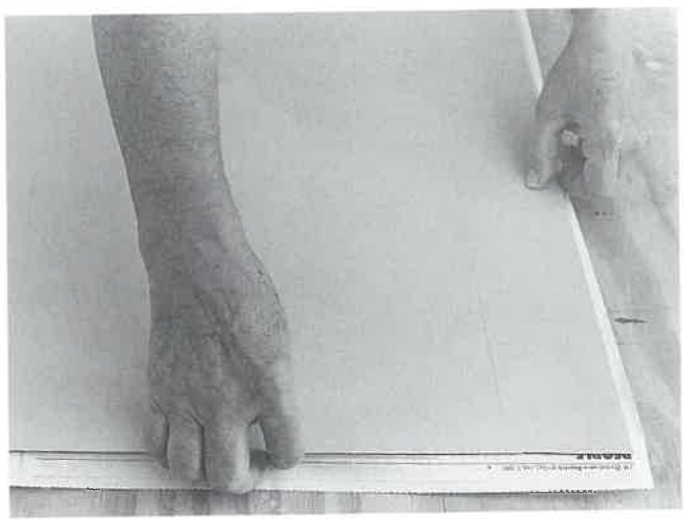
1. Measure the surface to be covered. Buy a single sheet of laminate larger than the surface. Cut it ½" (13 mm) wider and longer than the surface.
2. For irregularly shaped surfaces, lay the laminate on the surface. Mark it ½" oversize with a grease pencil.

3. Cut the laminate. Make sure the teeth of the saw enter the decorative side of the laminate on the cutting stroke. Use the overlapping method discussed earlier to butt two pieces together. Then cut them to size.
4. Coat the laminate and substrate with contact cement, and keep them separated. Remember to coat the visible edge of the edgebanding applied earlier. Let the cement set.
5. Place dowel rods or a layer of newspaper on the substrate.
6. Position the laminate on the rods or paper. See **Figure 36-14A.** This keeps the mating pieces apart until you are ready to join them.
7. Place the laminate over one edge of the substrate. It should overhang the edge by about ½″ (13 mm). Slide out some of the newspaper, or remove a dowel rod, to bond one section of the laminate. When using dowels, remove the middle dowel first and press the laminate to the substrate.
8. Continue to slide out the paper or remove dowels until the entire laminate is bonded. See **Figure 36-14B.** When any part of the laminate contacts the substrate, the laminate can no longer be adjusted.
9. Apply pressure with a J-roller or rolling pin to remove air pockets and fully bond the laminate. See **Figure 36-15.** Roll from the center to the edges. The more pressure you apply, the better the bond.
10. Trim the laminate overhang with a router (or laminate trimmer) and flush cutter. See **Figure 36-16A.** Rub petroleum jelly on the edge. This protects it from burning when the cutter's pilot is held against the edge. You can also trim with several hand tools that score and fracture the laminate. See **Figure 36-16B.**

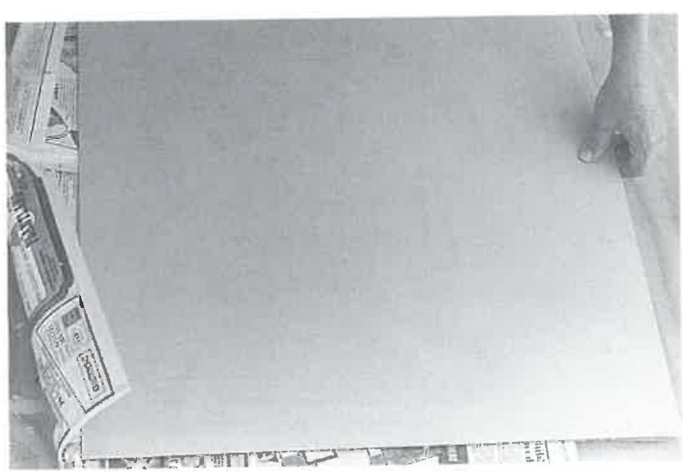
A

B

**Figure 36-13.** A—Practice will teach the proper amount of glue to apply. B—Use a white rubber mallet to avoid marking the laminate. *(Chuck Davis Cabinets)*

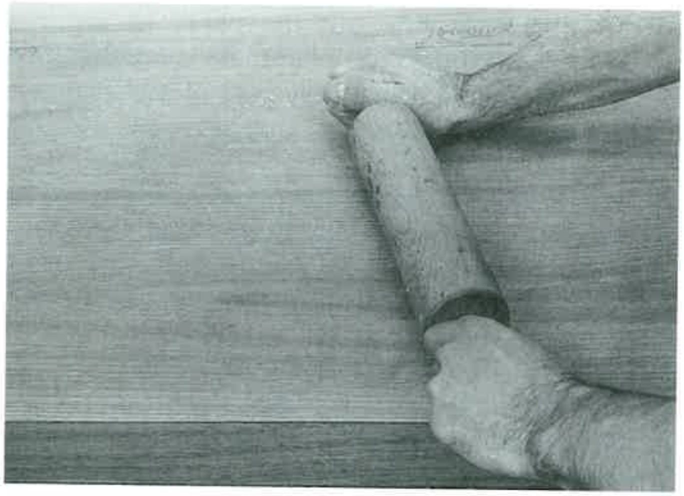


A

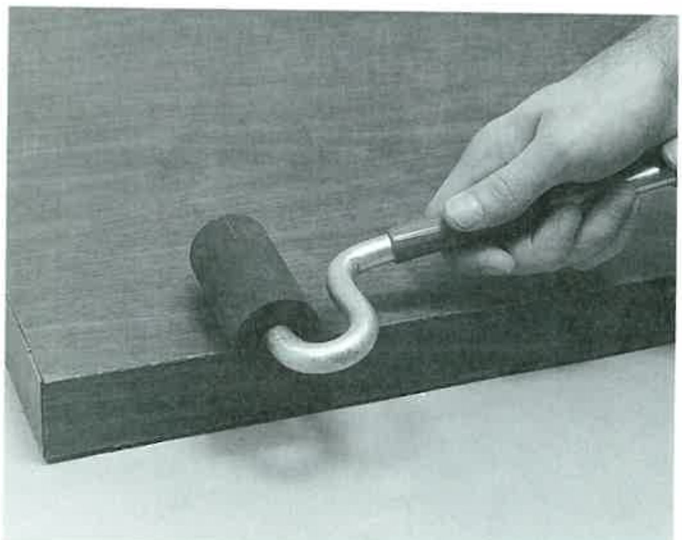


B

**Figure 36-14.** A—Place paper or dowels on the substrate and position the laminate on the paper or dowel. B—Proceed to bond the laminate by sliding out the paper or dowels.



A



B

C

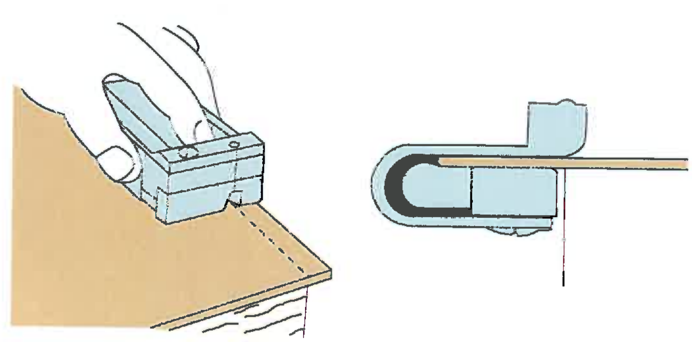
Figure 36-15. A—Use a rolling pin, outward from the center to remove air bubbles. B—Since it is difficult to apply adequate pressure, apply more pressure with a J-roller. C—Rap the surface with a wood block and hammer. *(Franklin International)*

11. Bevel the corner about 20°. This can be done with a router or file. See **Figure 36-17.** Beveling removes the sharp corner and extends the wear life of the laminate edge.
12. If necessary, sand the bevel with 180 grit abrasive wrapped around a wood block.

After laminate has been installed, remove excess adhesive. Either, rub it off with your fingers, or wipe it off with a rag soaked in solvent. (Be careful not to let solvent enter joints between laminate pieces.) Then use soap and water or alcohol to restore the original finish.

If a bubble forms in the laminate, place newspaper over it and press with a warm iron (300°F, 150°C). The temperature control should be set at *silk*. Press until heat penetrates the area around the bubble. Lower the heat setting if the newspaper scorches. Remove the iron and apply pressure with a J-roller until the area cools.

A



B

Figure 36-16. A—A hand-held laminate trimmer is efficient for trimming the surface flush with the edge. *(Delta International Machinery Corp.)* B—Hand trimmers score the surface. The waste is broken up and off, leaving an unchipped edge that may need filing. *(The Woodworker's Store)*

## Forming Curves

Cabinet surfaces and edges are not always flat. You may have to apply laminate to an edge of a curved table or countertop. The procedure is as follows:

1. Select postforming grade laminate.
2. Cut the laminate oversize to allow material for the curve.
3. Coat the substrate and laminate with contact cement. Place newspaper over the substrate.
4. Position and bond one end of the laminate.
5. In one hand, hold a warm (300°F; 150°C) iron to the laminate. (A heat gun can also be used.) With the other hand, pull the laminate around the curve. See **Figure 36-18.**
6. When a section of the laminate has formed around the curve, remove paper under that section and bond the plastic. Apply pressure with a roller.
7. Continue to heat, form, bond, and roll the laminate until the entire curved surface is complete.
8. Trim as necessary.

## Postforming

Other edge treatments have become available with advances in postforming technology. ***Postforming*** is the process of bending laminate with heat to a radius of ¾″ (19 mm) or less. Grades of laminate can achieve 1/8″ to 5/8″ (3 mm to 16 mm) outside radii. These bent items are useful for cabinet and casework panels, doors and drawer fronts, shelves, desk, credenza and countertops, and table and bar tops. You may use white, semirigid, nonflammable adhesives. See **Figure 36-19.** Equipment required to do postforming can range from a minimum investment to a major investment.

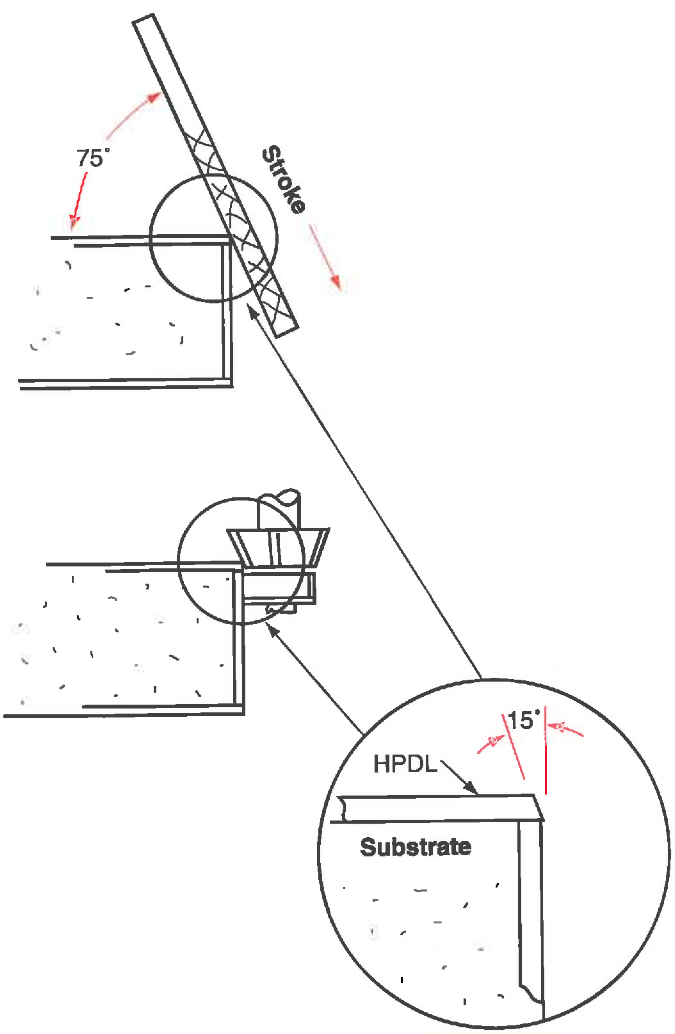



**Figure 36-17.** Bevel the surface laminate 15° with a mill file or bevel cutter bit installed in a laminate trimmer. *(Chuck Davis Cabinets)*

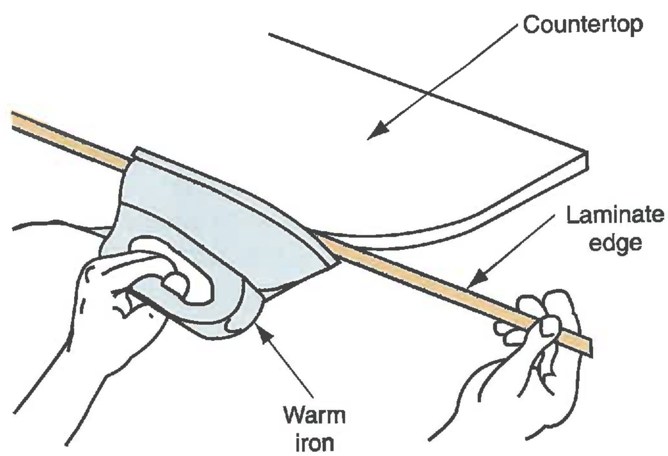



**Figure 36-18.** Heating a postforming grade laminate makes it flexible. Pull the laminate around the curve and press it against the substrate.

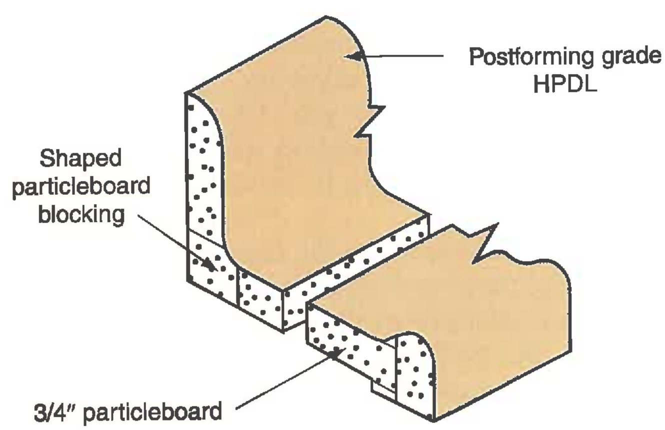



**Figure 36-19.** Many modern counter surfaces consist of a single sheet of laminate. It must be formed around the backsplash and the no-drip bullnose at the front edge.

## Forming Curves with KerfKore®

In *Chapter 34,* the properties of KerfKore were introduced. The product can be used in many applications. These included radiused side panels, column covers and wraps, free form tables, two sided structures, curved doors, and flexible pocket doors. For a complete technical information manual, contact your distributor. Most laminating techniques presented in this chapter can use this substrate. Some very important differences are noted.

### Adhesives

Any contact cement recommended for use with HPDL can be used. *Do not* use rigid setting glues. They may cause ridge lines and face fractures. However, there are instances where they may be used. These instances are discussed later in this chapter.

Always apply contact cement to the black side of KerfKore unless otherwise directed. Adhesives may be applied by spraying, brushing, or rolling.

### Making a J-panel

One of many typical applications is a J-panel, or radiused side panel for a cabinet. See **Figure 36-20.** To make a J-panel, proceed as follows:

1. Cut a KerfKore piece six slats wider than the total radius desired to allow for radius transition. Cut it 1" (25 mm) longer than the finished height of the panel.
2. Cut a wood front connecting piece and particleboard side panel 1" (25 mm) longer than the finished height.
3. Cut the HPDL (or other facing material) 1" (25 mm) longer than the finished height and 3" (75 mm) wider than the width of the assembly. Place it face down on a flat worktable.
4. Apply contact cement to HPDL, the black side of the KerfKore, and the particleboard.
5. Assemble the KerfKore and side panel. Adhere this to the laminate allowing 1½" of laminate to extend beyond each side. Use *light to moderate* pressure when bonding the face material. Firm hand pressure is usually adequate. See **Figure 36-20A.**
6. Trim the assembly to the finished panel height.
7. Adhere the front connecting piece to the assembly with aliphatic resin glue, **Figure 36-20B.**
8. Trim the excess HPDL flush to front edge of connecting piece.
9. Cut rabbet in the top and bottom of assembly to receive the top and bottom.
10. Using a KerfKore tool, open all grooves except for the first two and last two. See **Figure 36-21.**
11. Attach front connecting piece to side of main cabinet with glue and screws. See **Figure 36-20C.**
12. Cut and attach a rear connecting piece ½" (13 mm) from the back of the cabinet with glue and screws.
13. Bend J-panel assembly into position and attach the back panel with staples or screws. See **Figure 36-20D.**

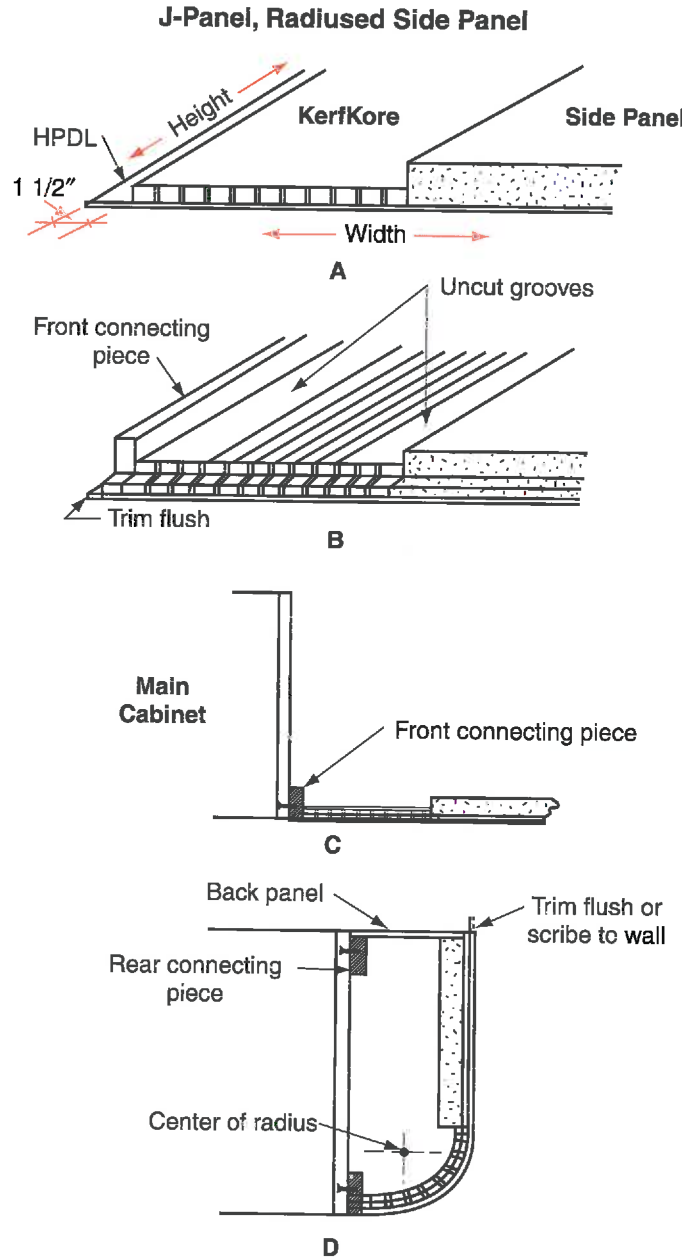



**Figure 36-20.** Constructing radiused side panel using KerfKore®. A—Apply light to moderate pressure when adhering KerfKore to HPDL with contact cement. B—Cut all grooves with KerfKore tool except first two and last two. C—Align front connecting piece carefully. D—Back panel, top and bottom complete the project. *(Interior Products, Inc.)*

14. Trace the J-panel shape onto ½″ (13 mm) particleboard and reduce the size by the thickness of the tongue of the rabbet. Glue it in place with contact cement or white glue.
15. Trim flush the excess HPDL at the rear edge. You may want to temporarily attach a protective strip behind the excess. During installation, remove the strip and scribe the HPDL to the wall.

## Other KerfKore applications

Curved doors require a bending form that matches the required inside radius of the door. The finished assembly does not *spring back*. Make the radius form exactly as needed. The fabrication procedure is as follows:

1. Cut materials and adhere the inside laminate to the black side of the KerfKore with contact cement.
2. Using the kerfing tool, open kerfs in the area that is curved.
3. Position the assembly on the form making sure the kerfs are parallel to the centerline and mark the door edges.

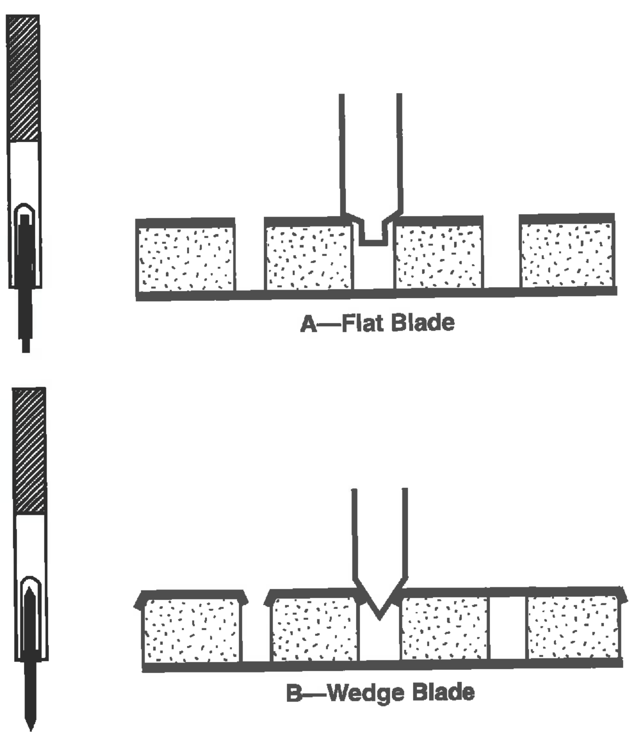



**Figure 36-21.** KerfKore® tool. A—This flat blade tool strips the brown paper backing from both sides of the groove area and permits maximum bending. B—The wedge shape tool slices the backing paper and wedges it into the groove. Although faster, the minimum radius achievable is less. *(Interior Products, Inc.)*

4. Remove the assembly and cut the KerfKore/laminate assembly to size, allowing for edge trim.
5. Cut a piece of laminate for the outside, 1″ (25 mm) larger in length and width than the finished door measurement.
6. Spread a *heavy* coat of aliphatic resin glue on the kerfed side. Reposition the assembly on the form, realign centerline and edges with marks on the form.
7. Position the oversized face laminate on top of the aliphatic resin glue so that it overhangs all edges.
8. Pull into place with strap clamps and a couple of wood strips near each door edge.
9. Trim the face laminate to ¼″ (6.3 mm) larger than door size on all four edges.
10. Clamp raw laminate to the end of the form and use the face of the door as a guide for a laminate trim router. Cut the curved end edgeband outside radius. Do not apply.
11. Apply straight strips of laminate on sides of door against the overhang and trim flush.
12. Apply curved end against the face laminate and trim the inside flush.
13. Trim the face laminate flush with edge laminate.
14. Bore holes for Euro-style hinges, press in the hinge and mount on the cabinet.

The procedure is much the same for many other projects where laminate will be visible on both sides of the finished product. See **Figure 36-22.**

**Figure 36-22.** This lazy Susan has substrate of KerfKore®. The process is similar to making a radius door. *(Chuck Davis Cabinets)*

## Causes of Panel Warpage

Laminate clad panels may warp if they are not physically held or balanced. A panel with balanced construction equalizes the forces acting on each side of the substrate. These forces are powerful. If they are not properly addressed, panel warpage will result. ***Warpage*** is due to the differences in dimensional movement between the laminate and the substrate and between the face and back laminate. This movement is caused by the expansion or contraction of the laminate's paper fibers and the wood fibers in the substrate.

Balanced panels can also warp if they are exposed to different humidity conditions on opposing sides. For example, warpage is likely when a panel in an air-conditioned room is mounted on a damp basement wall without the proper moisture barrier.

### Ways to avoid warpage

- The laminate and substrate should be stored in the same environment for 72 hours before assembly; preferably in a room with 45% to 50% relative humidity at 70°F (24°C). Store the adhesive in the room for 24 hours before use.
- For critical applications, such as doors and desktops:
  - Use the thickest substrate consistent with the design and requirements of the project.
  - Use the same laminate on each face of the substrate.
- Laminate movement is twice as much in their cross-grain as in grain directions. Sanding lines on the back will indicate grain direction. Always keep these grain directions aligned.
- Use the same adhesive and application techniques for bonding the front and back laminates. This is especially important when using water-based adhesives.
- Paint, varnish, and other applied materials will not provide the balance desired.
- When installed between two immovable objects (walls), allow 1/8" (3 mm) for each 48" (1220 mm) of panel for movement.

## Summary

Plastic laminates are an alternative to solid wood or veneer surfaces. They are durable, decorative, and relatively easy to apply. You can cut laminate with hand and power saws, or you can score and fracture it much like glass. The tool you select depends on whether the laminate is rigid or flexible.

To bond the plastic, coat it and the substrate with contact cement. Generously apply an even layer and allow it to dry to the touch. Once the laminate contacts the substrate, it cannot be adjusted. Place newspaper or dowel rods between them while you position the sheet. Excess laminate can be trimmed with a laminate trimmer, router, hand trimmer, or mill file.

Laminate clad panels can be susceptible to warpage. Proper preparation and precautions can prevent any warpage from occurring.

## Test Your Knowledge

*Do not write in this text. Answer the following questions on a separate sheet of paper.*

1. A loose joint between two substrate pieces could cause the laminate to _____.
2. The cutting edge of a saw should enter the _____ side of the laminate.
3. The most appropriate adhesive for applying plastic laminate is _____.
   a. polyvinyl
   b. contact cement
   c. resorcinol
   d. aliphatic resin
4. Applying an uneven layer of adhesive could cause _____ and _____.
5. In general, should the edge or surface laminate be applied first?
6. Why should you place dowels or newspaper between the substrate and laminate after they have been coated with contact cement?
7. What grade of laminate should you choose when planning to heat-form it around a curve?

# Caning and Upholstering

37

## Objectives

After studying this chapter, you will be able to:

- Select caning materials, tools, and supplies.
- Install cane webbing in a chair frame.
- Identify conventional, basket, open, and closed weaves.
- Weave cane in a frame.
- Weave a conventional rush design.
- Upholster a slip seat.

## Important Terms

binding cane
cane
caning
caning pegs
caning wedges
chair cane
flat oval reed
flat reed
glycerin solution
reed
round reed
rush
spline reed
twisted fiber rush
webbing

Caning and upholstering are methods of creating a soft covering on furniture. Caning consists of weaving a design using cane, reed, or rush. Upholstering refers to completely covering a surface with fabric, leather, or vinyl.

## Caning

***Caning*** is the process of weaving a fibrous bark material into decorative patterns. ***Cane*** is woven for chair seats, backs, and decorative covering on doors and panels. See **Figure 37-1.**

For centuries, cane, rush, and reed have been used in furniture making. These materials were first introduced to reduce the weight of furniture. Instead of installing a panel inside a frame, cane was woven through the frame. Cane is widely used today because its natural blond color blends with many contemporary furniture styles.

**Figure 37-1.** The color of these caned chairbacks blends with the light oak color of modern furniture. *(Thomasville)*

### Materials

Caning is done with cane, reed, and rush. Cane comes from the rattan palm, which has long, slender stems. This palm is also the source of rattan furniture. The outer bark of the stem is stripped off and dried. The outer surface of the bark is hard, smooth, and shiny. ***Reed*** comes from another species of palm that grows in warm moist climates. The plants are stripped of their leaves and bark. Then they are split, shaped, and dried. Reed has a softer, duller, and more porous surface than cane. ***Rush*** is the name given to many stemlike plants of the sedge family. (Cattail is a member.) When the plant leaves become dry, they are cut off and twisted together. Cords of rush are sold as ***twisted fiber rush.***

Cane is cut into several widths for different purposes. ***Chair cane,*** used for most weaving, is 1/16″ to 9/64″ (2 mm to 4 mm) wide. These sizes are named as shown in **Figure 37-2A.** It is sold in 1000′ (305 m) hanks. Chair cane is woven through holes drilled in the frame around an opening. ***Binding cane*** is 5/32″ to ¼″ (4 mm to 6 mm) wide. See **Figure 37-2B,** and sold in 500′ (153 m) hanks. It is installed over the edges of woven chair cane to hide the holes in the frame.

Reed is cut into several shapes and sizes. ***Flat reed, flat oval reed,*** and ***round reed*** are used for weaving. See **Figure 37-2C.** They are 3/16″ to 5/8″ (5 mm to 16 mm) wide and sold in 1 lb (0.45 kg) hanks or 55 lbs (24.95 kg) bales. Round reed is 3/64″ to 3/16″ (1 mm to 5 mm) and is sold in 1 lb (0.45 kg) coils. Reed is woven around the frame.

Rush, or twisted fiber rush, is made into 5/32″ (4 mm) and 3/16″ (5 mm) cords. See **Figure 37-2D.** It is wound around spools and sold by weight. Usually, 2 lbs (0.91 kg) of rush are needed for an average chair seat. Rush, like reed, is woven around the frame, not through holes drilled in the frame.

Most of today's caning is done with ***webbing,*** which is prewoven cane and/or reed. Weaving single strands of cane and reed is simply too time-consuming. Webbing is machine woven into many designs. See **Figure 37-3.** It is made into 14″ to 24″ (356 mm to 610 mm) wide sheets and sold by the square foot. ***Spline reed,*** another reed shape, holds webbing in a groove. The groove is made in the frame around the opening to be caned. Spline reed is a wedge shape. See **Figure 37-4.** It is specified by three dimensions: height, width across the top, and width across the bottom. The most commonly used spline reed is 3/16″ × 5/32″ × 3/32″ (5 mm × 4 mm × 3 mm).

The biggest concern you have when caning is moisture control. Cane, reed, and rush strands must be woven, or installed, while wet. Moisture makes fibrous materials more flexible. If they are not damp enough, pulling a strand around a sharp curve might crack it. However, leaving these materials in water too long will discolor them.

Moisture serves another purpose. It expands the material. When the woven strands or webbing are dry, they shrink and tighten the weave. This is why you do not have to pull the strands as tight as you want the completed seat.

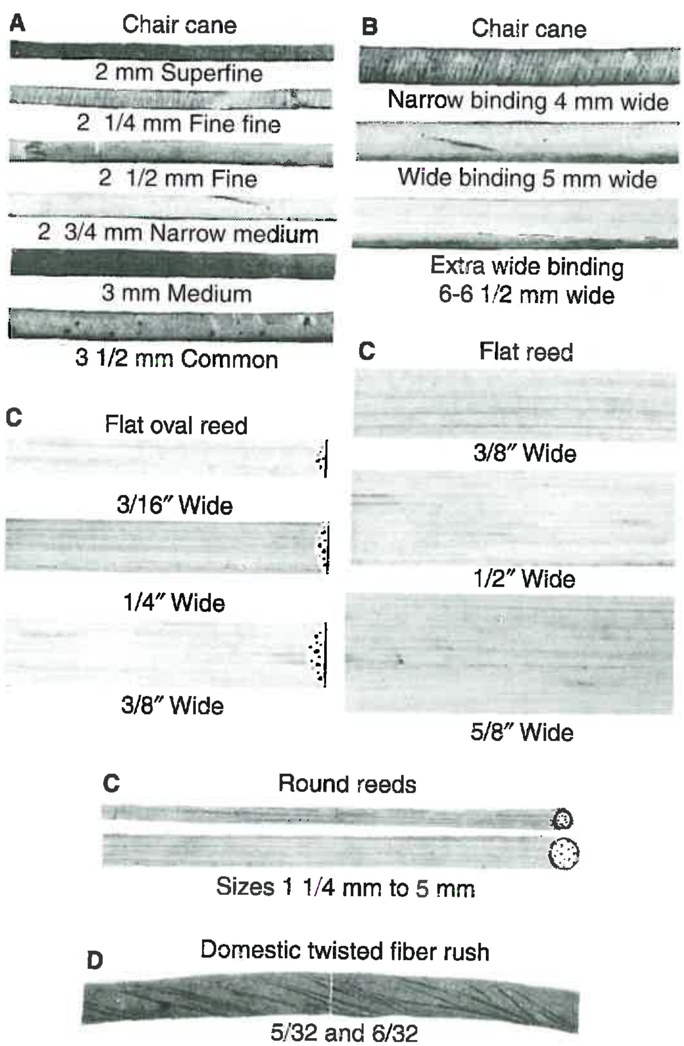



**Figure 37-2.** A—Chair cane is identified by name and size. B—Binding cane comes in three widths. C—Three styles of weaving reed. D—Twisted fiber rush is made into cords. *(The Otto Gerdau Co.)*

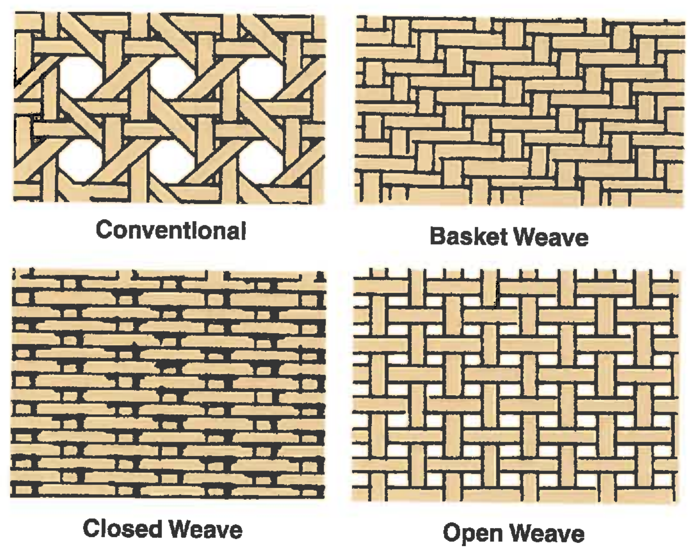



**Figure 37-3.** These are the four most common designs for webbing and for weaving loose cane.

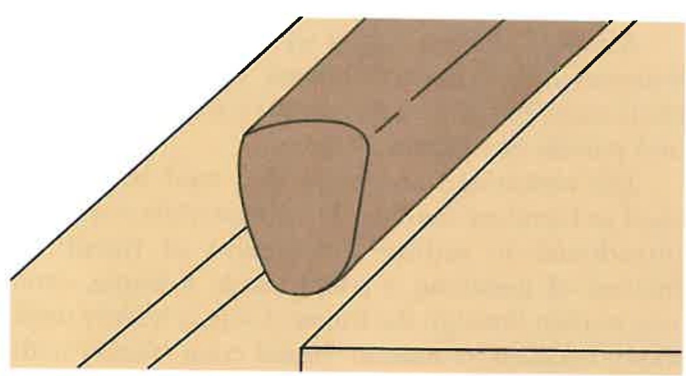


**Figure 37-4.** Spline reed is shaped so it wedges into a groove made in the frame. *(The Otto Gerdau Co.)*

The dry cane, reed, and rush can be finished like wood. However, apply stain to the wood frame first. Stain the cane after it is installed. Then, a suitable topcoating can be applied to both the wood and cane. You may prefer to leave the cane unfinished.

## Tools and supplies for caning

Few tools are necessary to install cane, reed, and rush. For webbing, you need scissors or tin snips, a mallet, and a small chisel. Supplies include ***caning wedges*** and hide or aliphatic resin (yellow) glue. For weaving loose cane, you also need a scratch awl and ***caning pegs.*** The wedges and pegs hold stretched cane during installation. See **Figure 37-5.** A sponge or cloth and water should be handy for keeping the cane moist.

## Installing cane webbing

Webbing is installed in a groove in the frame. A spline reed holds the webbing in the groove. See **Figure 37-6.** Cut the groove before measuring the webbing. It should be about 3/16" (5 mm) wide and 3/8" (10 mm) deep. These dimensions accommodate the most common size spline reed. If you are using a different size spline, cut the groove so the spline fits loosely in the groove. Rout the groove about 5/8" to ¾" (16 mm to 19 mm) from the inside edge of the frame. An easy way to do so is first make a hardboard template. Rout around the template with a straight shank router bit and template guide. You could also use a chisel.

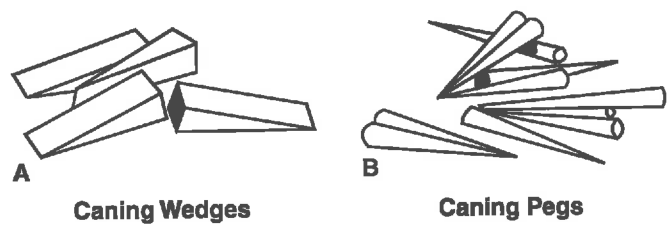



**Figure 37-5.** A—Caning wedges hold webbing in place. B—Caining pegs hold single strands of cane during weaving. *(The Woodworker's Store)*

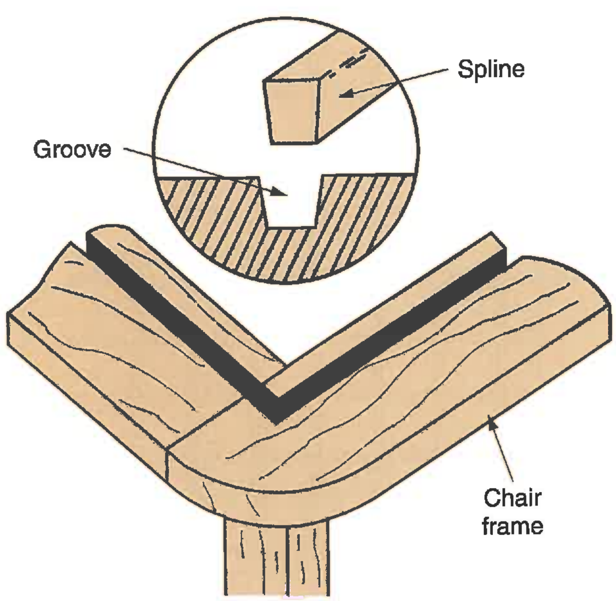



**Figure 37-6.** Spline reeds should fit loosely in the groove. Later, they will be pressed over cane into the groove to bond the webbing.

Draw a pattern of the groove on heavy paper (or make the template if you prefer). Place the pattern on the cane and cut the webbing about 1" (25 mm) larger in all directions.

Soak the cane in warm water from two to four hours. It will absorb water, expand slightly, and become pliable. An alternative method is to soak the cane in a ***glycerin solution*** for about 20 minutes. Make the solution 1½ tablespoons (20 ml) glycerin to 1 cup (250 ml) water. Soaking the cane too long will cause it to darken.

Prepare caning wedges while soaking the cane. You will need one for every 3" (76 mm) of the groove. Make them about 1" (25 mm) long with the narrow end of the wedge slightly smaller than the width of the groove.

Cut spline reeds. Prepare enough reed to fill the total length of the groove. Spline reed will bend around circular frames or curves on irregularly shaped frames. For rectangular frames, cut one reed for each side 1" (25 mm) longer than the groove lengths.

Remove the cane panel from the water. Place it between layers of paper or towels to absorb excess water. Then center the cane panel over the opening. Make sure you align the strands with the edges of the opening.

Next, install wedges in the groove to hold the webbing. Wet the end of a wedge. Position it in the groove at the back of the frame. Tap the wedge against the cane and into the groove. See **Figure 37-7A.** The wedge should be snug and about halfway into the groove. Insert additional wedges in the center of the front, then the sides. Proceed to install more wedges at 3" (76 mm) intervals, working from the center toward the corners.

Excess cane will be left around the outside of the groove. Remove loose strands from the panel that are outside the wedges. Then cut the remaining loose strands with a chisel and mallet. Cut them 1/8" (3 mm) below the top of the groove. See **Figure 37-7B.** At this point, check the dampness of the webbing. If it feels dry, wipe it with a wet sponge.

Now install the spline reed. For circular frames, begin in the least visible place. For rectangular frames, begin at one corner. Miter one end of each length of reed. Soak them in water for a few minutes. Then wipe them to remove excess water. Remove a corner wedge and spread glue in the open groove. Position the mitered end of the spline reed in the corner. The narrow edge goes in first. With a mallet, tap the side of a wedge on top of the spline to position it. Remove more wedges one at a time, add glue to the groove, and tap in more length of spline. When you reach the end of a groove, miter and bond that end of the spline. Wipe away excess glue. Follow the same procedure on all grooves.

As you install splines, make sure that they do not slip out. When all splines are inserted, again dampen the webbing. If it dries and contracts before the glue sets, the splines may pull out. Allow the assembly to dry for 24 to 48 hours. The webbing will become taut.

## Weaving Cane in a Conventional Design

Weaving cane is a tedious process. Single strands of cane are woven through a series of holes drilled in the frame. Three layers are woven. Then binding cane is placed to cover the holes. This lengthy process may be why most caning today is done with webbing.

As with webbing, keep all cane moist until the job is complete. In addition, always install cane with the shiny side up.

**Figure 37-8** shows the size and spacing of the frame holes for various widths of cane. Most weaving is done with medium size chair cane.

### First layer

Weave the first layer back to front and front to back. The starting point is the second hole from the corner on the back of frame (away from you). See **Figure 37-9.** Put about 3" (76 mm) of cane into the

| Chair Cane Size | | | Hole | | Spacing | |
|---|---|---|---|---|---|---|
| *Nominal* | *Inch* | *mm* | *Inch* | *mm* | *Inch* | *mm* |
| Common | 9/64 | 3.5 | 5/16 | 8 | 7/8 | 22 |
| Medium | 1/8 | 3 | 1/4 | 6 | 3/4 | 19 |
| Fine | 3/32 | 2.5 | 3/16 | 5 | 5/8 | 16 |
| Fine Fine | 5/64 | 2 | 3/16 | 5 | 1/2 | 13 |
| Superfine | 1/16 | 1.5 | 3/16 | 5 | 3/8 | 10 |

**Figure 37-8.** Hole size and spacing varies according to the chair cane size.

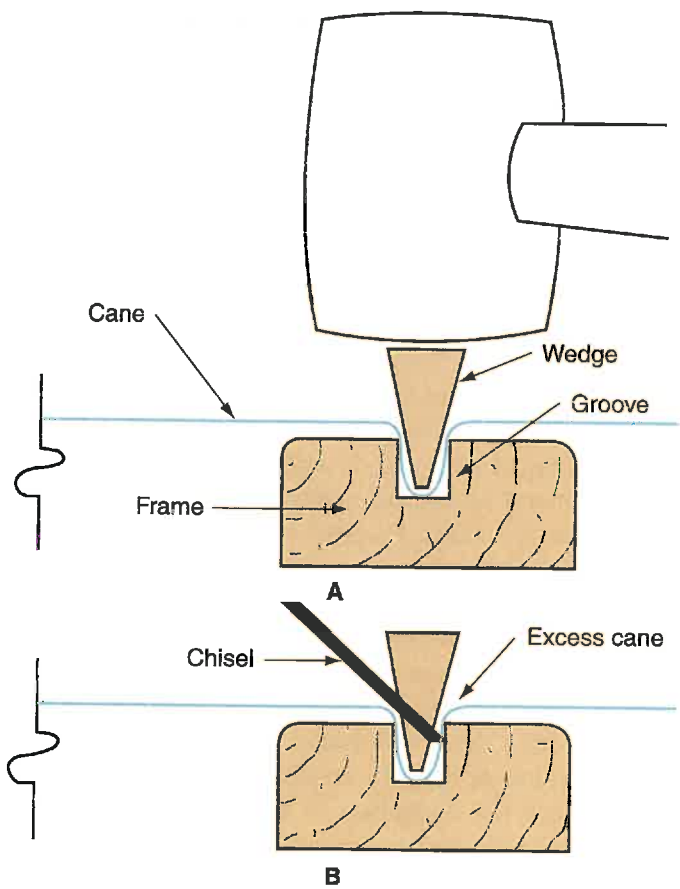



**Figure 37-7.** A—Tap the wet cane into the groove with caning wedges. B—Remove wedges when cutting off excess cane with a chisel.

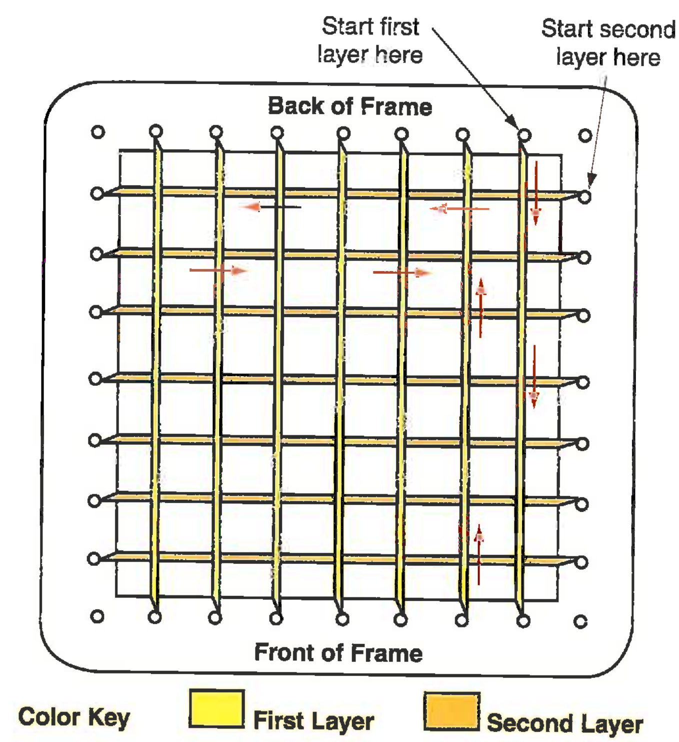



**Figure 37-9.** The first layer is a front to back weave. The second layer, placed over the first layer, goes from side to side.

hole. Secure it with a caning peg. Feed the other end of the strand down through the hole directly across on the front (nearest you). Pull the cane snug and twist it toward the next hole on the front. Then insert a peg to hold the tension.

Bring the strand up through the next hole on the front. Pull it snug, and twist it so the slick shiny side is up. Insert a caning peg in this hole. Feed the cane down through the next hole from where you started on the back part of the frame. Then pull it up through the next hole (third on the back). Repeat this sequence—two holes in front and two holes in back—until the cane is installed in one direction.

Eventually you will need another strand. As you near a strand's end, rewet the cane. Pull it down through the last hole it will reach. All ends are tied on the underside. To do so, loop the end twice around a nearby stretched strand. Slip the end back under the second loop and pull it tight. Cut the end about ¼" (6 mm) long. Be sure no nearby hole is covered. Also use this procedure to tie the first end of the woven cane. Tie it before removing the peg.

**Note**

The shiny side of the cane should always face up.

## Second layer

The second layer is installed side to side. Start in the hole across the corner from where you started the first layer. See **Figure 37-9.** Use the same procedure as the first layer. No weaving should be done at this time. All the second layer strands lie over the first layer.

## Third layer

The third layer is a repeat of the first layer procedure. Start in the beginning hole of the first layer. Secure the end with a peg as before. Position strands beside those of the first layer. Push strands together with an extra caning peg. Install the strands over the second layer.

## Fourth layer

The fourth layer is true weaving. The strands lie parallel to those from the second layer and in the same holes. However, you will weave over the strands of the third layer and under the strands of the first layer. Begin in the same hole as you did the second layer. Weave a few strands, then go back and pull the cane snug and peg it. After weaving all of the fourth layer, tie the ends. Now your woven frame should look like the one in **Figure 37-10.**

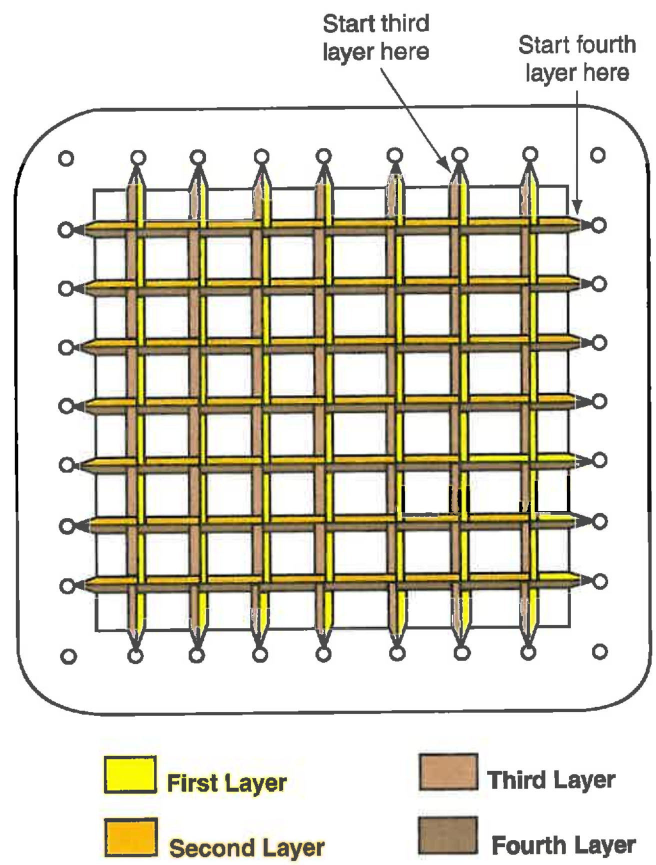



**Figure 37-10.** The third layer is in the same direction as the first and lies over the first and second layers. The fourth layer weaves over the third layer and under the first.

## Diagonal layer

The diagonal layer creates the six-sided effect of a conventional design. Start in the right front corner (the chair frame should be facing you) and weave toward the back left corner. Weave over layers two and four and under layers one and three. Work with one hand over and one under the frame. Tighten and peg the strand after each direction. Repeat another diagonal layer in the other direction. The result is seen in **Figure 37-11.**

## Binding

Binder cane covers all holes and gives a finished appearance. The conventional woven frame in **Figure 37-11** has binding cane attached. Be sure all strand ends of the previous five layers are knotted securely before attaching binder.

First cut the binding cane. You need four pieces. Make them about 12" (305 mm) longer than the row of holes on each side. Cut 8" (203 mm) lengths of chair cane for every hole in the frame. These become loops to hold the binding. Soak them in water for a few minutes.

Push one end of the binding cane down into a corner hole and secure the end underneath the frame. Lay the loose length of binding cane over the holes on one side. Push the loose end down into the corner hole at the other end. The length will be secured with the 8" (203 mm) strips of chair cane.

Push one end of an 8" (203 mm) length of weaving cane into each hole beside the binder. Loop and secure it around the weaving cane under the frame. Make a loop over the binding cane and push the loose end down through the same hole. See **Figure 37-12.** Pull the binding cane tight and draw the loops against it. Secure the ends underneath the frame.

Install all binding cane and loops one side at a time. Then add the four corner loops to tie together all four pieces of binding cane. Keep the cane wet until you are finished. Finally, trim all cane ends about ¼" (6 mm) from the loops and knots.

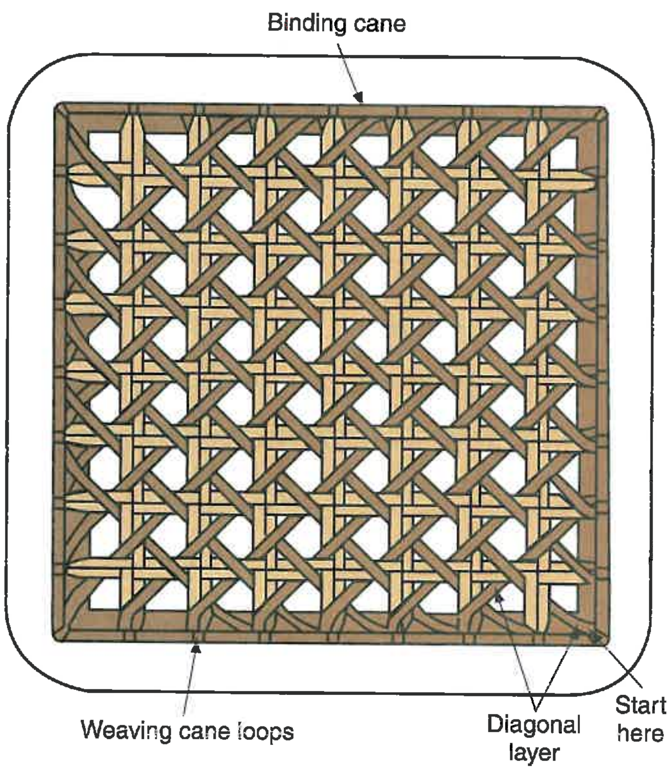



**Figure 37-11.** The diagonal layers complete the conventional design. Binding cane has already been placed over the frame holes.

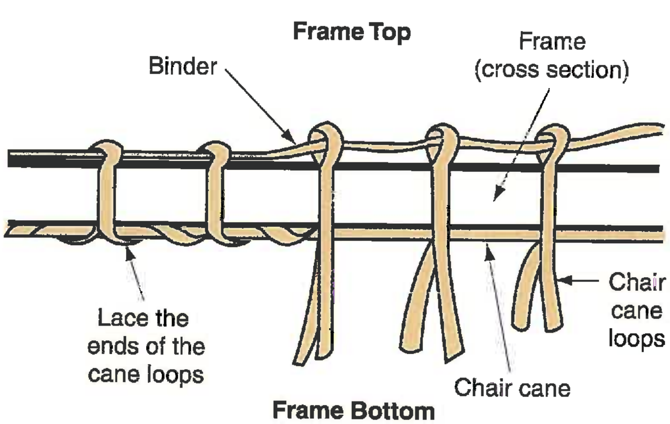



**Figure 37-12.** Binding cane is held down by loops of chair cane.

## Finishing

Caned surfaces may be finished like any other wood or be left natural. If stained, there will be heavy concentrations of coloring where several layers of weave intersect. This irregular distribution of stain is generally considered a pleasing effect.

## Weaving Rush

Rush is woven *around* the frame, not through holes. Materials and supplies for rush weaving include rush, bits of rush or cloth padding, and tacks.

Before weaving, the rush fiber should be soaked for about 10 minutes. This makes it flexible. As it dries, it will shrink and become rigid.

Start at one corner, laying the end of a strand of rush over the first rail. Draw the strand over the rail, under, and back over the adjacent rail. Pull this loop tight to secure the loose end. Then draw the strand to the opposite rail and loop it around as shown in **Figure 37-13.** Continue this weaving procedure until the entire seat is 2/3 complete. Then stuff the area between the two layers of rush with bits of rush or cloth padding. After stuffing, continue with the weave until the surface is finished. Tap a softwood block against strands to keep them close together. Tack the final strand to the frame. A completed seat is shown in **Figure 37-14.**

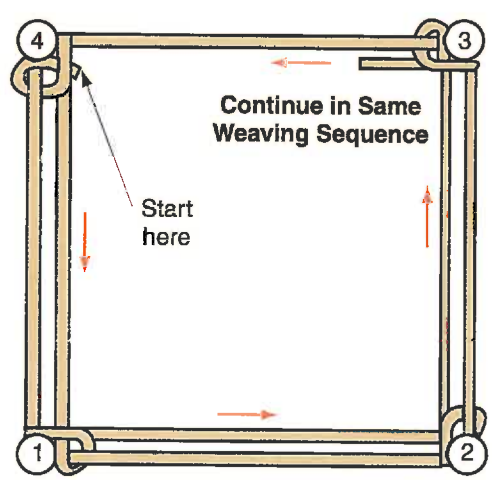



**Figure 37-13.** Weave rush using the same sequence until the surface is finished.

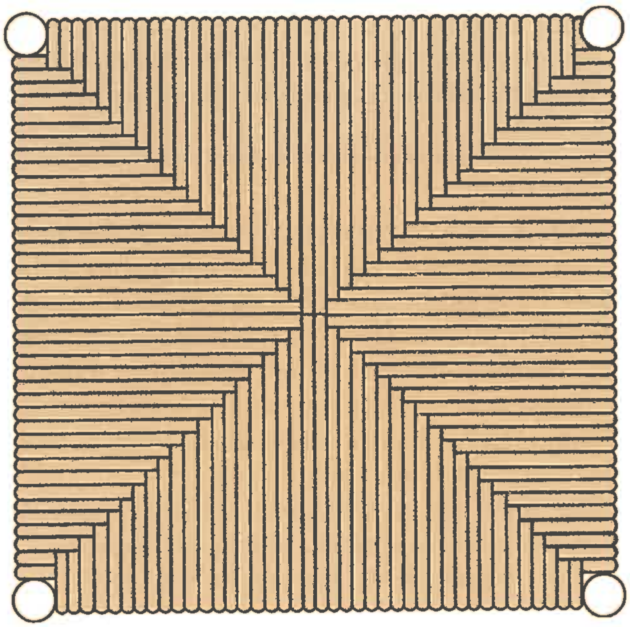


Figure 37-14. A completed rush woven seat.

Figure 37-15. Dining room chairs usually have padded slip seats.

## Upholstering Slip Seats

Slip seats are padded seats commonly found on dining room chairs, kitchen chairs, stools, occasional chairs, and vanity benches. See **Figure 37-15.** They consist of a foam pad covered with fabric, leather, or vinyl. The pad, attached to a ¼" or ½" (6 mm or 13 mm) plywood base, is fastened to the chair frame.

Slip seat upholstery requires only a small amount of materials, supplies, and tools. Materials you will need to complete the project include plywood, padding material (foam rubber, cotton, or animal hair), and the covering. Supplies include tacking tape or muslin and rubber cement, upholsterer's tacks, and staples. Tools include a tack hammer, staple gun, scissors, and a ¼" drill bit.

The procedure for making a slip seat is as follows:

1. Cut the plywood base to size. It should be ¼" (6 mm) smaller in all directions from the inside of the frame. The plywood base is supported by corner brackets or cleats inside the chair seat frame.
2. Drill ¼" (6 mm) holes, spaced 3" (76 mm) apart in the base. These will let the padding "breathe."
3. Determine the edge design for the seat. Three basic styles are cushioned, feathered, and squared. See **Figure 37-16.**
4. Lay the plywood base on 2" (51 mm) of padding material. Trace around the base with a marker. For a cushioned edge, A, add ¾" (19 mm) to all sides of the padding. For feathered and squared edges, B and C, add ¼" (6 mm).
5. Cut the padding with scissors. For foam rubber, dip the scissors in water. This acts as a lubricant. Undercut the feathered edges ¾" (19 mm). See **Figure 37-16B.**

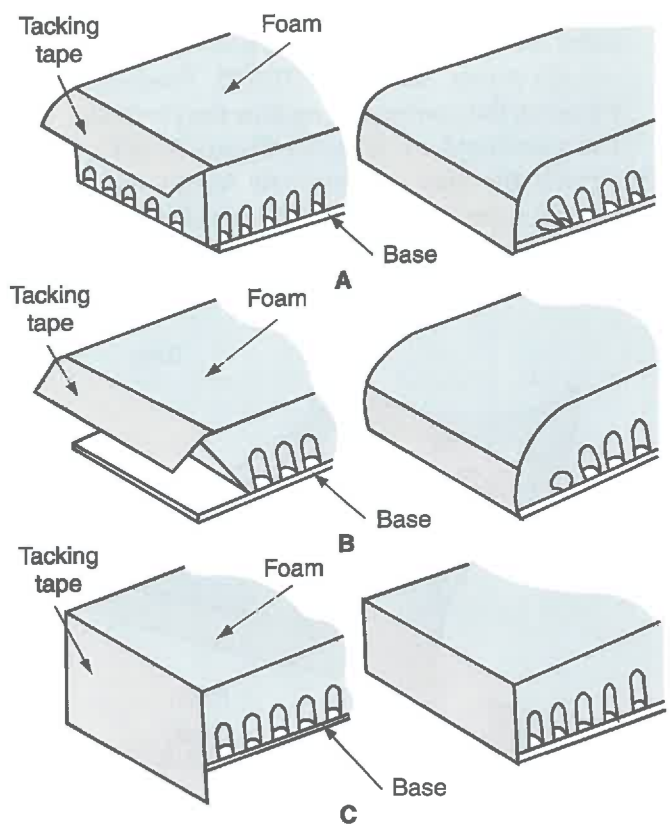



Figure 37-16. Edge designs for slip seats. Note how the material is cut and fastened to the base with tacking tape. A—Cushioned edge. B—Feathered edge. C—Squared edge.

6. Bond tacking tape to the foam. Put the tape on the top surface around cushioned and feathered edges. Place it on the side for squared edges. You can substitute muslin bonded with rubber cement for tacking tape.

7. Once the tape adheres to the foam, pull it and the foam around one side of the base edge. Tack or staple it in place. Then secure the opposite side. Next, staple the other two. Start tacking or stapling in the center and work toward the corners. The amount you pull the tape under varies with the type of edge. You may want to rubber cement the foam to the plywood. This prevents it from shifting.
8. Place the covering, face down, on a clean surface. Then center the seat, plywood base up, on it. See **Figure 37-17A.** Cut a covering large enough to wrap around the seat with about 2" (51 mm) extra per side. Secure the center of the first side. Pull the covering and staple it toward each corner. Make sure the covering is tight but not stretched. If it wrinkles, remove the necessary tacks or staples. Take out the wrinkles and retack the fabric.
9. Secure the covering from the center toward the corners on the opposite side. Pull the fabric gently toward the corner to remove wrinkles. When four sides are done, you will have a small loop of fabric at each corner. See **Figure 37-17B.** Press the excess fabric on the corners flat against the plywood. Tack them so they look alike. See **Figure 37-17C.**
10. Attach the seat in the chair frame with wood screws from underneath. Be sure there are clearance holes through the cleats or corner brackets.

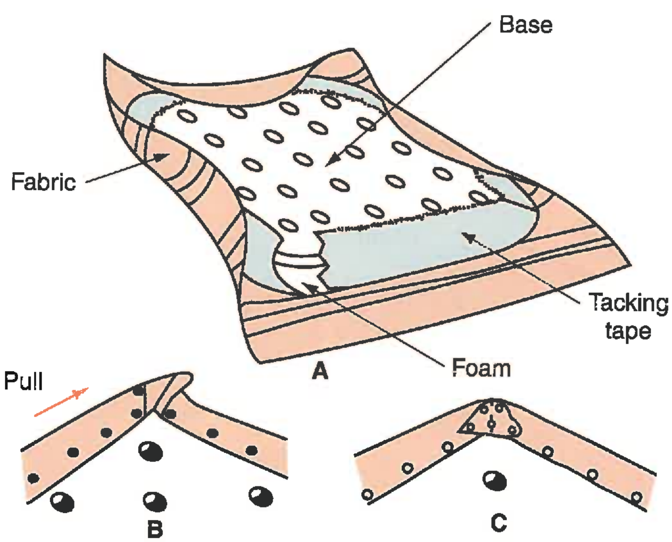



**Figure 37-17.** Procedure to fasten covering to the padded base. A—Lay the seat, base up, on the back of the covering. Pull the sides onto the base and tack in the center. B—Pull the fabric from the center toward the corner as you tack. C—Fold down the excess loop of material and tack that also.

Four screws will hold the seat firmly. Screw length should be ¼" to 3/8" (6 mm to 10 mm) longer than the cleat or bracket thickness.

## Summary

Caning and upholstery provide a decorative textured surface to furniture. Caning has a long history of applications. Originally, it was used to reduce furniture weight. Now, it is done for appearance reasons. Most cane installed today is purchased as webbing. You cut and install panels of webbing. However, you might also choose to weave loose strands of cane, reed, or rush.

Slip seats are upholstered surfaces commonly found on various chairs, stools, or benches. As shown in **Figure 37-1,** you might find both caned and upholstered surfaces on a piece of furniture.

## Test Your Knowledge

*Do not write in this text. Answer the following questions on a separate sheet of paper.*

1. Explain the difference between cane, reed, and rush.
2. Weaving is done with what type of cane?
3. Most caning today is done with _____.
4. Hold webbing in place with _____ _____.
5. List two reasons for soaking cane before installing it.
6. List the steps to install cane webbing.
7. When weaving strands of cane, how do you hold stretched strands in place while continuing to weave through another hole?
8. Cane ends, when weaving, are secured with _____.
   a. glue and nails
   b. nails only
   c. loops and knots
   d. glue only
9. Which of the four layers of woven cane is threaded above and below previous layers?
10. The side of cane that should always face up is _____.
11. Binding cane is secured with _____.
    a. spline reeds
    b. caning pegs
    c. glue
    d. chair cane
12. A rush seat is stuffed with _____ or _____ when it is 2/3 done to soften the seat.
13. Describe the construction of a normal slip seat.

# Case Construction

38

## Objectives

After studying this chapter, you will be able to:

- Explain the purpose of cases.
- Identify the types of case construction.
- Select materials used in case construction.
- List the components of a typical case.
- Recognize assembly steps for case work.
- Describe the advantages offered by using the 32 mm System of case construction.

## Important Terms

32 mm System
case
case back
case body
case top
construction holes
dividers
face frame
face frame case
frame and panel case
frameless case
kick plate
plinth
shelves
system holes
V-groove assembly

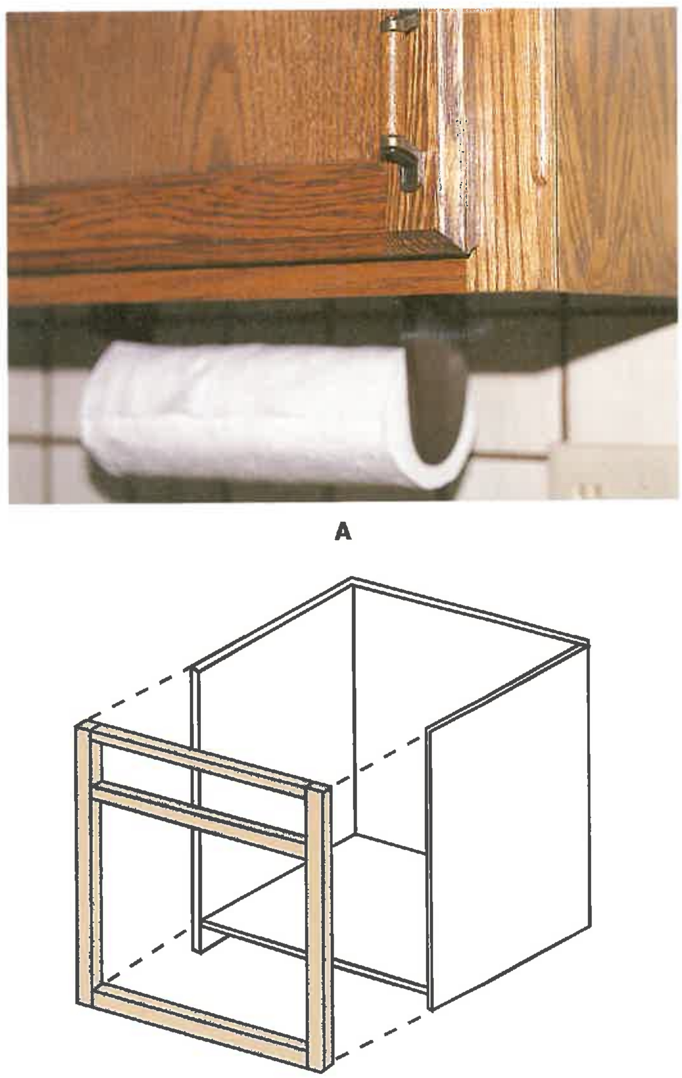
Cases are storage units that hold or display items. They basically consist of a box that is either, open to the top, or to the front. Shelves and dividers may be added to create compartments. Some typical cases are: jewelry boxes, chests of drawers, gun cabinets, desks, microwave carts, china hutches, bookcases, storage chests, and kitchen cabinets. The case can be open or fitted with doors.

## Types of Case Construction

Three types of case construction are common: face frame, frameless, and frame and panel. A fourth, less used method, is V-groove design. Each has unique advantages and disadvantages.

A *face frame case* begins with a case made of solid wood or manufactured wood panels. You do not have to edge band the cut edges of plywood or particleboard. A frame is then attached to the front. See **Figure 38-1.** It can be made of solid wood, edgebanded plywood, or laminated particleboard. The frame adds stability to keep the case square. It also supports the door hinges. The construction of a face frame case requires more labor than a frameless case.

A frameless case has no face frame; the edges of top, bottom, and side members are exposed. See **Figure 38-2.** If the case is made of manufactured wood panels, edgebanding is applied to exposed



A

B

**Figure 38-1.** A—This wall cabinet was constructed with face frame casework. B—The frame is attached with glue and/or mechanical fasteners.

edges. The back provides most of the structure to keep the case from racking. Door hinge mounting plates attach directly to the side. The doors are usually full overlay, but may be half-overlay or inset. The most popular variation of frameless construction is the 32 mm System. It sets size standards for components, hardware, and fasteners. This allows for interchangeable parts. The 32 mm System is covered in detail later in this chapter.

Frame and panel case surfaces are not flat. Surfaces are made with panels mounted to or within a frame. If the panels are made of thinner plywood, the weight of the product is reduced. Solid wood panels, commonly referred to as raised panels, may have a decorative edge that fits into a slot in the frame. You often see finished frame and panel construction for desk sides and cabinet doors. See **Figure 38-3.** Web frame cases are a form of frame and panel construction. They have surface panels attached to an internal frame. This technique, widely used for high quality casework, is covered in *Chapter 39*.

Regardless of which method you choose, any assembled case should be perfectly square. This requires matching components and joints accurately.

## Case Materials

Consider these factors when choosing materials for casework:

* **How will the case be used?** Kitchen cabinets are made to be rugged and easily cleaned. A bookcase, on the other hand, may receive little wear, but may carry heavy books.
* **Will the case be lifted or moved often?** There are movable, mobile, and built-in cases. Movable cases generally sit on glides so the wood does not chip or mar the floor. Mobile cases have wheels or casters. In addition, a large case should be made as light as possible.
* **What surfaces will be visible when the case is in use?** Exposed parts include the exterior and the front-facing edges of shelves and dividers. Undersides of cases less than two feet from the floor are considered hidden and generally are not finished.

**Figure 38-2.** With frameless cabinets, the doors attach directly to the case side. *(Quaker Maid)*

**Figure 38-3.** With frame and panel doors, a glass or wood panel is held within a solid wood frame. *(Thomasville)*

- **How will surfaces be coated or covered?** The finish or laminate must protect the case from daily wear.
- **Will manufactured wood panels be better, both in structure and cost, than lumber?**

Answers to these and other questions affect decisions about materials.

### Lumber or manufactured wood panels?

Solid lumber is costly to buy and process. To form large panels, it must be surfaced, glued, resurfaced, and smoothed. Approximately 50% of rough sawn lumber could be wasted. In addition, lumber comes in random sizes and requires more storage space than manufactured panel products. Lumber can also change in dimension plus or minus 1/8" (3 mm) for each 12" (305 mm) of width. These dimensional changes are caused by moisture content changes, and often result in joint failure. *Waterproof* finishes slow the effects somewhat, but cannot stop them entirely.

Plywood, MDF, and particleboard are alternatives to lumber. They are more stable and less expensive. Thermofused melamine panels are less expensive than hardwood veneer plywood. It does not require finishing. Solid colors and matrix patterns do not require grain direction decisions, thereby providing increased yield from a given number of panels and an additional reduction in labor cost. Veneer surfaces, on one or both sides, vary by species and grade. They can match solid lumber parts used in the case. Bond edgebanding to the exposed edges.

Use matching panels for case backs that are visible when doors are opened. Hardboard might be used for case backs, drawer bottoms, and dust panels on economy grade casework. Install tempered hardboard where more strength is needed, such as in the bottoms of wide drawers. For premium appearance and performance, install 1/4" (6 mm) thermofused melamine panels in the drawer bottoms. Where extra strength is required, use thicker material or apply reinforcing rails beneath the panel.

## Case Components

A typical ***case*** has many components. Included are the front, top, bottom, sides, shelves, dividers, and backs. Doors and drawers may be installed on or in the case. A separate base (plinth) might be placed under the case. This discussion focuses on traditional methods of case construction, including the face frame. The section on 32 mm System of construction details the use of special mechanical fasteners, hardware, and methods for frameless cases.

### Case body

The ***case body*** refers to the top, bottom, and sides. The body opens either to the top or front. See **Figure 38-4.** Examples of cases that open to the top include toy boxes and cedar chests. Those that open to the front include dressers, bookcases, and kitchen cabinets.

The corners of wood cases can be joined with many joints. See **Figure 38-5.** Joints should be selected so that a minimal amount of end grain is visible. Install any glue blocks where they will be hidden. (Make sure that they will not interfere with shelves or drawers.) Edgeband plywood, MDF, or particleboard if a face frame is not attached.

### Shelves

***Shelves*** divide a case into levels for storage. Plywood or particleboard shelving is less likely to warp than solid lumber. Edgeband the front edge. Shelves may be fixed or adjustable.

**Figure 38-4.** Cases may open to the top or front. *(Chuck Davis Cabinets)*

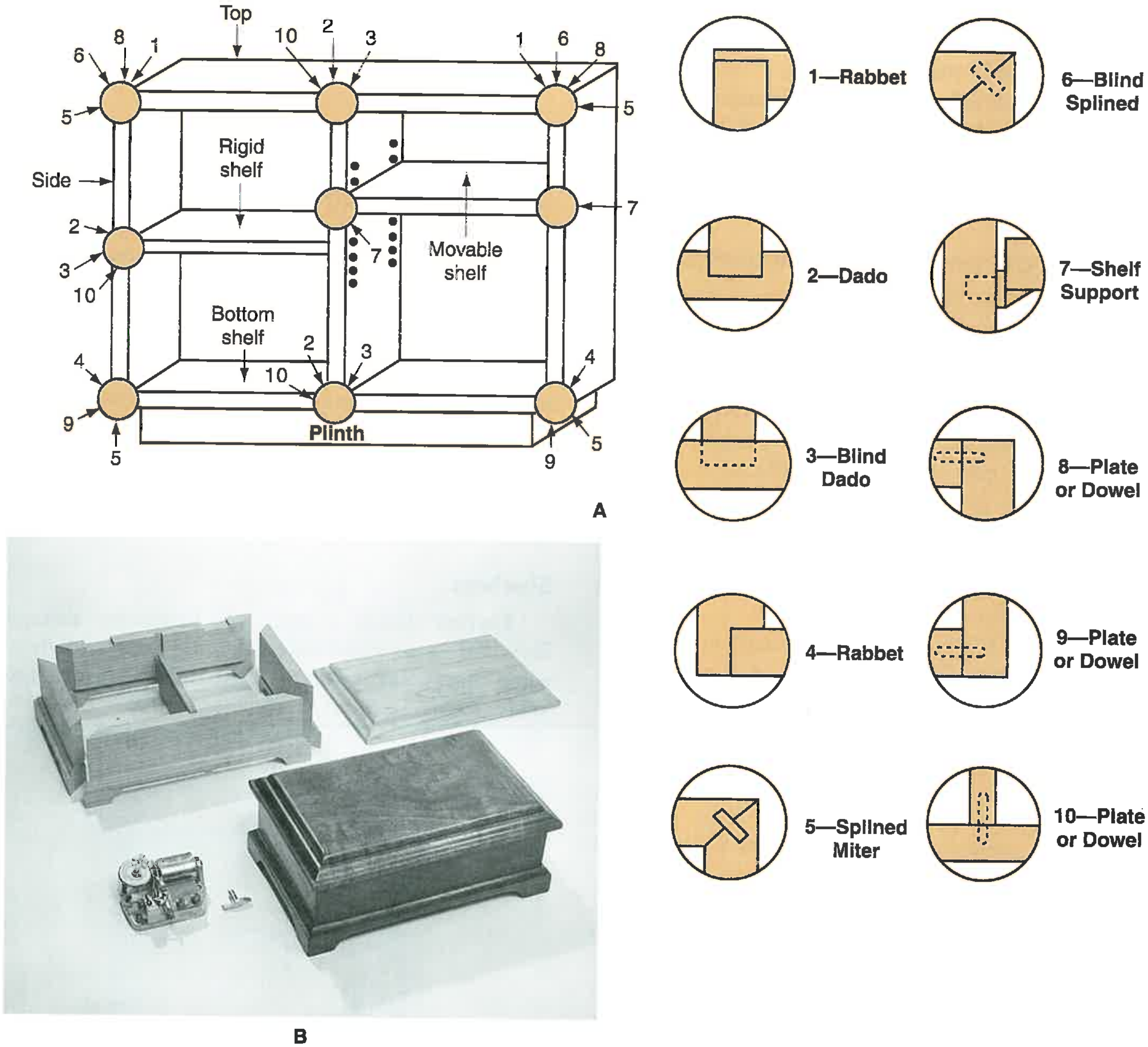



**Figure 38-5.** A—Several alternative joints can be used on case goods. B—The corners of this jewelry case are mitered and the bottom is dadoed. *(Craft Products)*

Fixed shelving can be installed several ways. You can use dado joints or cleats. Create the joints or glue the cleats to the case sides before assembly. Be certain they are aligned so the shelves are level. Like glue blocks, cleats are unattractive. Use them where they will be hidden, such as behind a door.

The type of dado—through or blind—depends on the application. For cases with face frames, it is easier to cut a through dado. The frame will cover the exposed joint. You can also use a through dado with frameless cases that are edgebanded. When using solid wood sides, cut a blind, or stop dado. See **Figure 38-6.**

Adjustable shelves improve the utility of the case. Several styles of shelf supports were described in *Chapter 17*. Standard ¾" (19 mm) thick shelving should not be placed on supports spaced more than 42" (1067 mm) apart.

## Dividers

***Dividers,*** or partitions, separate the inside of the case. They can be placed horizontal or vertical. When the edge of a divider is visible on the finished case, and it is not solid lumber of the same species as the case, cover it with veneer or laminate edgebanding.

Dividers can be positioned easily with dado joints. Dados are cut 1/3 of the way through the supporting components. Cut half-lap joints when dividers cross, as in drawer dividers, or shallow display shelves. Saw all cross-lap joints at the same distance setting—one-half the width. See **Figure 38-7.**

## Plinth

Cases may set directly on floors, legs, shaped frames, or plinths. A ***plinth***, or base, provides toe clearance on one or more sides. See **Figure 38-8.** (The term ***kick plate*** is given to the plinth under kitchen cabinets.) The frame for kitchen cabinets is inset 3" (76 mm) and its height is usually 4¼" (107 mm). It can be made of lumber, plywood, or laminated (or veneered) particleboard. The plinth is fastened to the case with glue blocks, cleats, pocket joints, corner brace plates, or other fasteners. Install glides on movable cases to prevent them from chipping when moved. Install casters on mobile cases.

The plinth can be recessed under or outset from the case. Sometimes the top edge of outside plinths is shaped. Moldings may be attached as an alternative to shaping. The corners can be rabbeted or mitered, often with a spline. Plinths usually are added after the case body is assembled and the glue joints have cured.

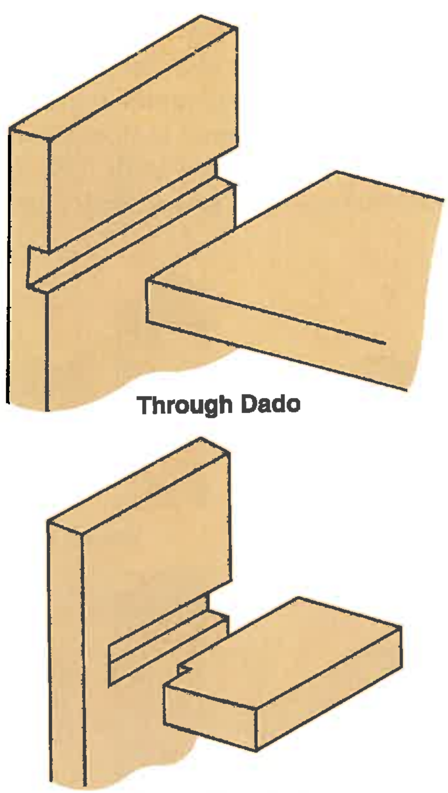



**Figure 38-6.** Blind or through dadoes hold fixed shelves.

## Back

For face frame casework, the ***case back*** usually is 1/10" to ¼" (3 mm to 6 mm) thick. The rabbet, formed around the inside of the back edges, should be slightly deeper than the thickness of the back. Where appearance is important, as in the back of wall cabinets, the back panel should be the same material as the side panels.

## Case top

The ***case top*** may be fixed, removable, or hinged. Those which open to the front are usually fixed. Tops on cases that open up are generally hinged.

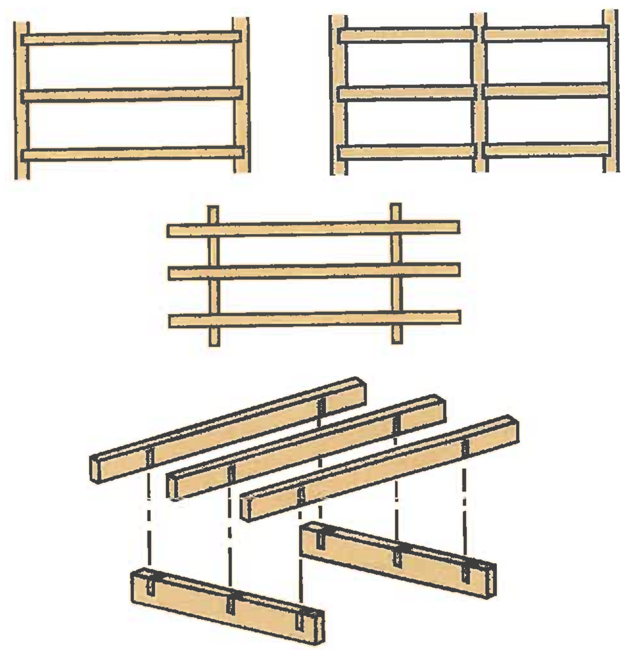


**Figure 38-7.** Dividers create individual storage areas.

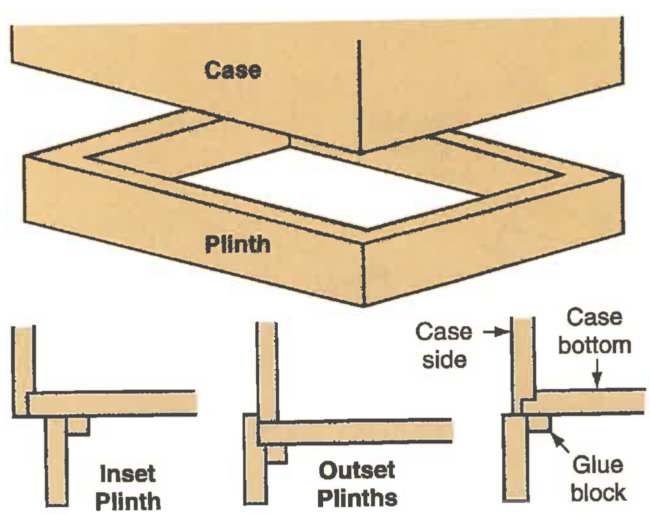



**Figure 38-8.** Plinths, or base frames, may be inset or outset.

### Fixed tops

On tall cases with doors, a fixed top is not seen. Therefore, it can be rabbeted and glued, dadoed, or otherwise fastened. The top can be made of plywood, particleboard, or solid wood. Cover exposed surfaces of manufactured panel products with veneer or plastic laminate.

A visible top, such as a dresser, should be made of solid wood, plywood, veneered or laminated particleboard, or MDF. Most often, the top is a separate component attached to the case. The edges may be contoured.

### Hinged tops

Case goods that open upward usually have lid type hinged tops. Examples are recipe boxes and cedar chests. Smaller case tops may include part of the front, sides, and back. For these, rabbet, glue, and assemble the entire case, including the top. The box is completely sealed. After the glue cures, cut the case open on a table saw or band saw. See **Figure 38-9.** Thus the figure in the grain continues all across the surface.

## Face frame

A *face frame* attached to the front of the case provides strength and style. The frame can be made of solid wood, edge banded plywood, or laminated particleboard. The frame typically covers the exposed edges of the top, bottom, sides, and dividers. Horizontal parts of the frame are called rails. Vertical parts of the frame are called stiles. They vary in size from 1" to 2½" (25 mm to 64 mm) depending on the particular design. They can be assembled with mortise and tenon joints, dowels, plate joinery, or pocket joints. See **Figure 38-10.** Butt and miter joints do not provide the needed strength.

Most often, the face frame is glued and clamped to the body. It can also be secured with clips, plate joinery, or pocket joints. On economy cabinets, nails are set below the surface and then filled.

## Doors and drawers

Leave space, width, height, and depth for doors and drawers. For drawers, also take into account the dimensions of the slides. Refer to the plans to determine whether doors are flush, overlay, or lip edge. Each requires different hardware.

## Case assembly

Successful case assembly requires planning and preparation. All components must be sized accurately and wood components sanded smooth. All joints have to fit exactly. Preset clamps to their approximate openings. Use small blocks or bar clamp pads to prevent clamp damage. Select the proper adhesive based on set and clamp time. A quick-setting adhesive may not allow enough time for assembly.

In a production setting, cases may be assembled with nails and staples driven with a pneumatic gun. Staples have better holding power, but are more difficult to cover. They are mostly used to assemble parts that will not be seen on the finished product. High quality casework should not have any visible fasteners.

Assemble the case without adhesive first (a dry run). This is necessary to preset clamps and be sure all corners are at 90°. It also helps determine the steps in assembly. Check all joints to make sure they fit properly. You do not need to position hardboard backs that will be reinforced with nails or staples. Glue blocks can be left off unless they position some

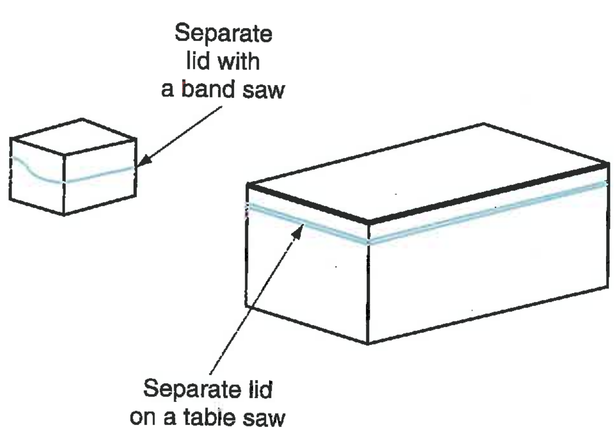



**Figure 38-9.** You can saw cases to separate the lid.

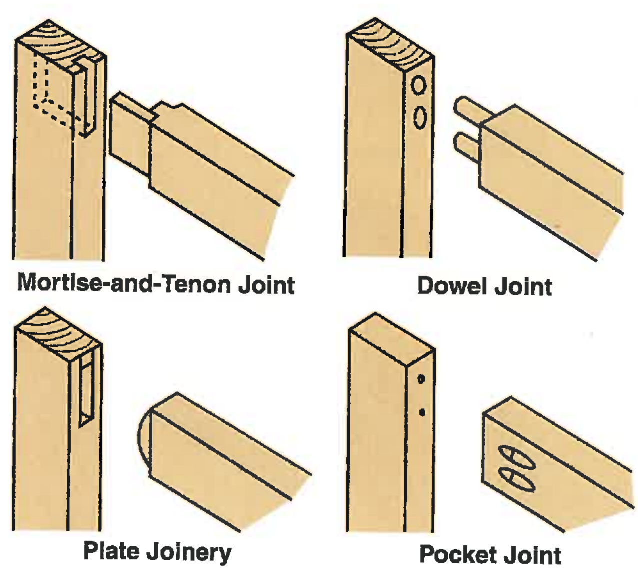



**Figure 38-10.** Joinery for face frames.

components. Those needed should be secured to one side of the joint. Plan to apply the glue to parts in the order that you put the unit together dry.

Once you verify the dry run, disassemble the case. Lay the clamps, protective blocks, and components aside in an orderly manner.

Begin the final assembly. (Follow the assembly and clamping procedure presented in *Chapters 32* and *33*.) Spread the adhesive evenly, according to your plan. Fit the pieces together. Position the protective blocks and clamps. Tighten the clamps only enough to hold them in place. When all components are assembled, increase the clamping pressure as you check for squareness. Excessive pressure can damage soft surfaces and break weak components.

Inspect all joints immediately after assembly. They should be closed and square. Wipe away all excess adhesive with a damp sponge or cloth. This is easier than scraping or sanding away excess dry adhesive. Do not use this technique on veneer surfaces, if you can avoid it. Finishing stains will be absorbed at a different rate than where there has been no moisture. Instead, allow the squeeze out to set partially, and then remove it with a hand scraper. Of course, you must place clamps to allow access to the squeeze out. Keep glue and water away from places where steel clamps touch the case. Tannin in the wood will react with the glue and the metal to stain the wood black.

### V-groove assembly

***V-groove assembly,*** also known as miter folding, involves folding a grooved panel to create the case. See **Figure 38-11.** The case begins with a sheet of particleboard covered with flexible laminate. Cuts for each corner are made at a 90° included angle to a precise depth equal to the particleboard thickness. This forms two 45° miter cuts. Do not cut through the laminate.

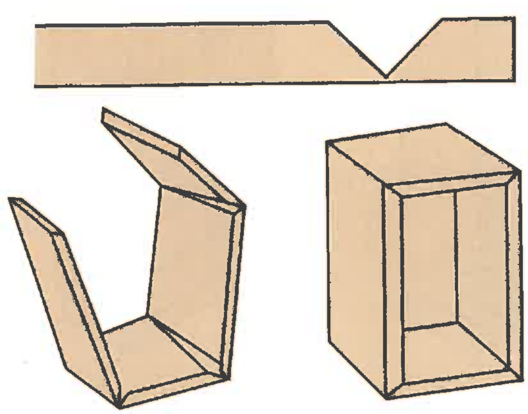


**Figure 38-11.** V-groove assembly.

Cut V-grooves with router motors mounted in bases designed for this process. Production firms have special computer-controlled routers that cut V-grooves accurately.

When designing cases for V-groove assembly, carefully consider how the different surfaces will fold together. It may be simple to create a box with three cuts. However, adding cross grooves for folded edges can make the layout quite complex.

## Introduction to 32 Millimeter Construction

Europe heavily depleted its forests during World War II, and was forced to develop alternative materials, such as particleboard. They could not afford to use what little solid wood that was available in such applications. The cooperative efforts of particleboard, hardware, machinery and cabinet manufacturers developed a system better able to use the available raw materials. This system created a revolutionary case making technique called the 32 mm System. The case has no face frame as found in traditional cabinet construction.

The 32 mm System of frameless cabinetmaking has caused the biggest change in cabinetmaking since the development of plywood. Paul Hettich of West Germany is given credit as the father of the 32 mm System. An Italian, Arturo Salice, was granted the first patent on a concealed hinge with automatic closing action for furniture. With many refinements, this hinge has become known as the ***Euro-hinge, European-style hinge,*** or simply a ***concealed hinge.***

Central to the frameless system are vertical rows of holes in each cabinet side or partition. These rows of holes are known as ***system holes*** and are spaced 32 mm apart. The 32 mm dimension was not established at random. When the system was initially being developed, 32 mm was the minimum spacing available using technology of the time. Any further reduction in the spindle spacing would have shortened the service life of spindle bearings and gears. The system came to be known as the ***32 mm System*** or ***System 32.***

### System approach

For the first time a system approach to case assembly and hardware installation was developed. Case components include cabinet sheet material, edgebanding materials, hardware, machines, and a procedure of constructing cabinets that makes use of the other parts of the system.

There is no single design that is the 32 mm System/design. All frameless designs may embody one or more attributes of the 32 mm System. Cabinet manufacturers develop variations that enable them to meet their customer's requirements.

The 32 mm System illustrated in **Figure 38-12**, may be based on the following set of standard dimensions:

- Side panels and partitions feature two vertical rows of system holes 5 mm in diameter on 32 mm centers.
- The distance from the front edge to hole centerline of the first vertical row is 37 mm. This distance provides precise alignment of hinge base plates, drawer glides and other system hardware.
- The distance from the first vertical row to the second vertical row is usually in multiples of 32 mm, and depends on the function of the holes.
  - Base cabinets, that accommodate drawer slides, will have additional vertical rows of holes. The quantity and spacing will be determined by the length and boring pattern of the 32 mm system slides being installed.
  - Wall and base cabinets without drawer slides may have a vertical row of holes near the back of the cabinet to receive shelf supports. Automated machinery will place the row at a multiple of 32 mm. The distance may be 37 mm from the back for shelving. This distance will save set-up time when you use less sophisticated multiple-spindle boring machines.
- The system hole diameter is 5 mm, with a depth of 13 mm. For assembly purposes, 8 mm and 15 mm holes may be bored. Kerfs for plate joinery may be used.
- Accurate hole location ensures precise fit and smooth operation of installed hardware.

## Benefits of the 32 mm System

The development and use of the 32 mm System eliminated many labor intensive procedures needed for traditional face frame cabinet construction. Among the procedures eliminated was the construction of face frames, cutting dado, rabbet, and miter joints. Also, material savings resulted because of the extensive use of laminated particleboard, in place of hardwoods, and the elimination of the face frame.

The beauty of the 32 mm System is that it standardizes case construction and hardware mounting. It allows you to do all the work—from machining panels to installing hinges and drawer glides—before the case is assembled.

From a manufacturing standpoint, fewer people can complete more frameless cases than face frame cases in a single shift. However, hole size, location, and spacing must be precise to guarantee interchangeable parts. Each component must be sized accurately to fit together perfectly during assembly. The use of a computer to help design the cabinets, produce shop drawings, and generate cutting lists reduces work and errors. Some computer software programs will print part identifying labels. These labels may be barcoded to enable machines to read the label for inventory purposes.

Once the 32 mm System is in place, a manufacturer can expect the following benefits:

- Increased productivity.
- Simple and automated machines provide high precision and high quality.
- The manufacturer is less dependent on skilled labor.

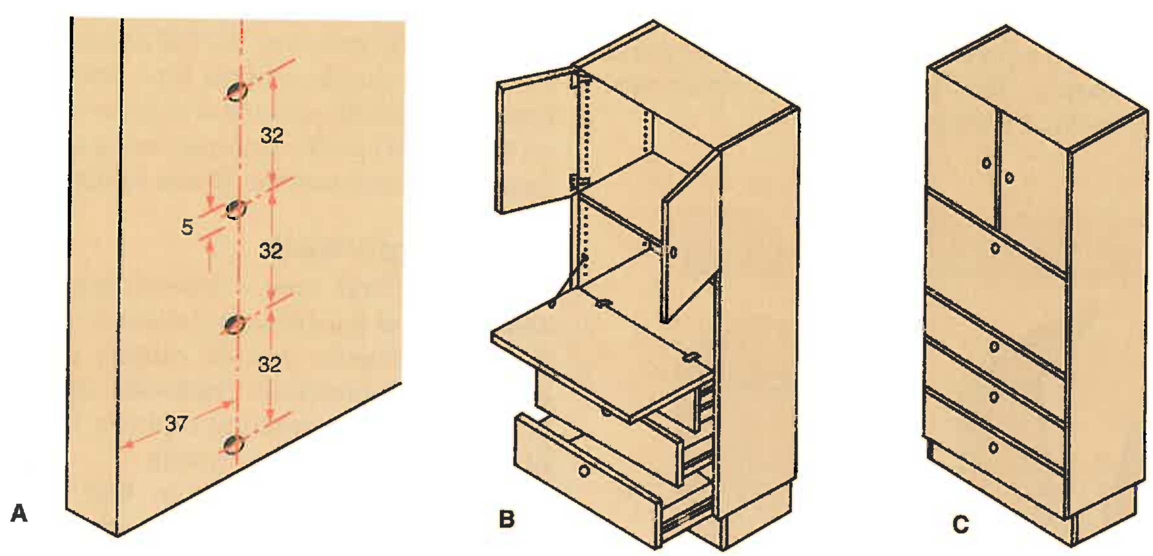



**Figure 38-12.** A—Spacing for 5 mm System holes. B—Completed case showing hardware and horizontal members attached. C—Closed case looks no different from one assembled with traditional joints and hardware. *(Häfele America Co.)*

- Labor savings can result from mounting hinge plates and drawer guides in the system holes before assembling the cabinet. This eliminates reaching inside an assembled cabinet for attachment. Attachment locations are exact.
- Material costs are reduced due to standard component sizes that make efficient use of manufactured wood panels. Accurate cutting lists also reduce waste.
- Base cabinet levelers also reduce material costs by allowing six side panels to be produced from each 49" by 97" (1220 mm by 2440 mm) sheet.
- The manufacturer has avoided the dimensional instability of solid lumber by using veneered or plastic-laminated particleboard.
- Components can be produced at different locations stored for any length of time, and assembled later with accurate fit.
- When orders exceed production, panels may be bought from outside vendors, and integrated into the product line.
- Finishing operations are greatly reduced. HPDL clad MDF or particleboard, as well as thermofused melamine panels, require no finishing.

## The use of system holes

The vertical row of 5 mm system holes are spaced 32 mm apart. The first vertical row is 37 mm from the front edge of the panel. They are used for mounting drawer slides, hinge mounting plates, adjustable shelf pins, and other accessories.

### Determining cabinet height

A typical kitchen counter top is 36" (914 mm) off the top of the finished floor. A built-in under counter appliance, such as a dishwasher requires up to 34½" (876 mm) above the top of the finished floor. Most countertops are 1½" (38 mm) thick.

Ideally, the height of case side panels should be a multiple of 32 mm, plus one thickness of the material being used. See **Figure 38-13.** This allows the spaced holes to be drilled one-half the material thickness from the top or bottom of the case. In this instance the ideal and practical may be equal, depending on your requirements. A 768 mm base cabinet side panel is approximately 30.24 inches. When a 4.26" (108 mm) toe space from the top of the finished floor is added, the resulting 34.5" height is standard for under counter appliances in the United States.

## The use of construction holes

A fully machined cabinet side will have precisely placed receptacles for fastening hardware and assembly connectors. See **Figure 38-14.** The case is held together in several different ways.

- Dowels secured with glue in 8 mm construction holes.
- Plates secured with glue in kerfs.

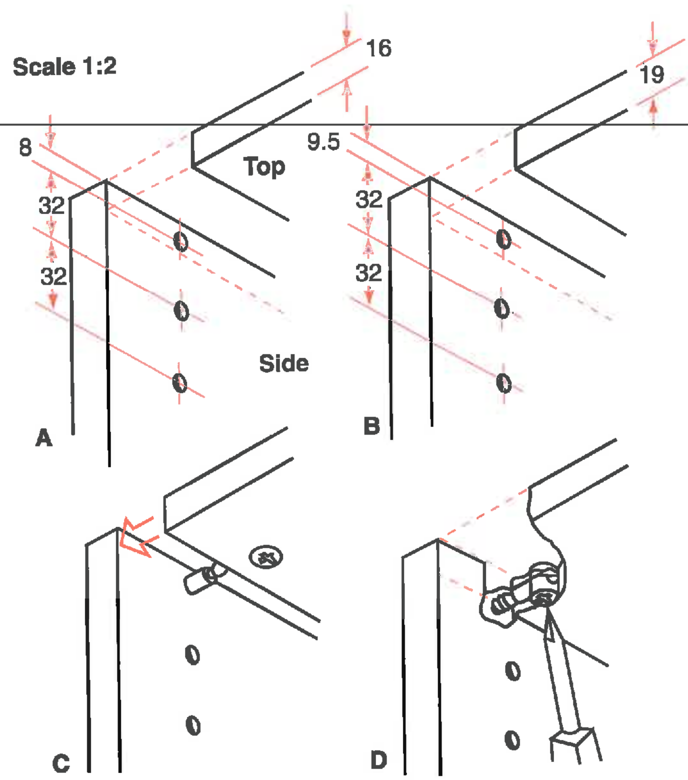



**Figure 38-13.** A—Hole spacing from the top so that a 16 mm (5/8") thick horizontal member fits flush. B—Hole spacing from the top so that a 19 mm (3/4") thick horizontal member fits flush. C—A bolt is threaded into a 5 mm hole. D—Turn the cam or casing to draw the horizontal and vertical members together. *(Häfele America Co.)*

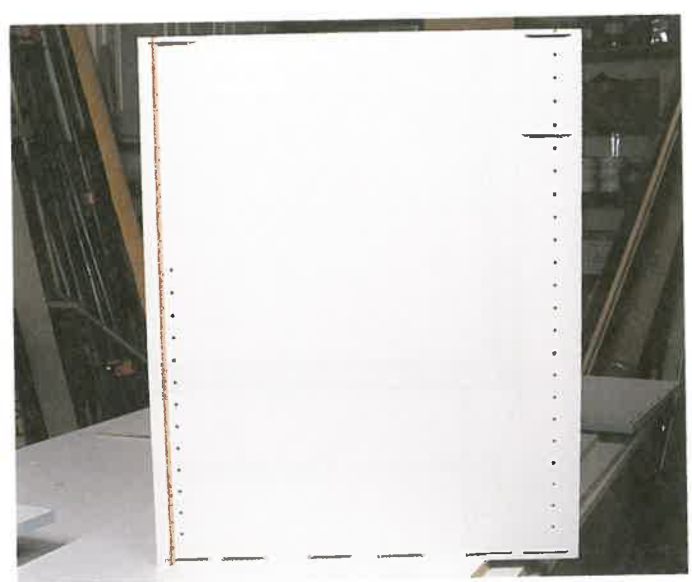


**Figure 38-14.** This panel is ready for assembly with plate joinery. *(Chuck Davis Cabinets)*

- RTA fasteners secured by screw threads in a variety of different sized construction holes.

## Dowel construction

For dowel construction, the 8 mm holes may be spaced horizontally along the top, bottom, and mid-section of the sides. They typically are placed in pairs, 12 mm from the edges and 64 mm apart. See **Figure 38-15.**

## Plate construction

Another method of holding the case together is by using plate joinery. See **Figure 38-14.** Dimensions for side panels with one to four drawers vary. See **Figure 38-16.**

## Ready-to-assemble construction

Several styles of ***ready-to-assemble (RTA) construction*** provide for the use of various RTA

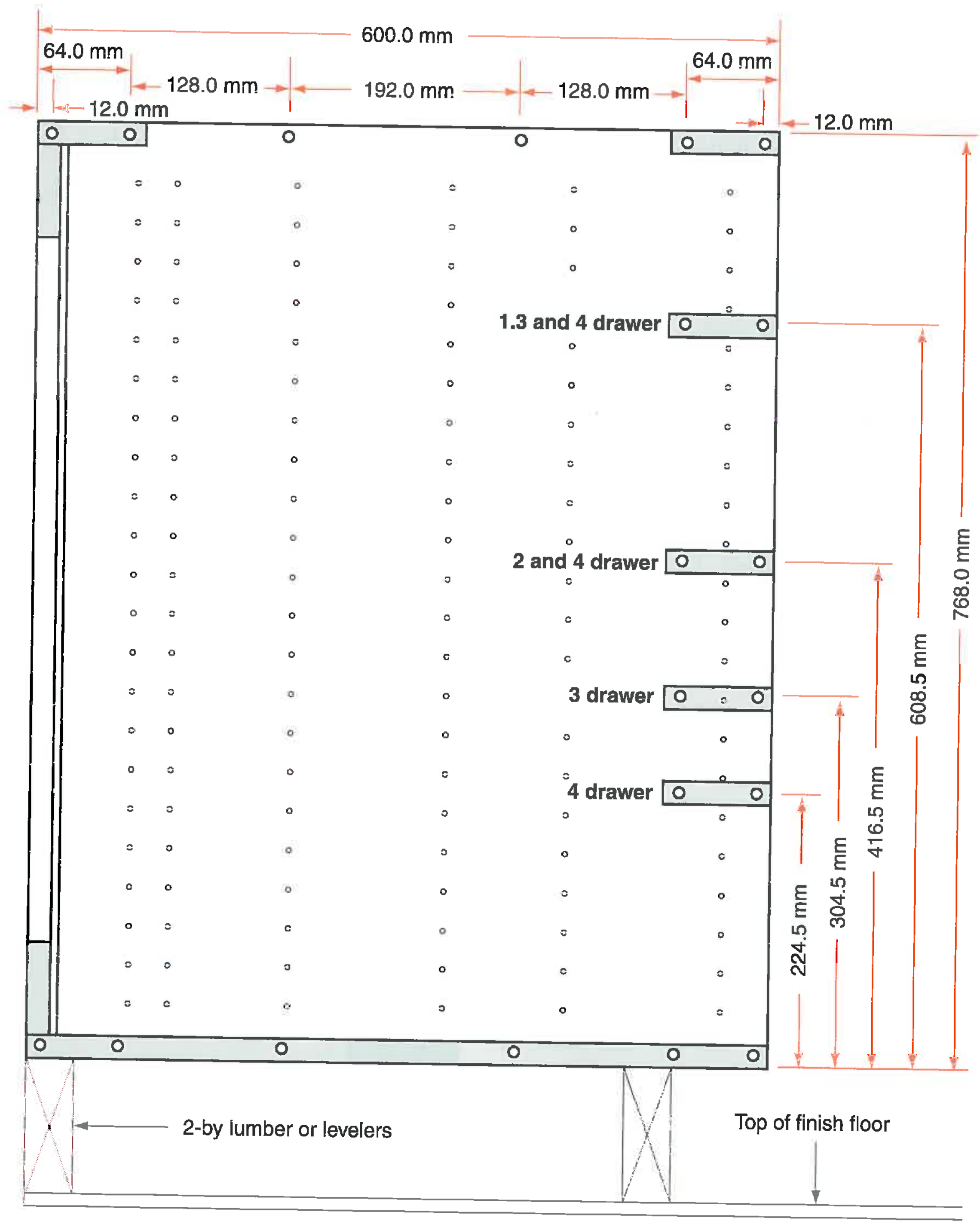



**Figure 38-15.** This illustration shows the dowel drilling pattern for a 1, 2, 3, or 4 drawer base cabinet's side panel. Other than the front row, not all 5 mm System holes need to be drilled. *(Chuck Davis Cabinets)*

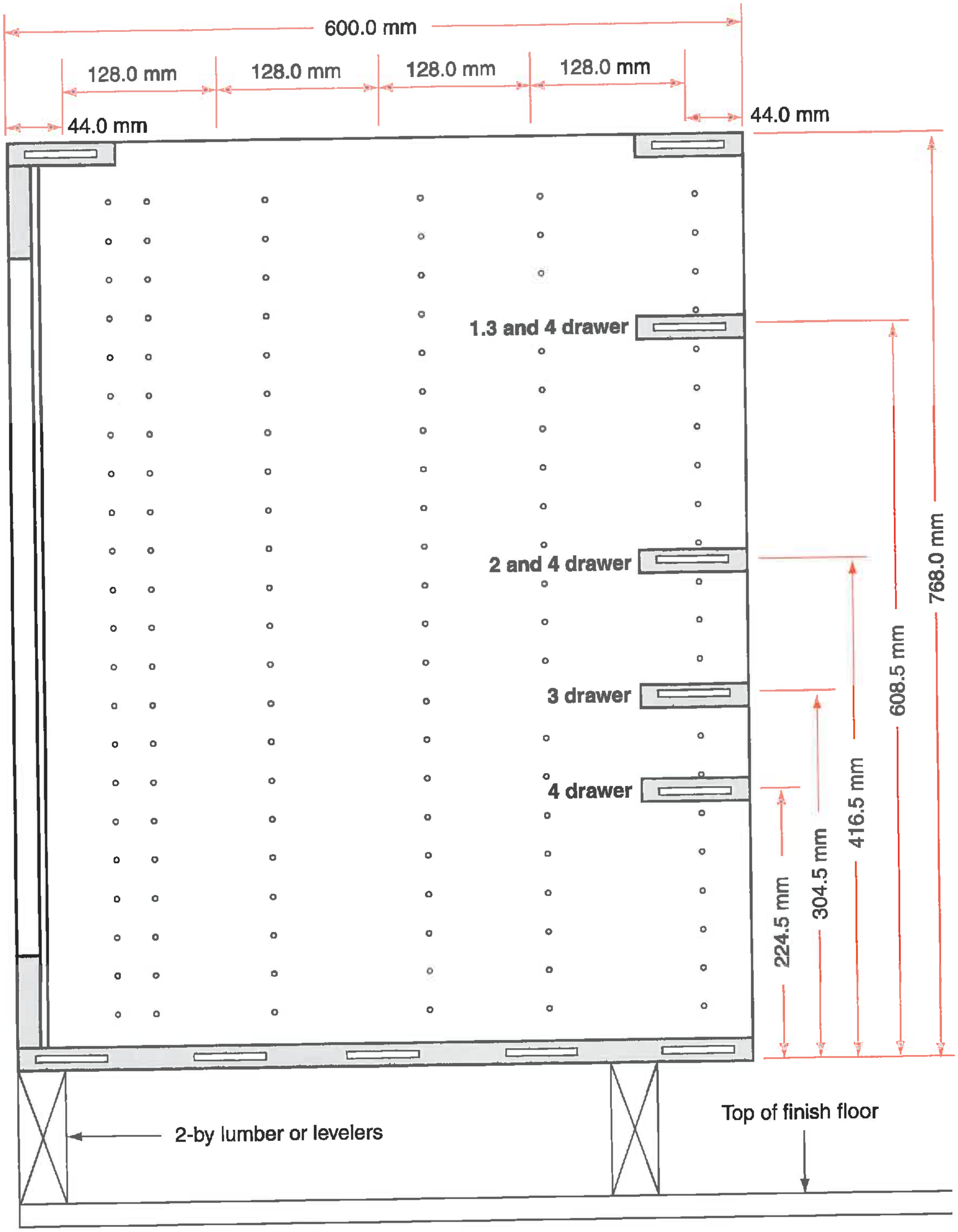



**Figure 38-16.** This illustration shows the plate kerf pattern for a 1, 2, 3, or 4 drawer base cabinet side panels. Other than the front row, not all 5 mm System holes need to be drilled. *(Chuck Davis Cabinets)*

fasteners. For RTA fasteners, 15 mm holes are drilled in the top, bottom, and other horizontal components, in place of the 8 mm holes, to accept RTA connectors for easy assembly. The connecting bolt of a bolt-and-cam or casing connector is threaded into one of the 5 mm holes. See **Figure 38-18B.** The bolt head fits into the cam through a hole drilled in the end of the horizontal member. (Refer to *Chapter 17.*) A turn of the cam or casing draws in the bolt and tightens the joint.

Confirmat® industrial type one-piece connectors combine a long shank with a straight, deep-cut thread to ensure an accurate, close fitting joint between panels. See **Figure 38-17.** The connectors come in different sizes, finishes and head styles. Plastic cover caps in several colors and stems will cover the screw head. With special one piece drill bits and drilling jigs, the requisite holes can be drilled in a single step.

In doors, one 35 mm or 40 mm and two 8 mm holes are drilled for the cup and plastic fixing dowels of most concealed hinges. See **Figure 38-18C.** Some hinges developed for specialized purposes may require other size holes for the cups. The hinge mounting plate fastens into two 5 mm system holes. Refer to *Figure 17-23.* As illustrated in *Figure 17-24* the door hinge is fully adjustable.

Other 32 mm details for base and wall kitchen cabinets are given in **Figure 38-18D.**

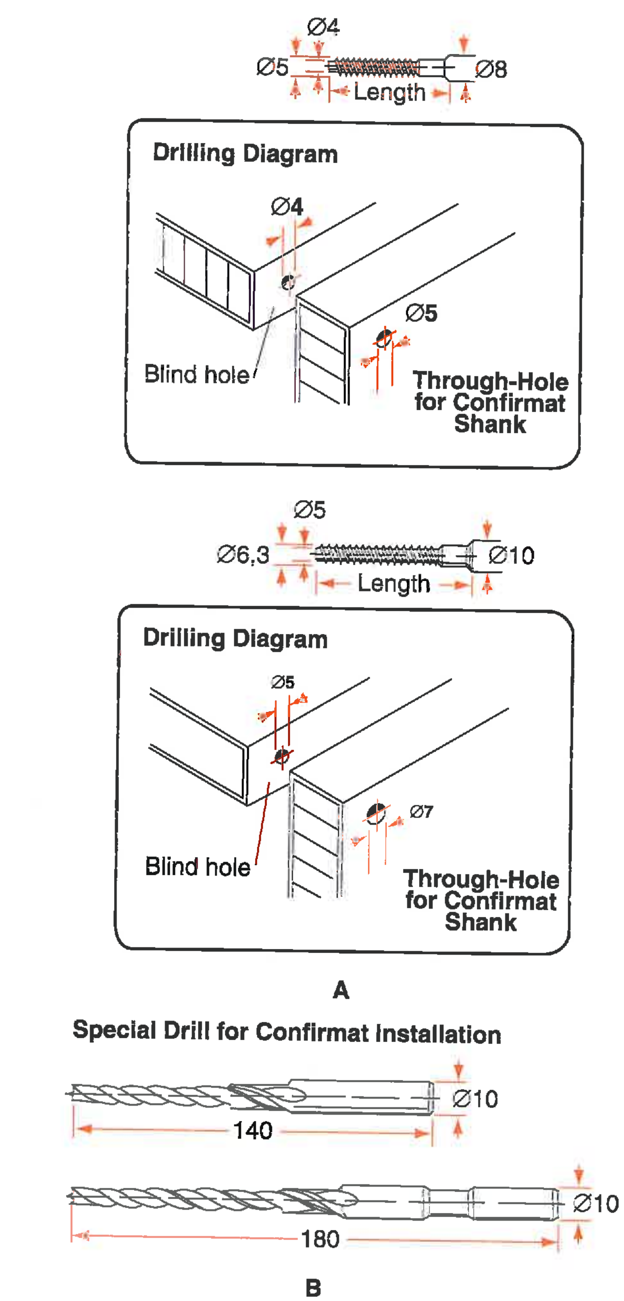



**Figure 38-17.** A—Confirmat® screws are one-piece connectors. B—Special step drills are used to provide both clearance and pilot holes. *(Häfele America Co.)*

## Design advantages

Products manufactured using 32 mm features have several advantages. Flexibility in production is a trademark of the 32 mm System. The standardized hole distance presents a wide range of options. **Figure 38-19** shows three options available from the same case body. If made with RTA fasteners, assembled products can be shipped unassembled. The installer simply reassembles the parts upon delivery. RTA furniture items may be easily taken apart if they need to be moved.

Most 32 mm constructed products look no different from face frame construction having a full overlay door. In addition, time and money is saved on raw material by eliminating the face frame and labor. Furthermore, the frameless cabinet is laid out more efficiently than if it had a face frame.

The simple, yet sturdy, 32 mm design is very economical. Many traditional joints require long machine setup time and multiple cuts. Evenly spaced holes and mechanical fasteners provide a precise fit with little machine setup time.

## Equipment

To run the 32 mm construction system, you may use simple traditional machines, but high precise measuring is required. To fully implement a 32 mm production system, a larger equipment investment is required. A high-volume cabinetmaking firm will spend thousands of dollars to purchase the following:

- Computer numerical control (CNC) panel saw.
- Automated double-sided edgebander.
- Two or more multiple-spindle boring machines.
- Case clamp.
- Point-to-point boring machine. (Computer controlled point-to-point router.)
- Dowel, fastener, and hardware insertion machines.
- Conveyor system.
- Finishing system.

The small shop can produce equal quality cabinets with less equipment. The drawback is reduced production. Typical equipment in a small shop includes the following:

- Multiple-spindle boring machine. See **Figure 38-20.**
- Hinge-boring and setting machine. See **Figure 38-21.**
- Laminate trimmer or router.
- Panel saw, or table saw, with added accessories, for safe and accurate panel cutting. See **Figure 38-22.**

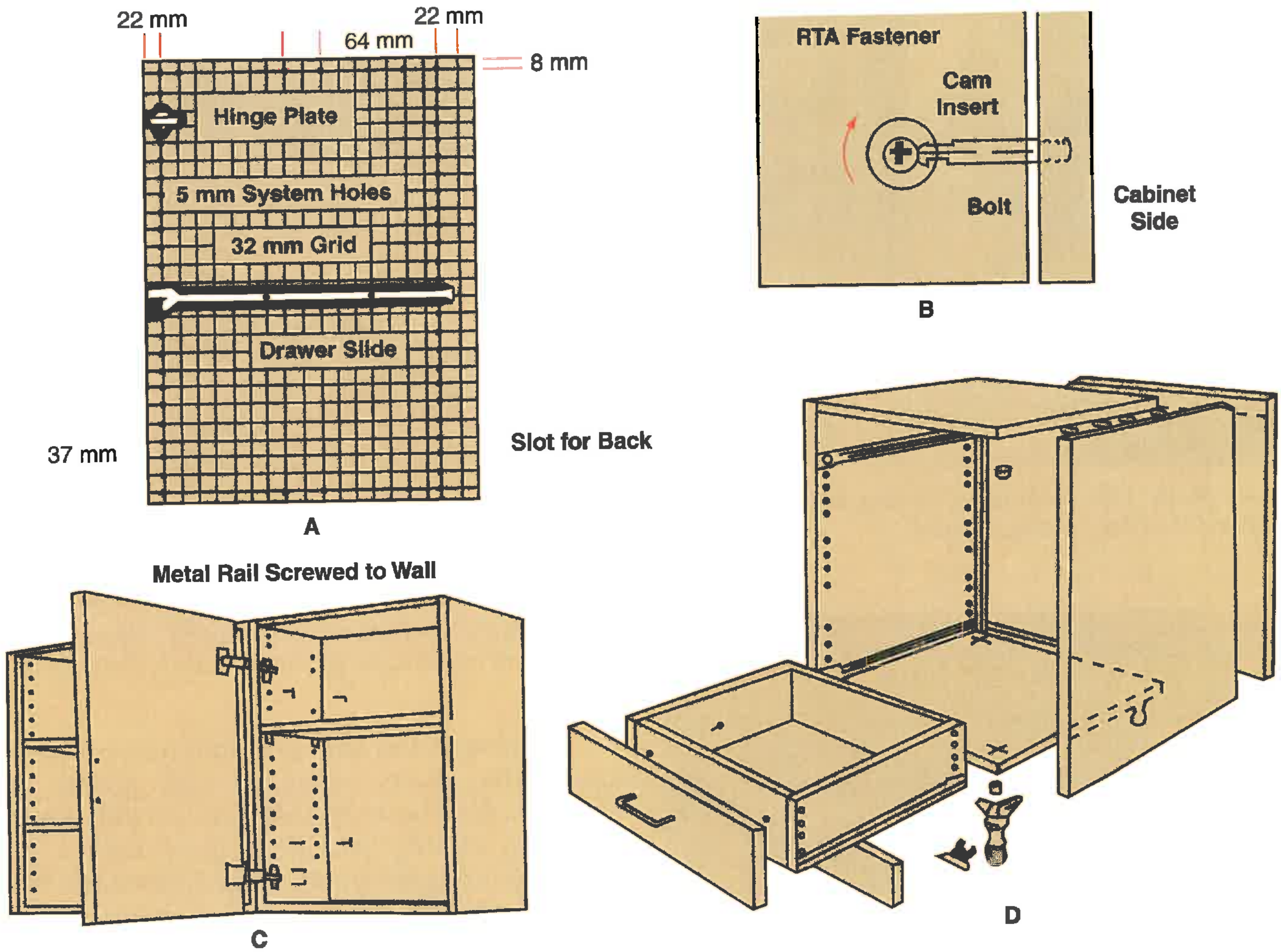



**Figure 38-18.** Production details for kitchen cabinets based on the 32 mm System.

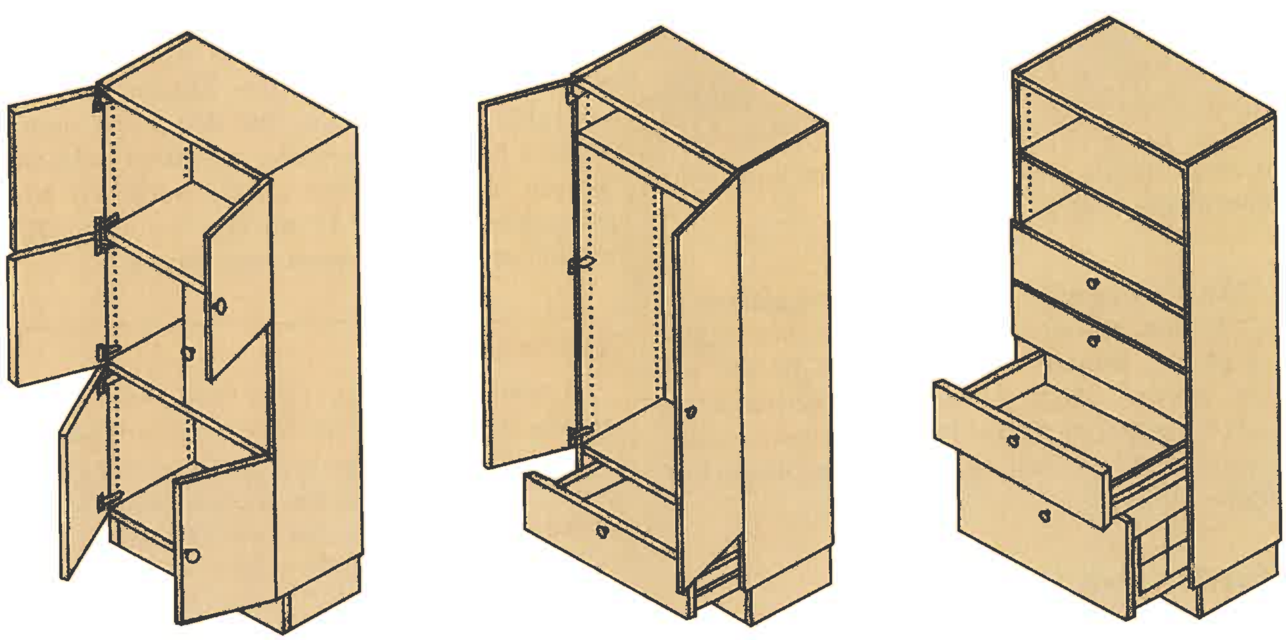


**Figure 38-19.** Three different cabinet designs are made easily using the same case sides, top, and bottom. *(Häfele America Co.)*

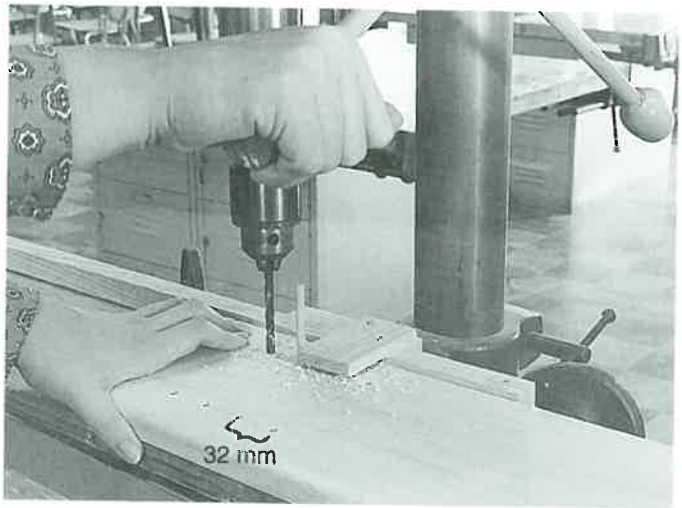



**Figure 38-20.** Line boring for system holes in a base cabinet side. *(Chuck Davis Cabinets)*

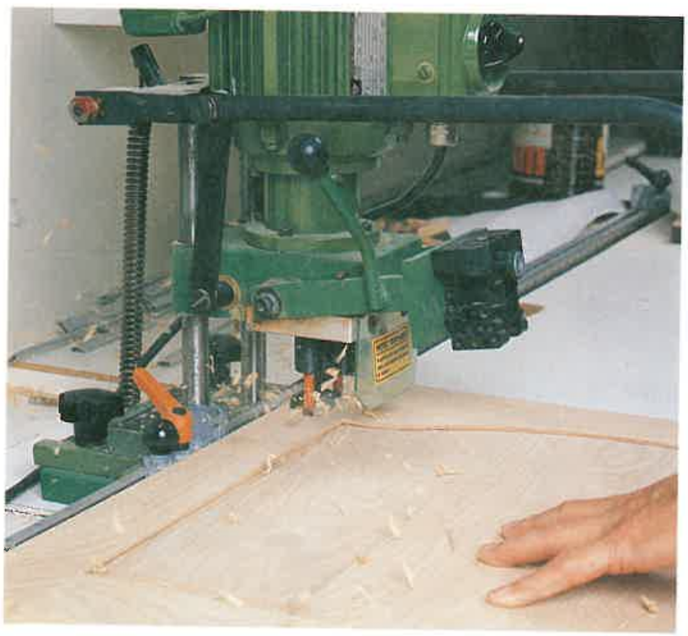


**Figure 38-21.** Boring holes for insertion of Euro-style concealed hinges. *(Chuck Davis Cabinets)*

* Manually operated, single-sided edgebander.

In addition, either large or small firms might have a planer, jointer, and shaper for producing custom doors. Also, frameless construction accounts for approximately 17% of cabinets made. Thus, most firms are fully equipped for producing face frame cabinets.

## Production and assembly

Firms establishing a 32 mm System first set standard part sizes. They then set the machinery to comply with those dimensions. The 32 mm System is flexible enough to satisfy most designs.

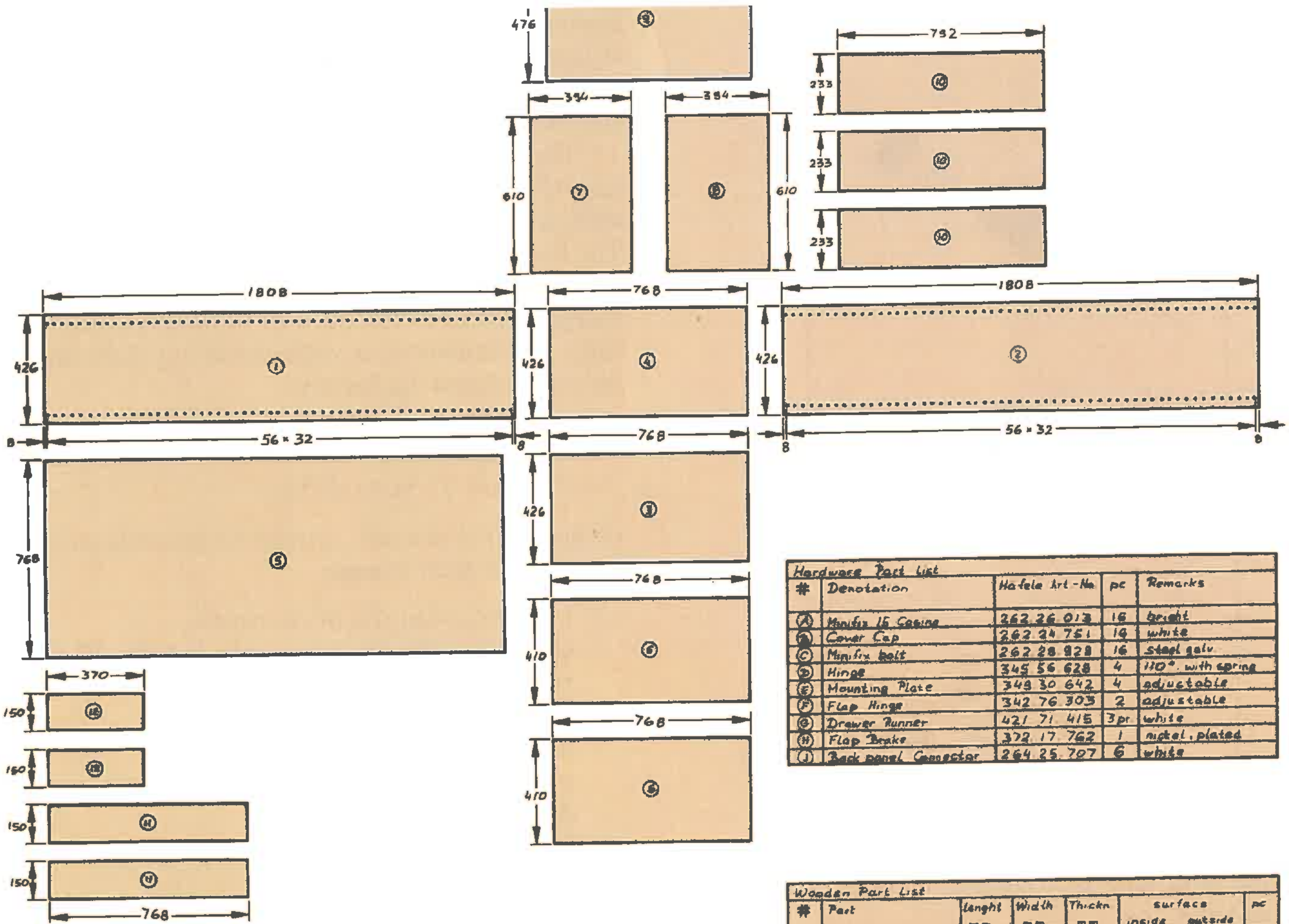
**Figure 38-22.** This table saw is equipped with accessories that permit handling large panels. *(Chuck Davis Cabinets)*

Planning is the key. Take into account all the case parts, doors, drawers, kick plates, and fasteners. See **Figure 38-23A.** Create a bill of materials and cutting list. Mark parts with a part number, cutting list number, and dimensions. Mark this on the hidden edges or mark the information on tape. There are computer programs that allow identifying part numbers and machine readable bar codes to be printed on self-adhesive labels.

Almost all assembly steps are done with the prefinished panels lying flat on the workbench. Install hardware, usually with strong, yet detachable Euro-style screws. See **Figure 38-24.** Next, assemble the case. Hang the doors and attach the drawer fronts. Then, make any final adjustments. Simply turn set screws on the hardware to align components. *Chapter 49* introduces additional information on 32 mm System case assembly.

## Summary

Cases are storage units designed to hold or display items. There are three common types of case construction: face frame, frameless, and frame and panel. A face frame covers the edges of the case top, bottom and sides. It also provides structure. With frameless cases, visible edges usually are edgebanded. The case back provides the stability lost without a face frame. Frame and panel construction may consist of thinner wood panels mounted within a frame. *Raised* panels may be almost as thick as the frame.



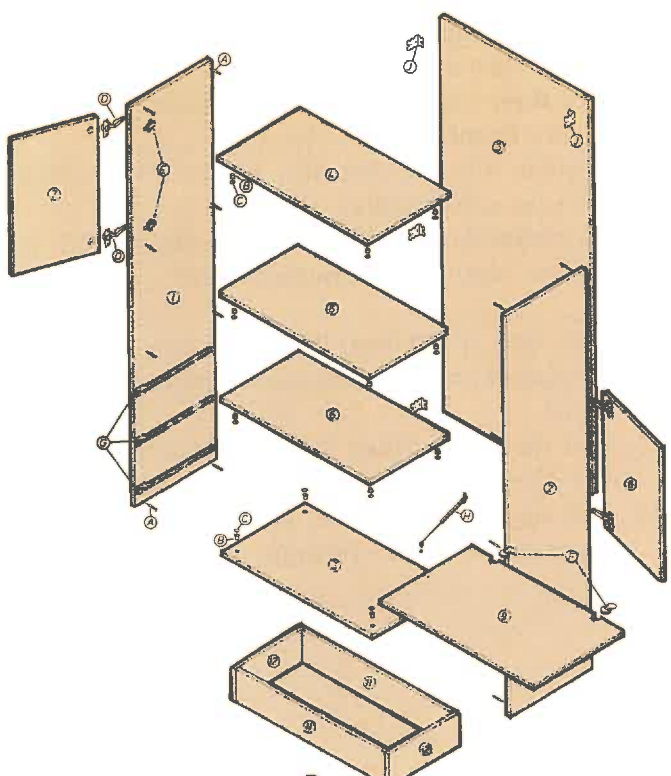
**Hardware Part List**

| # | Denotation | Hafele Art.-No. | pc | Remarks |
|---|---|---|---|---|
| A | Minifix 15 Casing | 262.26.013 | 16 | bright |
| B | Cover Cap | 262.24.751 | 16 | white |
| C | Minifix bolt | 262.28.928 | 16 | steel galv. |
| D | Hinge | 345.56.628 | 4 | 110°, with spring |
| E | Mounting Plate | 349.30.642 | 4 | adjustable |
| F | Flap Hinge | 342.76.303 | 2 | adjustable |
| G | Drawer Runner | 421.71.415 | 3pr | white |
| H | Flap Brake | 372.17.762 | 1 | nickel, plated |
| J | Back panel Connector | 264.25.707 | 6 | white |

**Wooden Part List**

| # | Part | Lenght mm | Width mm | Thickn mm | surface inside | surface outside | pc |
|---|---|---|---|---|---|---|---|
| 1 | Side panel left | 1808 | 426 | 16 | Melamin white | Melamin white | 1 |
| 2 | Side panel right | 1808 | 426 | 16 | " | " | 1 |
| 3 | Bottom panel | 768 | 426 | 16 | " | " | 1 |
| 4 | Top panel | 768 | 426 | 16 | " | " | 1 |
| 5 | Back panel | 1776 | 768 | 16 | " | " | 1 |
| 6 | Shelfs | 768 | 384 | 16 | " | " | 2 |
| 7 | Door left | 610 | 410 | 16 | " | " | 1 |
| 8 | Door right | 610 | 410 | 16 | " | " | 1 |
| 9 | Flap | 792 | 476 | 16 | " | " | 1 |
| 10 | Drawer Front | 792 | 233 | 16 | " | " | 3 |
| 11 | Toe Kick | 768 | 150 | 16 | " | " | 2 |
| 12 | Toe Kick | 370 | 150 | 16 | " | " | 2 |

A



B

**Figure 38-23.** A—Bill of materials and cutting list. B—Exploded view of product based on 32 mm System. *(Häfele America Co.)*

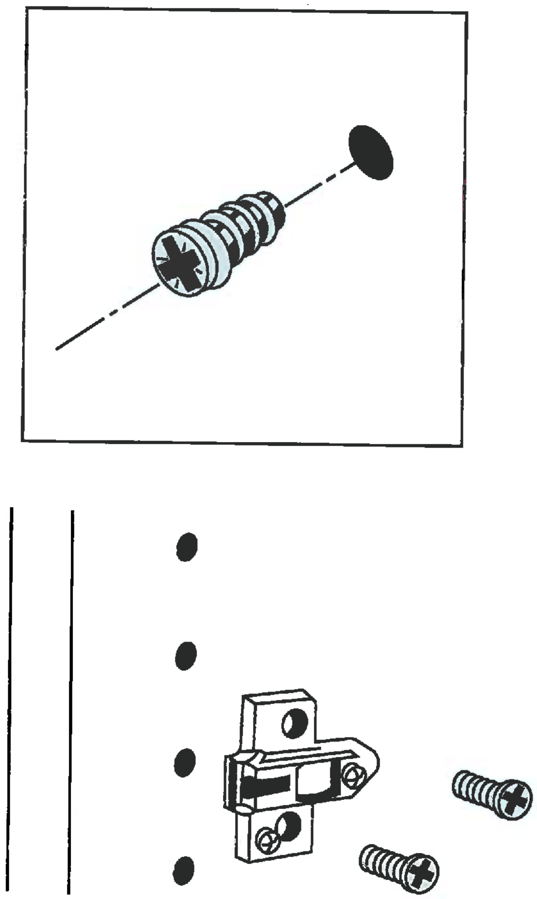


**Figure 38-24.** Euro-style screws that attach hardware into 5 mm holes.

All case goods should be assembled carefully, with square corners. This means cutting the lumber or wood product components accurately. Joints should align and fit properly. All of this must be assured before applying the adhesive.

Case lids are of two types. Some may be lids that are added. Others are rabbeted and glued to the case sides and ends. Then the top is cut off.

Cases may have shelves and/or dividers inside. These typically involve accurately placed shelf hanger hardware or dado joints.

Assemble the case dry initially. Be sure that all surfaces are smooth and joints fit properly. Inspect for squareness. Then disassemble the case with clamps laid aside in the reverse order of use. Assemble the case with the proper adhesive. Clamp it together and inspect for squareness. Be sure to remove all excess adhesive before it sets. Assemble the base or plinth and allow the glue to cure.

The 32 mm System is a standardized form of frameless case construction. Components are drilled with accurately located, standard size drills. The holes accommodate dowels or special mechanical fasteners, hinges, and other hardware. There are many benefits to the 32 mm System. However, to fully implement it, a cabinetmaking firm should buy specialized machinery.

## Test Your Knowledge

*Do not write in this text. Answer the following questions on a separate sheet of paper.*

1. List five examples of casework.
2. Carbide tools are recommended for all materials, except _____.
   a. particleboard
   b. plywood
   c. hardboard
   d. MDF
3. When are dado joints cut only 1/3 of the way through a component?
4. Describe the two types of air cushions for hinged tops.
5. List two steps taken before adding adhesive to assemble a cabinet.
6. List three forms of case construction.
7. A face frame keeps a case from _____.
8. Explain why lumber may not be a wise choice for case construction.
9. Particleboard surfaces and edges that are visible should be covered with _______ or _______.
10. Standard ¾"(19 mm) thick shelving should not be placed on supports spaced more than _____ apart.
11. List the critical hole size dimensions found in the 32 mm System and explain each.
12. List several design and manufacturing advantages of the 32 mm System.

# Frame and Panel Components


## Objectives

After studying this chapter, you will be able to:

- Identify the applications of frame and panel components.
- Create square- or profiled-edge frames.
- Saw or shape raised panels.
- Select joints for frame assembly.
- Describe web frame case construction.

## Important Terms

beveled and raised panel
flush panel
frame and panel
inset panel
intermediate rail
mullion
rail
raised panel
sticking
stile
web frame case construction

Frame and panel assemblies are an alternative to solid wood or wood product surfaces. They consist of a flat or contoured panel held in a grooved or rabbeted wood frame. You will find frame and panel parts used for cabinet sides, fronts, doors, and partitions between drawers. See **Figure 39-1.**

A ***frame and panel*** component serves both design and engineering purposes. As a design factor, it:

- Gives contour to otherwise plain, flat surfaces.
- Allows you to use glass, plastic, cane, fabric, ornamental metal, and veneer for appearance.

As an engineering factor, a frame and panel assembly:

- Provides a stable surface. You might choose plywood for the panel since solid wood tends to warp as a result of moisture changes. The distortion is greatest when only one face is finished.
- Reduces the weight of the product. A thin panel set in a wood frame weighs much less than an equal size solid component.
- Allows a large panel surface to expand or contract within a narrow frame.
- Can use precoated or covered panels, which cost less than lumber of a comparable size. This bypasses surfacing, gluing, smoothing, and some finishing operations.
- Can be sized rather quickly when the frames are precut.

You can also use a frame without a panel. This is done for a face frame or for drawer supports in web frame construction. See **Figure 39-2.**

## Frame Components

Frames and panels are sawn to size and shaped separately. Work from your drawings and specifications to be sure that the two parts fit when assembled.

Several terms are associated with frames. See **Figure 39-3.** Vertical frame side members are called ***stiles***. They are the full height of the frame. Horizontal frame members are called ***rails***. There will be top, bottom, and possibly ***intermediate rails***. A vertical piece other than the outside frame is called a ***mullion***. These separate glass panels or drawers.

Frames usually are made of 5/8" or ¾" (16 mm or 19 mm) lumber. Plywood, particleboard, and MDF are also common materials. You must edgeband plywood. Cover all visible surfaces of particleboard and MDF with laminate or veneer. See **Figure 39-4.** Good quality MDF will receive high gloss polyurethane for an exceptional finish. Composite products offer greater dimensional stability.

The width of frame members varies according to the application. For most products, the width of stiles and rails is 1½" to 2½". A large, paneled door or tabletop might require a larger frame.

Shaping the inside edge of frame members is known as profiling. This process changes the appearance of the frame. The most common profiles are square, bead, bead and cove, and ogee. The shape of the panel set in the frame can also vary. See **Figure 39-5.**

A groove is cut around the inside edge of the frame for the panel. It must hold the panel securely without adhesive. Usually, the groove is ¼" (6 mm)


**Figure 39-1.** Frame and panel products. A—Frame and plywood panel doors. *(Chuck Davis Cabinets)* B— Frames with etched glass panels for upper doors, flat solid wood wall panels and drawer fronts, and wood air vents. Radius frame and solid wood panels. Halogen lighting provides true color to the crystal, and the work surface below. *(Chuck Davis Cabinets)* C—Frame with metal grille panel. *(Bassett)* D—The dresser has frame and panel sides. The mirror is framed. *(Thomasville)*

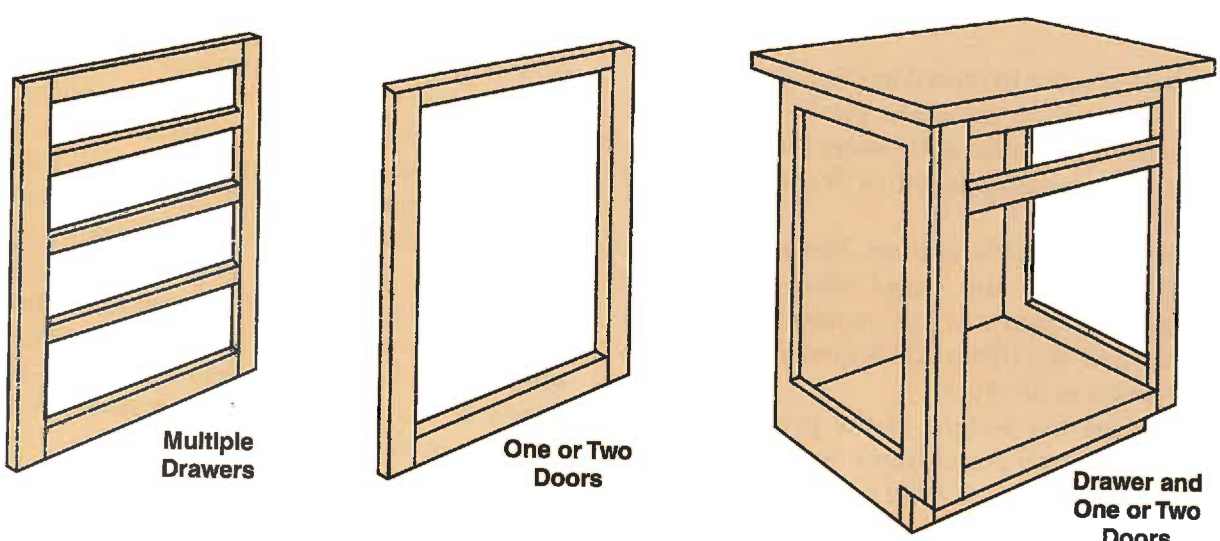



**Figure 39-2.** Face frame is a frame and panel assembly without the panel.

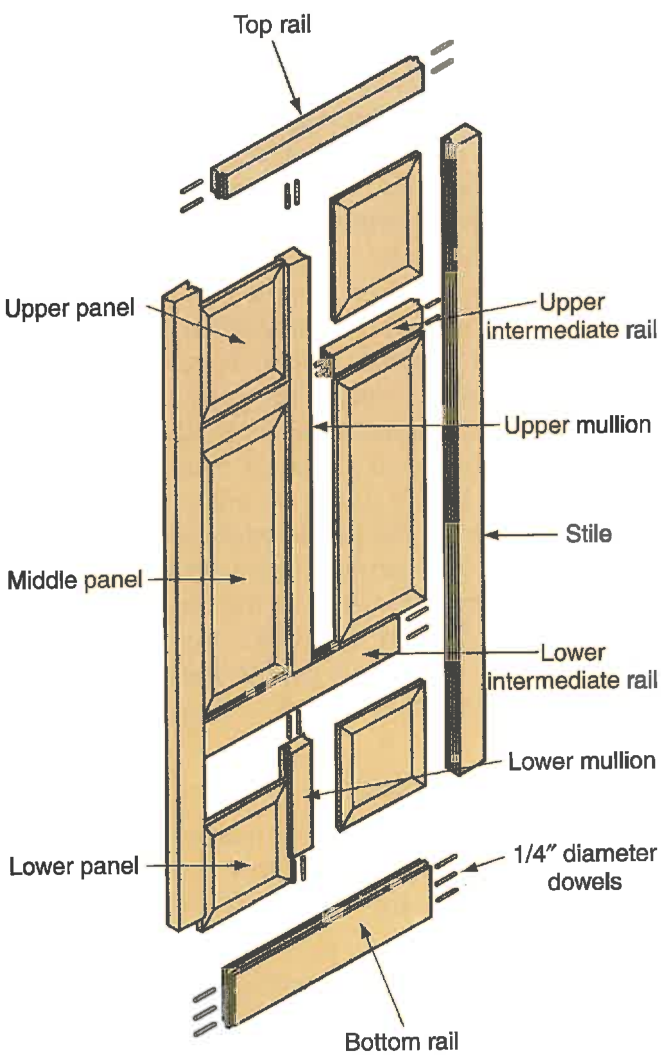



**Figure 39-3.** Learn the individual part names of a frame and panel assembly. *(Shopsmith, Inc.)*

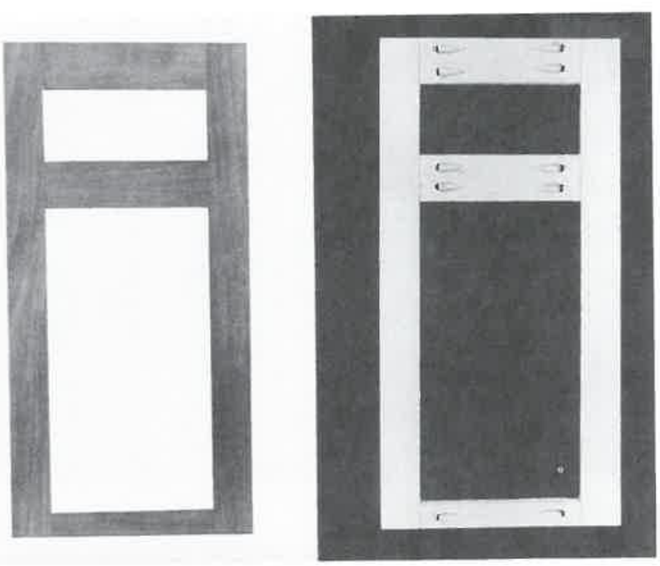


**Figure 39-4.** This is a laminated particleboard frame assembled with pocket joints. *(Evans Rotork)*

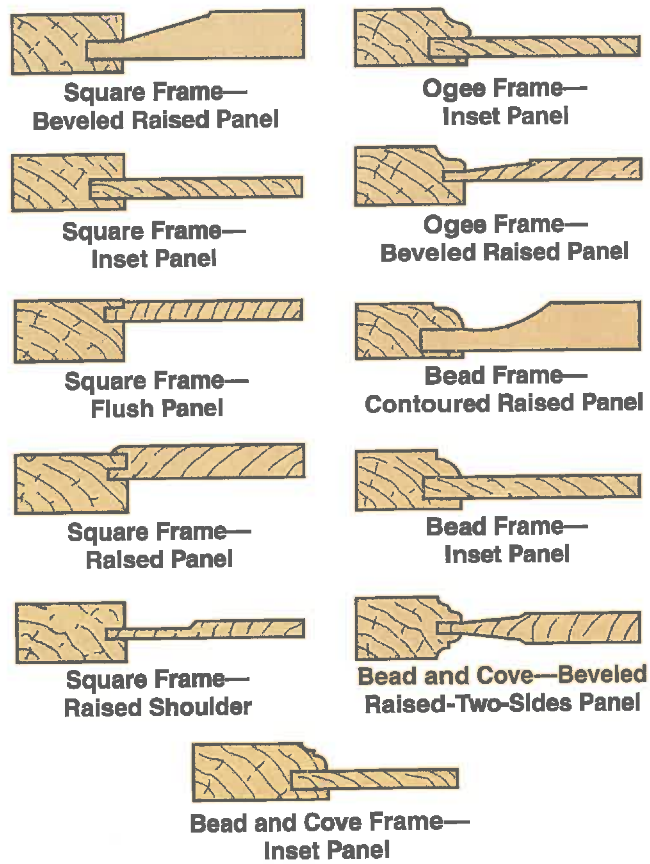



**Figure 39-5.** Frame and panel profiles.

wide and 3/8″ to ½″ (10 mm to 13 mm) deep. However, if a solid wood panel is used, make the groove deeper in the stiles to allow cross-grain expansion. When framing glass panels, a rabbet and stop are used instead of the groove. This allows you to insert the glass into the finished frame. You can also replace the glass if it is broken.

The type of frame you make depends on answers to the following questions:

- What tools, machines, and accessories are available?
- Will the frame be open or paneled?
- Will the frame edges be visible after the product is assembled?
- Will you install the panel while assembling the frame or add it later?

## Square-edge frame

The square-edge frame is one of the easiest to make. You typically use the same type of joint at each corner. These include mortise and tenon, lap, dowel, plate, and pocket joints. Simplify the frame joints as much as possible.

A stub mortise and tenon can be made quickly. See **Figure 39-6.** Add the stub lengths to the total rail length. Then cut the groove around the inside edge of all members. The groove also serves as the mortise. Finally, cut shoulders to form the stub tenon. Reinforce the corners with gussets (mending plates) or add dowels to strengthen the joint further. See **Figure 39-7.** A haunched mortise and tenon does not require dowels. See **Figure 39-8.**

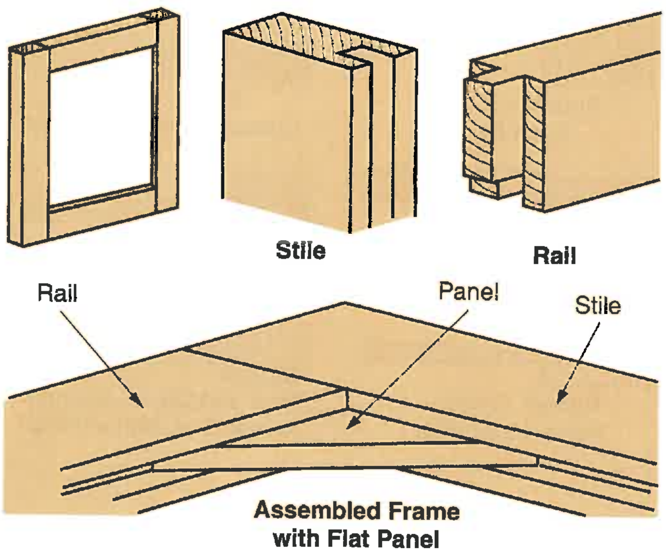



**Figure 39-6.** A stub mortise and tenon is a popular frame joint because the panel groove also serves as the mortise.

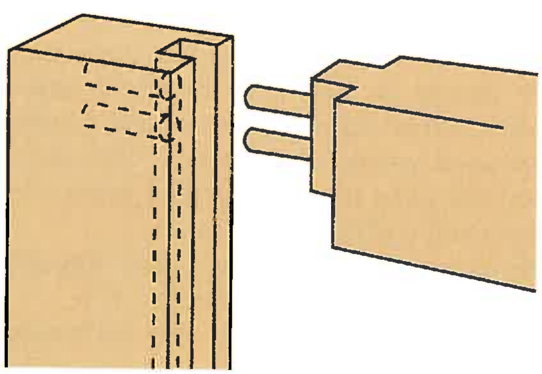


**Figure 39-7.** Dowels reinforce a stub mortise and tenon.

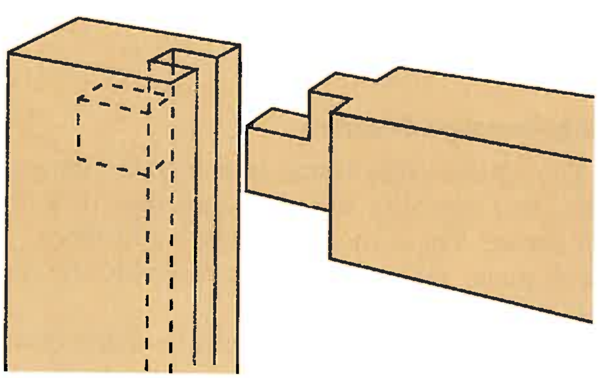


**Figure 39-8.** A haunched tenon adds strength to the joint.

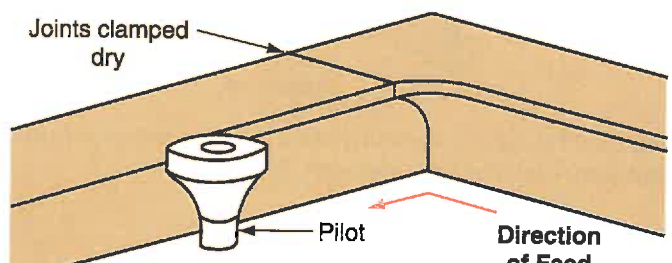
Select dowel, plate, or pocket joints for open frames (no panel). A doweled butt joint is adequate. Drill two holes in each rail. Use dowel centers to align and mark hole locations on the stile edges. Then drill the stiles using a doweling jig. Insert dowels and assemble the frame dry. Inspect for squareness. Disassemble the frame, add glue, reclamp, and square it.

Occasionally, edges on an open frame can be inset or hidden. This occurs if the frame is between two other cabinet sections. Another option is to cover visible edges with molding. Almost any joint is appropriate, because the edge and end grain are hidden.

You may choose to shape or rout frame edges after assembly. Before doing so, make sure the glue is dry. If you shape the inside edge, remember that you will round the corners. Use a router bit with a pilot. See **Figure 39-9.** Contour the edges on one or both sides as desired. However, to have square inside corners, shape the profile before assembly using a matched pair of router or shaper cutters.

## Profiled-edge frame

A contoured inside edge is made by routing or shaping the rails and stiles before assembly. Then, the inside corners are square, not rounded. The




A

B

**Figure 39-9.** A—Contour the edges of assembled frames with a router bit and pilot. B—The doors on this desk show a routed profile. *(Thomasville)* contour also serves as a joint. See **Figure 39-10.** This cut requires special two-piece router bits or a matched set of shaper cutters. There are bead, bead and cove, and ogee profiles.

A profiled inside edge requires that you first shape the inside edges of stiles and rails. Then shape the ends of rails and mullions. Matched sets of shaper cutters are shown in **Figure 39-11.**

A two-piece router bit is shown in **Figure 39-12.** One bit shapes and grooves the stile edges. To cope the rail edges, reverse the position of cutters on the bit.

Try to change cutters without adjusting the bit height. Matched cutters usually are the same thickness. Shape a rail end on scrap material and compare it with a stile just cut. Then, shape the ends of the rails. Use a miter gauge with clamp on the shaper to hold the part.

### Adding panels after frame assembly

To install a panel after the frame is assembled, you must cut a rabbet, rather than a groove. Cut the joint along the inside edge of the back of the frame. Fit the panel inside the rabbet and secure it with stops made of plain or decorative lengths of wood or vinyl. See **Figure 39-13.** Miter or cope the corners as you cut the stops to length. Secure the wood stops with brads or staples. Some vinyl stops are pressed into a groove in the frame.

## Panel Components

Panels may be inset, raised, or flush with the frame. Refer to **Figure 39-5.** ***Raised*** or ***beveled and raised panels*** provide decoration or the look of depth. The raised, beveled one-side panel is the

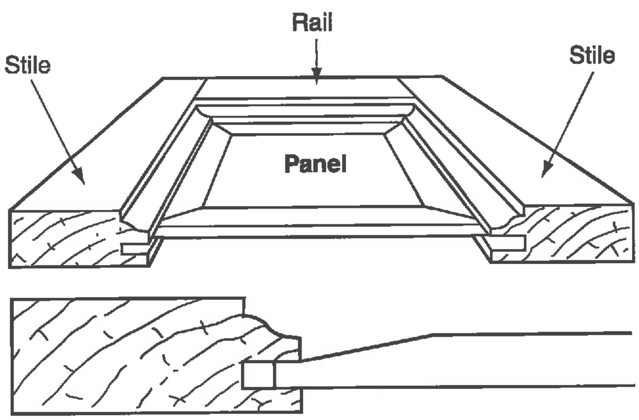



**Figure 39-10.** A profiled-edge frame. The contoured edge also serves as the joint. *(MCS)*

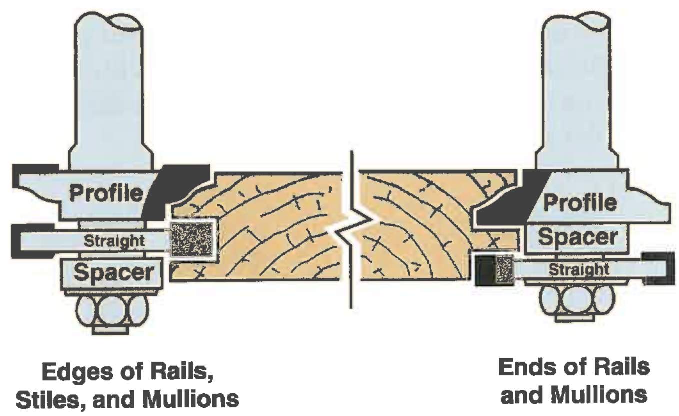



**Figure 39-12.** Two-piece router bit for profiling. Note how the position of the cutters is changed. *(MCS)*

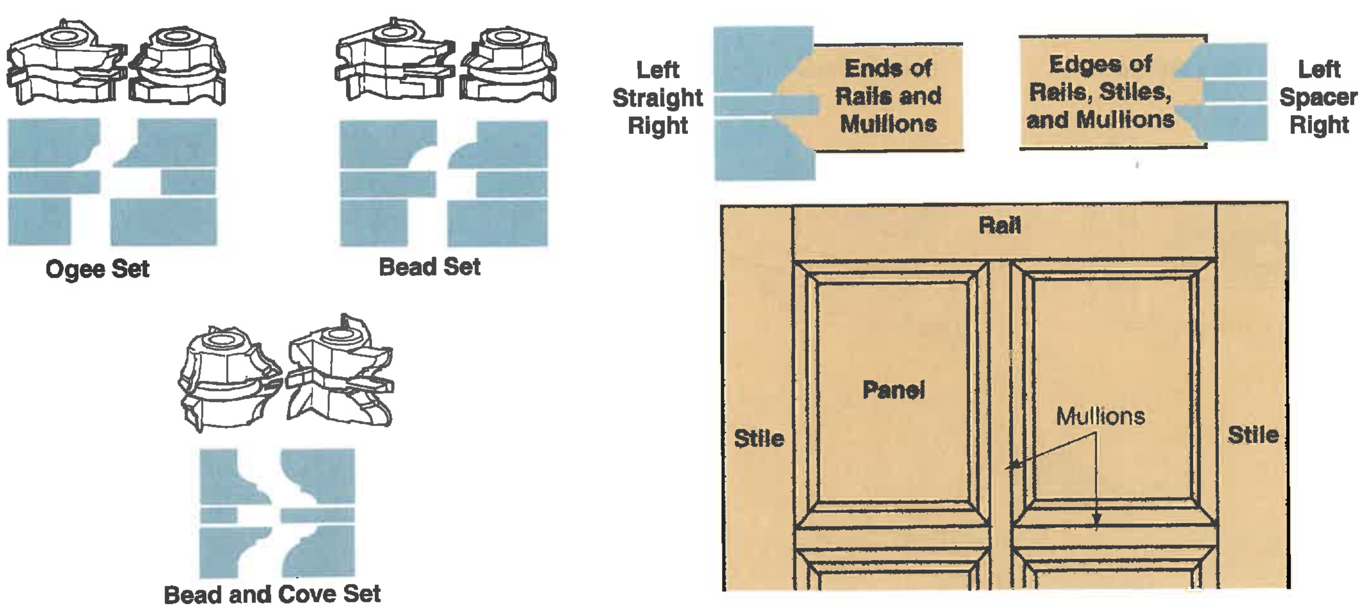



**Figure 39-11.** Profile one or two sides of a panel frame with one-pass matched shaper cutters. *(Delta International Machinery Corp.)*

most common, especially on furniture doors. The inside is flat, while the outside is shaped. The ***beveled-two-sides panel*** is often found on doors visible from both sides.

A ***flush panel*** is made when the surfaces of a product should be flat. Be extremely accurate when measuring and cutting the frame and panel. Gaps can occur if either component is out-of-square.

An ***inset panel*** lies below the surface of the frame. It may be flat or have a shoulder cut.

Panels can be made of plywood, particleboard, or glued-up stock. Standard plywood is not recommended for raised paneling because there may be voids in the crossbands. Also, because crossbands are rotary cut, they are likely to split and tear when sawn or shaped. Smoothing them may not be worth the time or effort. Furniture manufacturers often select custom-made plywood with extra thick veneer faces or special crossbands.

Particleboard is not often used for raised panels. It is difficult to cover the shaped edges with plastic laminate. However, you could select particleboard for a flat panel.

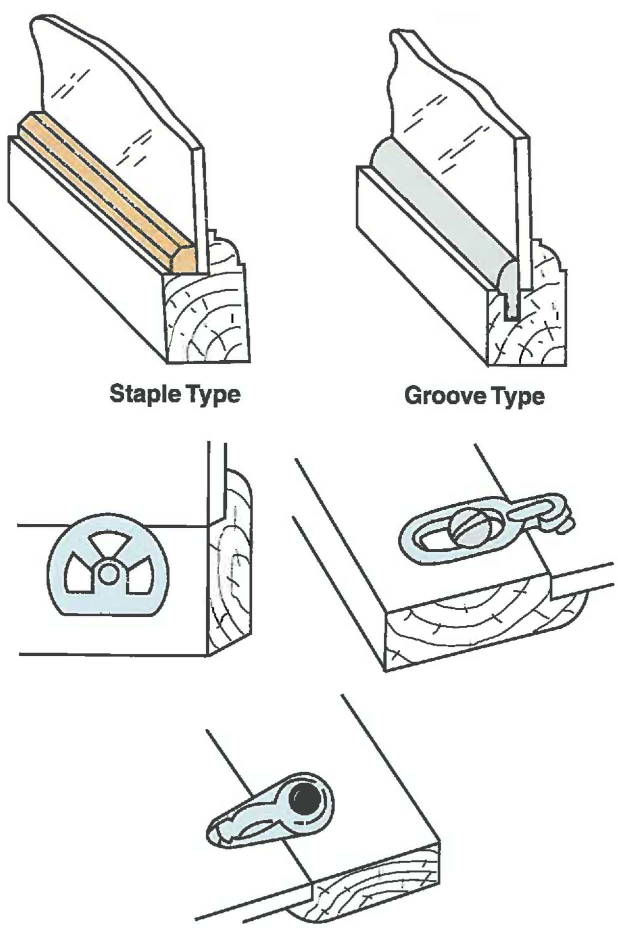



**Figure 39-13.** Wood or vinyl stops and plastic retainers hold panels in rabbeted frames. *(The Woodworker's Store)*

At times, you might install panels before applying the finish. However, it is best to finish the panel first. Install glass, cane, metal grille, or fabric panels in a rabbeted frame after the cabinet is finished.

## Sawing panel profiles

To saw a raised, beveled-one-side panel, adjust the table saw blade 5° to 15° from vertical. Set the blade to the desired height, about 1½" (38 mm) above the table. Stand the panel against a facing board (auxiliary wood fence) fastened to the rip fence. You might also construct a jig, with clamps, that slides against the fence. See **Figure 39-14.** Saw the bevel on the good face or make two cuts for a raised-two-sides panel. You may wish to add a shoulder on the bevel to create the appearance of depth. To do so, move the fence closer to the blade. Remove saw marks with abrasives before assembling the panel and frame.

## Shaping panel profiles

Before using the router or shaper, review setup, operation, and safety topics covered in *Chapter 26*. With some cutters, you hold the material vertically. With others, you feed the panel horizontally with the best surface against the shaper table. See **Figure 39-15.** Adjust the height so that the edge of the panel will slide into the frame groove. Make a test cut to check your setup. Shape the end grain of solid wood panels first.

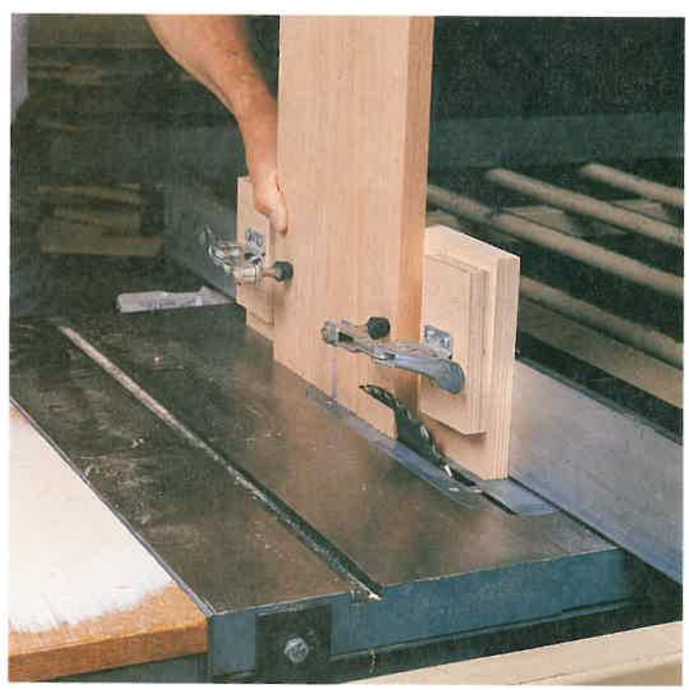
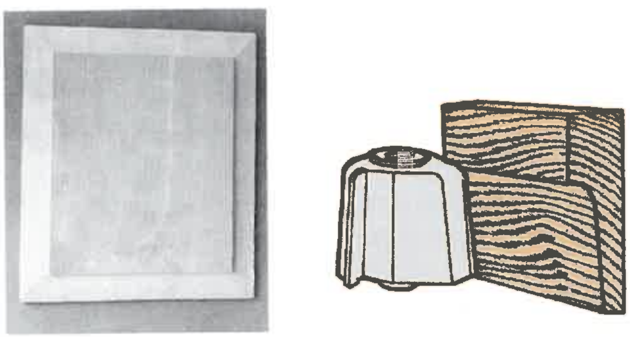


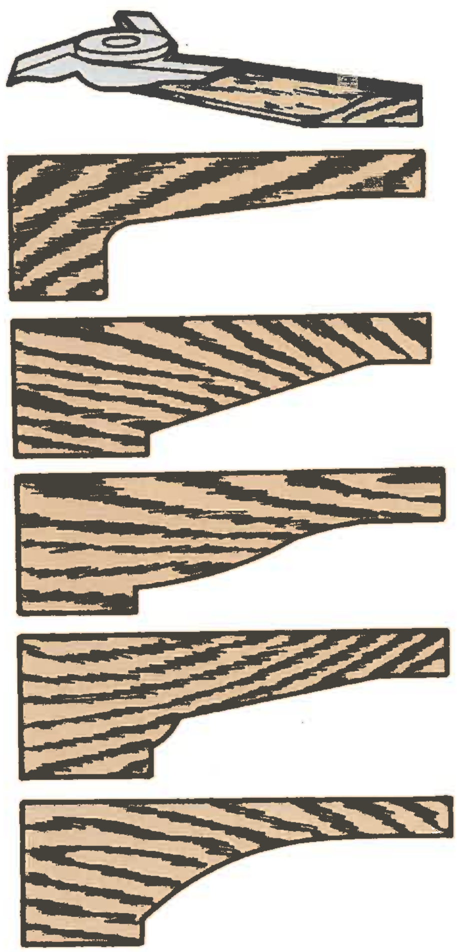
**Figure 39-14.** Beveling the panel on the table saw. (Chuck Davis Cabinets)

## Fitting panels

Solid wood and wood product panels are installed in frames differently. Any panel should slide snugly into the frame. However, since lumber tends to expand and contract with moisture changes, the panel should not fill the groove completely, and should not be glued in place.



**Vertical Panel Raising**



**Horizontal Panel Raising**

**Figure 39-15.** Shaping raised panels. *(Delta)*

## Web Frame Case Construction

***Web frame case construction*** represents one form of high quality cabinetry. The web is an internal frame that adds stability and provides support for drawers. Solid outer surfaces or frame and panel assemblies are added to the frame. See **Figure 39-16.** While open frames are acceptable, a thin hardboard panel usually is placed within the frame to form a dust panel. It prevents dust from falling from one drawer into the next. It also divides chests with locked drawers to prevent access to the drawer below simply by pulling out the drawer above.

There are several methods used to assemble the case. See **Figure 39-17.** When the frames fit into side panels, cut dadoes or stub mortise and tenon joints. If the frame fits into legs or corner posts, cut mortise and tenon joints. Cut a groove along the inside edge of the frame to support a drawer guide and dust panels. Normally, the groove is cut just deep enough to hold the tenon. After assembly, trim the frame to size as needed.

In some quality furniture construction, you see framed panels used for the entire case. The legs become the stiles. Rails are attached directly to the legs. Grooves cut in the rails and legs hold the panels. To mount flush panels, rabbet the legs and rails.

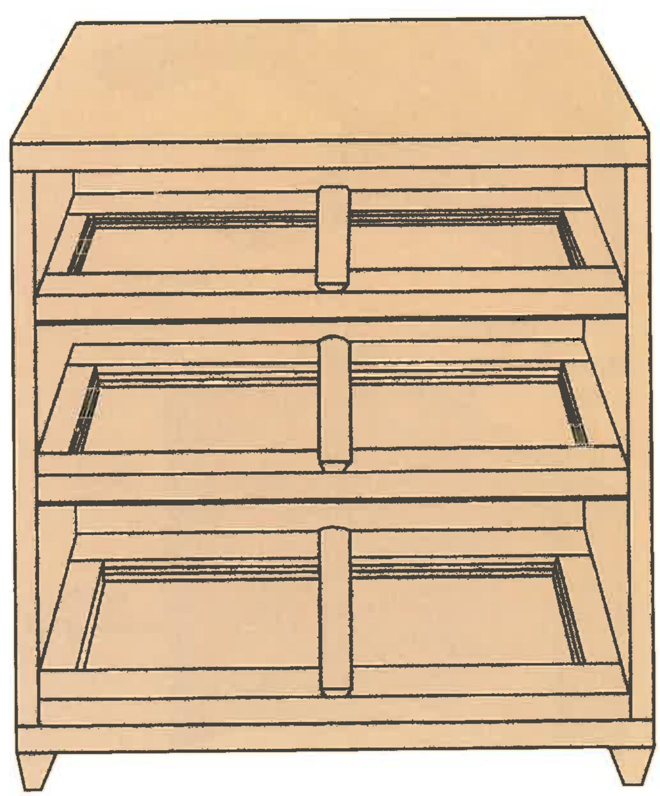


**Figure 39-16.** Web frame construction with internal frame and solid sides.

## Summary

Frame and panel assemblies serve many purposes in cabinetmaking. From a design standpoint, they add contour to otherwise flat, unattractive surfaces. Besides wood, panels can be made of glass, cane, fabric, or other materials. From an engineering standpoint, frame and panel components are stable, weigh less, and can reduce the cost of a product.

The product design, available tools, materials, and experience all affect your decision for using frames and panels. In some situations, special equipment is needed. For example, a matched pair of shaper cutters is needed to shape a profiled-edge frame.

Panels may be flush, raised, or inset. They can be flat or profiled to give the appearance of depth. In most cases, the panels are installed in grooves cut along the inside edge of the frame. Glass, metal grille, and other special panels are held in a rabbet joint by stops.

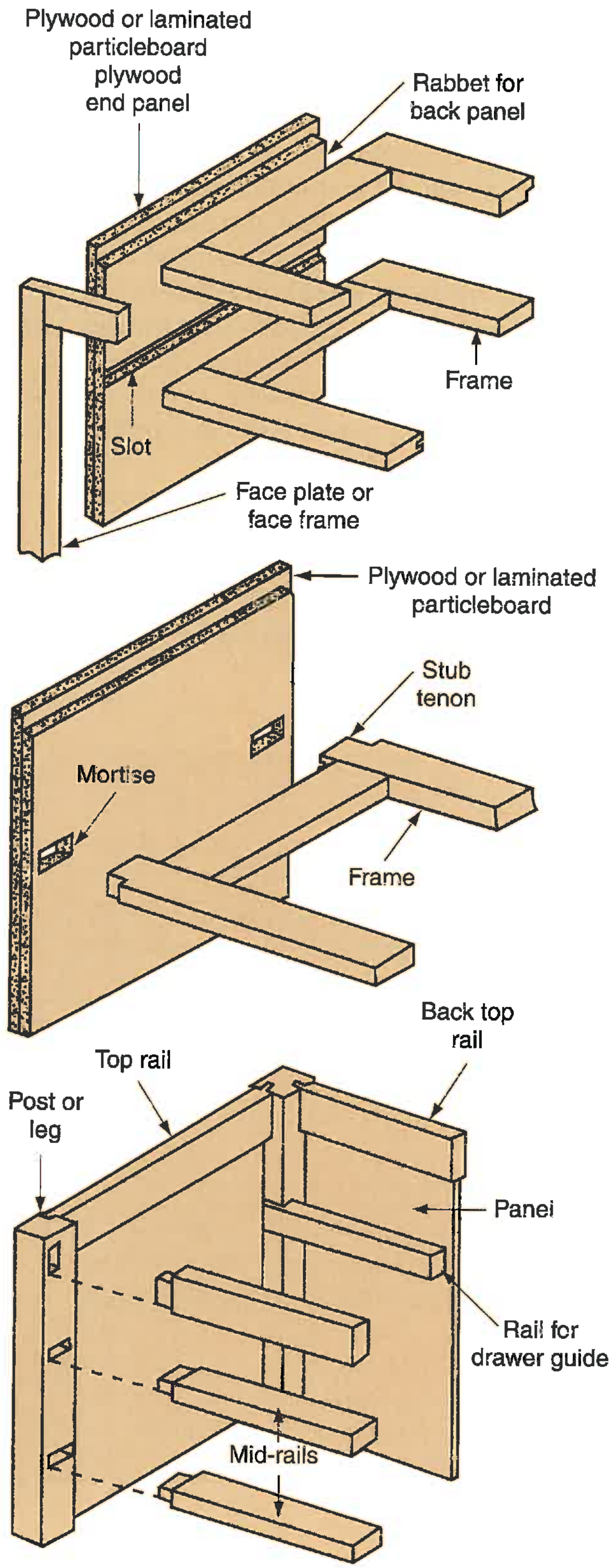



**Figure 39-17.** Joinery in web frame construction.

## Test Your Knowledge

*Do not write in this text. Answer the following questions on a separate sheet of paper.*

1. Frame and panel assemblies are not intended to replace _____.
   a. partitions
   b. cabinet sides
   c. drawers
   d. doors
2. Name four materials used for panels.
3. Vertical members of a frame are called _____ and _____.
4. Horizontal members of a frame are called _____.
5. The shaped inside edge of frame members is called _____.
6. When you shape the inside edge of a frame after assembly, the corners will be _____.
7. The easiest square-edge frame joint to use is the _____.
   a. butt
   b. stub mortise and tenon
   c. dowel
   d. tongue and groove
8. Why might you avoid designing components with flush panels?
9. Standard plywood is not recommended for profiled paneling due to _____.
   a. weight
   b. voids in the crossbands
   c. processing time
   d. lack of stability
10. The best machine for profiling the frame edge is the _____.
    a. router
    b. shaper
    c. table saw
    d. tenoner
11. Cut the groove deeper in the _____ _____ when you will be installing a solid wood panel.

# Cabinet Supports

40

## Objectives

After studying this chapter, you will be able to:

- Identify the types of cabinet supports.
- Prepare feet, legs, plinths, and sides as supports.
- Assemble legs to aprons and stretchers.
- Install glides and levelers to protect cabinet supports.

## Important Terms

adjustable leveler
cabinet supports
cabriole leg
caster
clinch nut plate
feet
ferrule
flat bracket feet
fluting
glide
leg-and-apron construction
legs
ogee bracket foot
plinth
post
reeding
rung
stretcher
tripod leg
working angle

*Cabinet supports* raise cases or furniture above the floor. They include feet, legs, posts, and plinths. On a perfectly flat floor, any support system is stable. On a slightly uneven floor, lumber and wood products may be flexible enough to make the furniture stable. However, when the floor is quite uneven, you will need to install adjustable glides and levelers. These are covered later in the chapter.

## Feet

*Feet* are short supports under casework. They come in a variety of shapes and sizes. Those made from short lengths of square or round stock are the easiest to create. You could also produce bracket feet. These consist of two parts joined at 90° with a miter, usually splined.

There are two types of bracket feet: flat and ogee. ***Flat bracket feet*** are quite simple to make since no shaping is needed. See **Figure 40-1.** On the other hand, each side of an ***ogee bracket foot*** is S-shaped. See **Figure 40-2.** The concave curve may be made on the table saw using a plough cut. The concave curve and the convex curve may be made on the shaper using a large-radius cutter. It is better to shape one long piece of stock, then cut it into the required number of individual pieces. Make sure the grain will be parallel to the floor. Miter and assemble the parts in pairs and add glue blocks or mechanical fasteners to strengthen the foot and attach it to the case.

## Legs

***Legs*** are longer supports for tables, chairs, and some casework. They may be round, square, tapered, turned, shaped, or fluted. They could be lumber or laminated materials, and are usually shaped to match a particular cabinet style. See **Figure 40-3.**

**Figure 40-1.** Each flat bracket foot consists of two parts joined with a reinforced miter joint. Here the edges are shaped for appearance. *(Mersman Tables)*

Figure 40-2. An ogee bracket foot is shaped. *(Thomasville)*

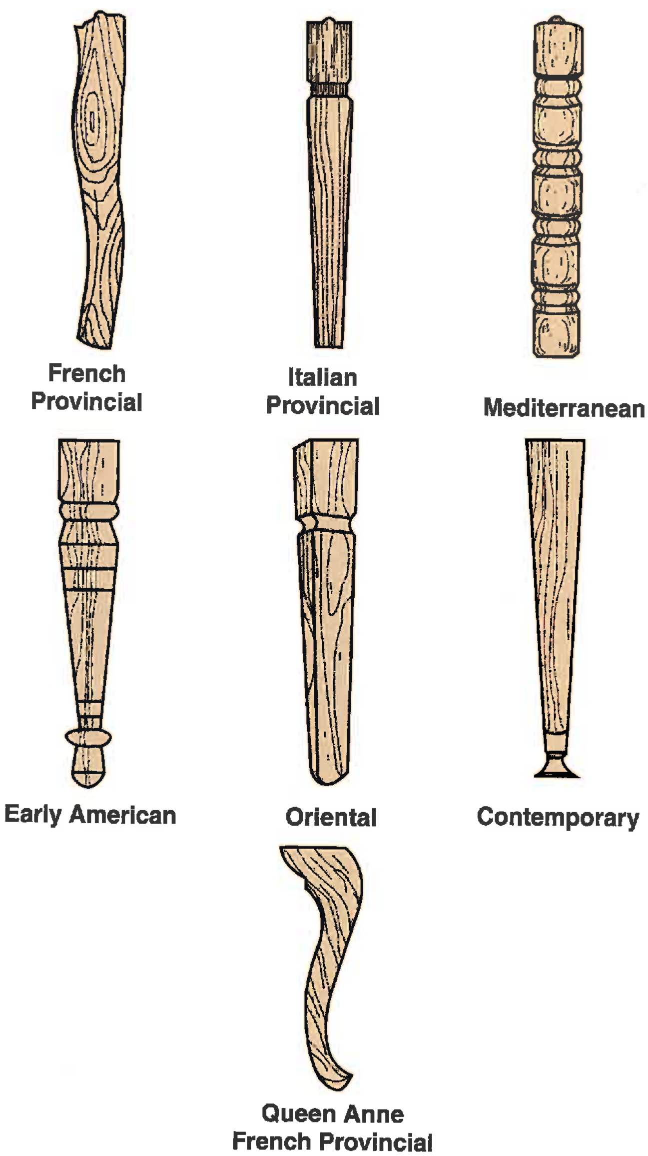



**Figure 40-3.** Match leg styles with the cabinet. *(Gerber)*

Leg selection is a make-buy decision. Some manufactured shapes and lengths come already smooth, with mounting hardware, ready to install and finish. However, you may not be able to find legs made of the same wood specie as your product. Stain the manufactured legs to match the cabinet or design and produce custom legs.

Most straight or tapered one-piece legs follow *Early American*, *contemporary*, and similar cabinet styles. They can be square, round, or a combination of both. Shaped legs, such as the cabriole leg, are commonly found on *Queen Anne*, *French Provincial*, and *Chippendale* furniture.

Legs can also be assembled. See **Figure 40-4.** Made of several pieces glued together, they are sturdy, but weigh less than solid wood legs.

## Mounting legs

You can mount legs vertically or at an angle. See **Figure 40-5.** Tall cabinets with vertical legs often look top heavy. See **Figure 40-6.** Legs at a slight angle appear to add stability. However, no part of the leg should extend beyond the top surface. Someone could trip over it. A common angle is 5° to 12°. Too large an angle makes the legs look weak.

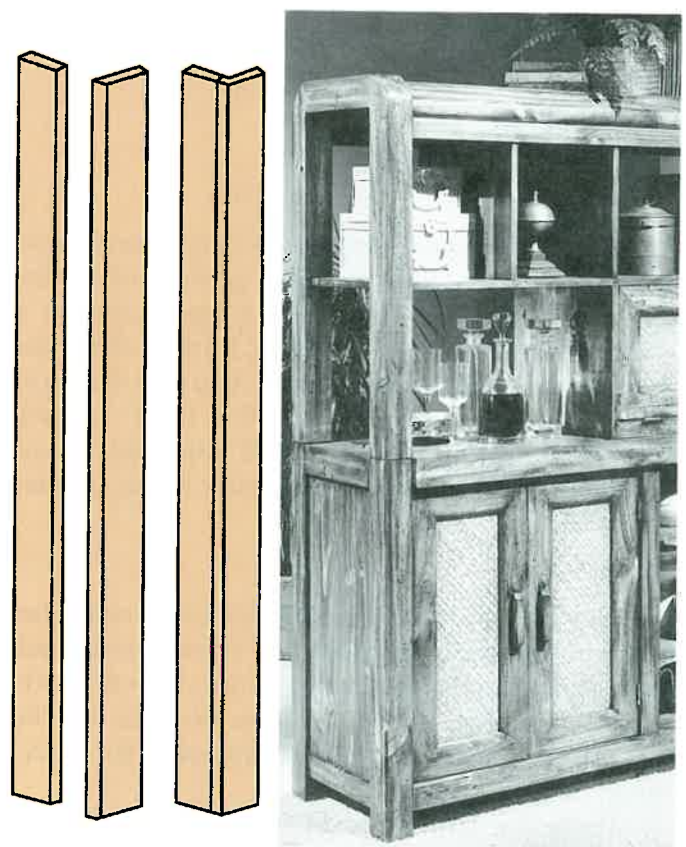
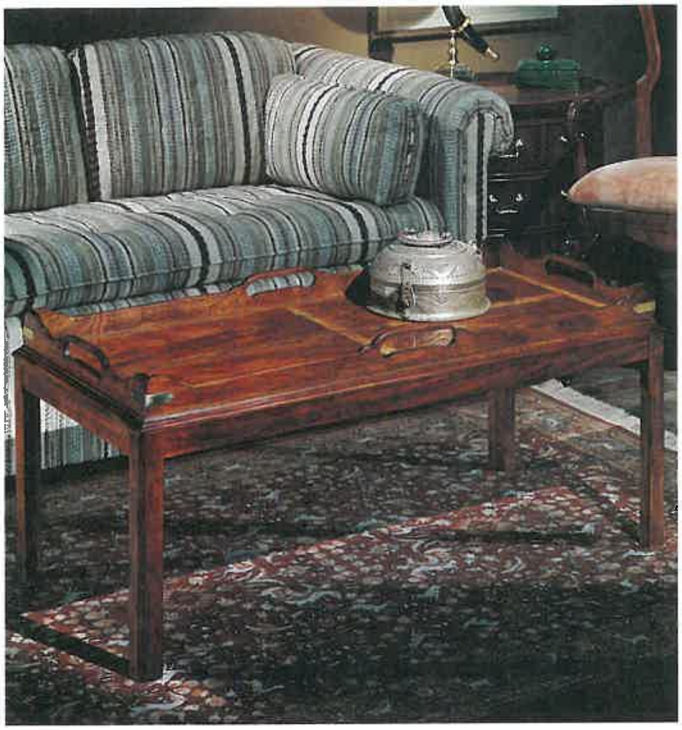


**Figure 40-4.** Assembled legs often are easier than the one-piece legs to create. *(Mersman Tables)*



A

B

**Figure 40-5.** A—Vertical legs. *(Thomasville)* B—Legs at an angle. *(Butler)*

**Figure 40-6.** Tall cabinets with vertical legs may appear top heavy, but this often is a design feature. *(Thomasville)*

You can bond legs permanently to the product or attach them with fasteners. With some fasteners, the legs can fold for easy storage. Others allow easy disassembly.

## Mounting four legs vertically

The four basic methods to mount legs vertically are direct assembly with wood joinery, direct assembly with clinch nut plates, leg-and-apron construction with wood joinery, and leg-and-apron construction with steel corner braces. Remember that wood joinery makes the support permanent. Select mechanical fasteners if you might need to disassemble the product in the future.

### Direct assembly with wood joinery

You can attach legs directly to most cabinetry using many of the joints studied in *Chapter 29*. Examples are various styles of mortise and tenon. Still others are made with plates, dowels, or glue blocks.

### Direct assembly with clinch nut plates

Clinch nut plates and ***hanger bolts*** provide sturdy attachment of the legs. A ***clinch nut plate*** fastens to the underside of the cabinetry or chair seat. See **Figure 40-11.** Screw a hanger bolt into the leg and thread it into the clinch plate. Simply unscrew the leg for disassembly.

### Leg-and-apron construction

A more sturdy support than direct assembly is ***leg-and-apron construction.*** See **Figure 40-7.** The legs and apron assemble with corner braces or joinery. The apron attaches to the underside of the tabletop. Stretchers, discussed later in the chapter, further strengthen the legs. The basic leg-and-apron support consists of four legs and four apron pieces. The legs should be square where they attach to the apron.

For a permanent support, attach the legs to the apron using wood joinery. A mortise and tenon traditionally has been the joint of choice. You should miter the tenons as shown in **Figure 40-9.** Dowel joinery is used to reduce production costs and processing time. Another solid bond for leg-and-apron components is plate joinery. **Figure 40-10** shows slotting and assembling workpieces by this method.

For removable legs, use steel corner braces. See **Figure 40-8.** Attach the apron to the tabletop with

A

B

**Figure 40-7.** Leg-and-apron construction. A—With contoured legs. *(Thomasville)* B—With straight legs. *(Ethan Allen)*

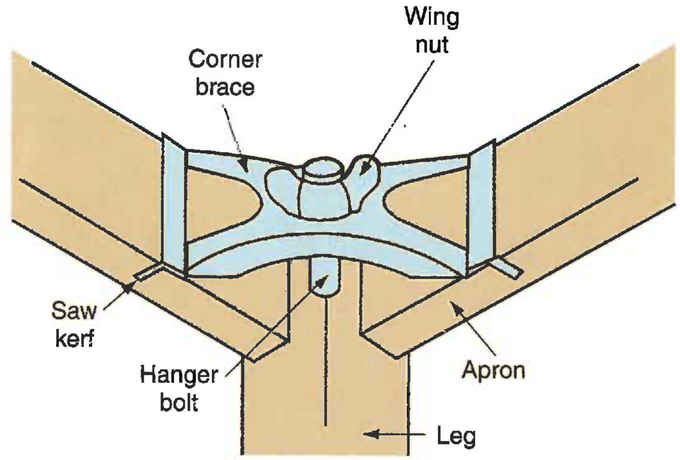
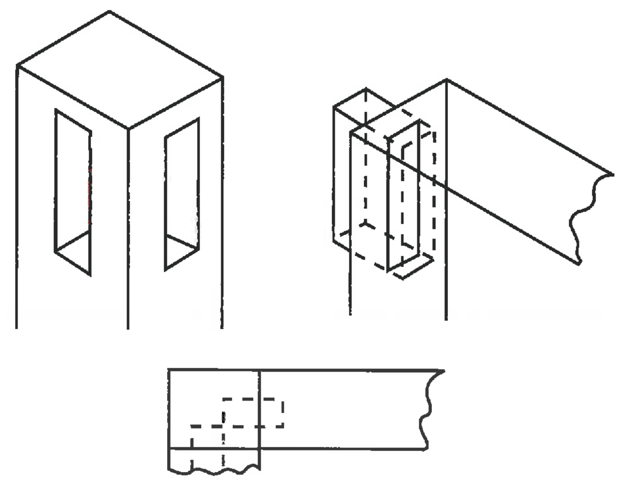



**Figure 40-8.** Use a corner brace, hanger bolt, and wing nut to secure removable legs to the apron.



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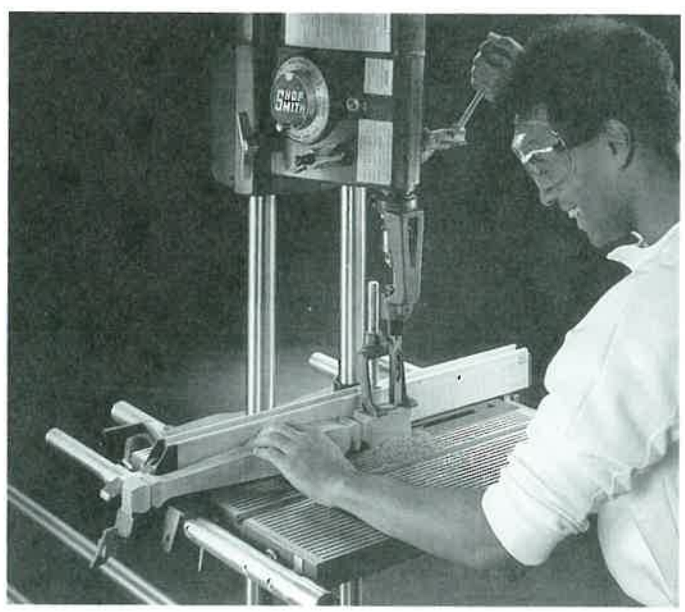


B

**Figure 40-9.** A—Miter apron tenons so that they fit in the mortises. B—Mortising the legs on the drill press. *(Shopsmith)*

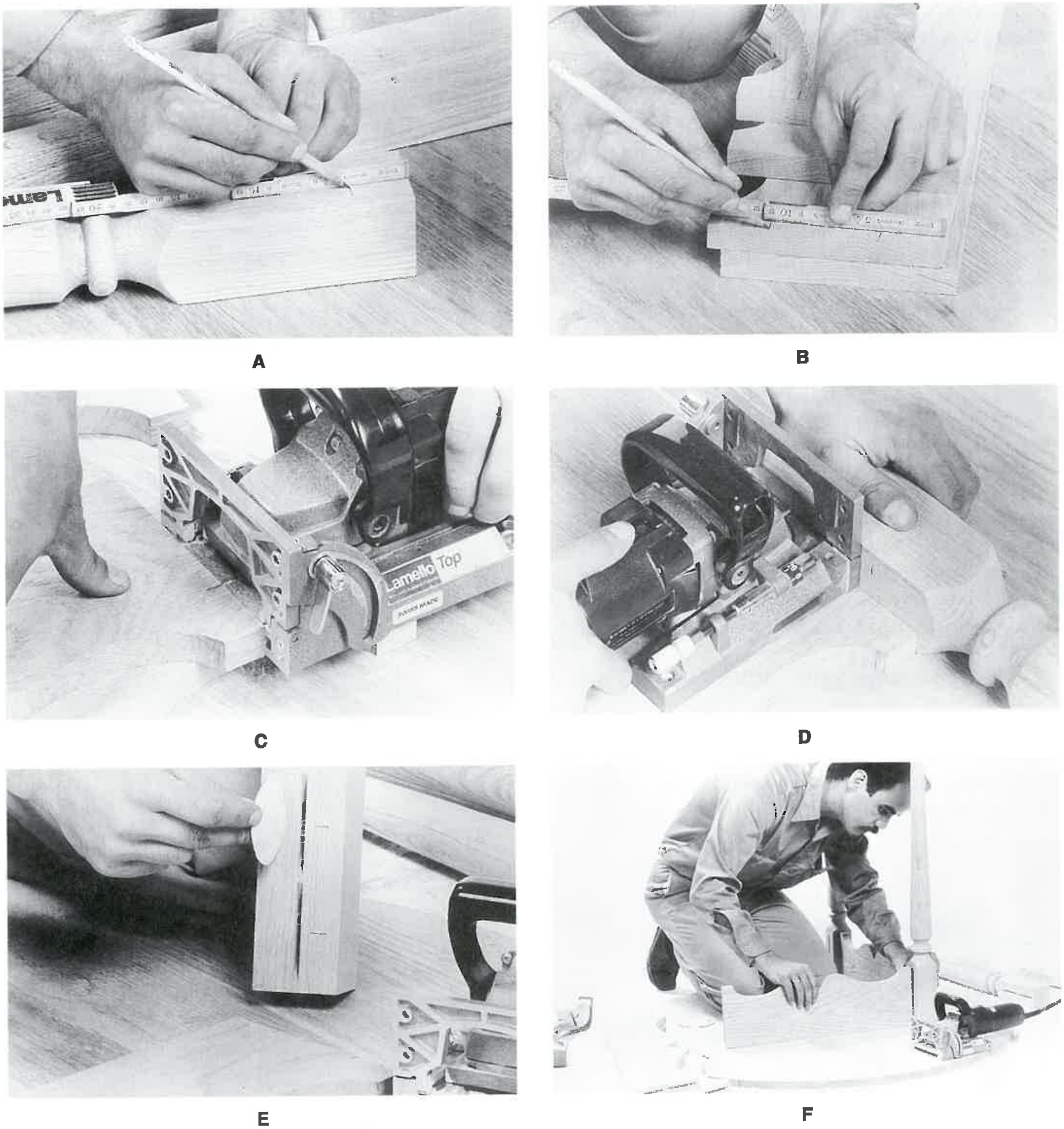



**Figure 40-10.** Assembling the legs and apron pieces using plate joinery. A—Mark slot locations on the legs. B—Mark slot locations on the apron pieces. C—Cut the apron slots. D—Align the apron and leg to cut the leg slots. E—Put glue and a plate in both slots on one leg. F—Assemble the legs and apron on a flat surface. *(Steiner-Lamello)*

glue blocks, joinery, or mechanical fasteners. Make sure the apron length allows the leg to fit squarely in the corner. Cut saw kerfs in the apron ends to match the size of the corner brace. Then install a hanger bolt in the inside corner of each leg. Tighten the leg in place with a wing nut.

## Mounting legs at an angle

Slanted legs can mount at equal or unequal work angles. In addition, two legs might mount at an angle while the other two are vertical. This is quite common in chairs. Always lay out and drill screw holes or make socket joints while the seat or tabletop is square. By shaping the seat first, you lose reference corners from which to mark hole locations.

### Equal work angles

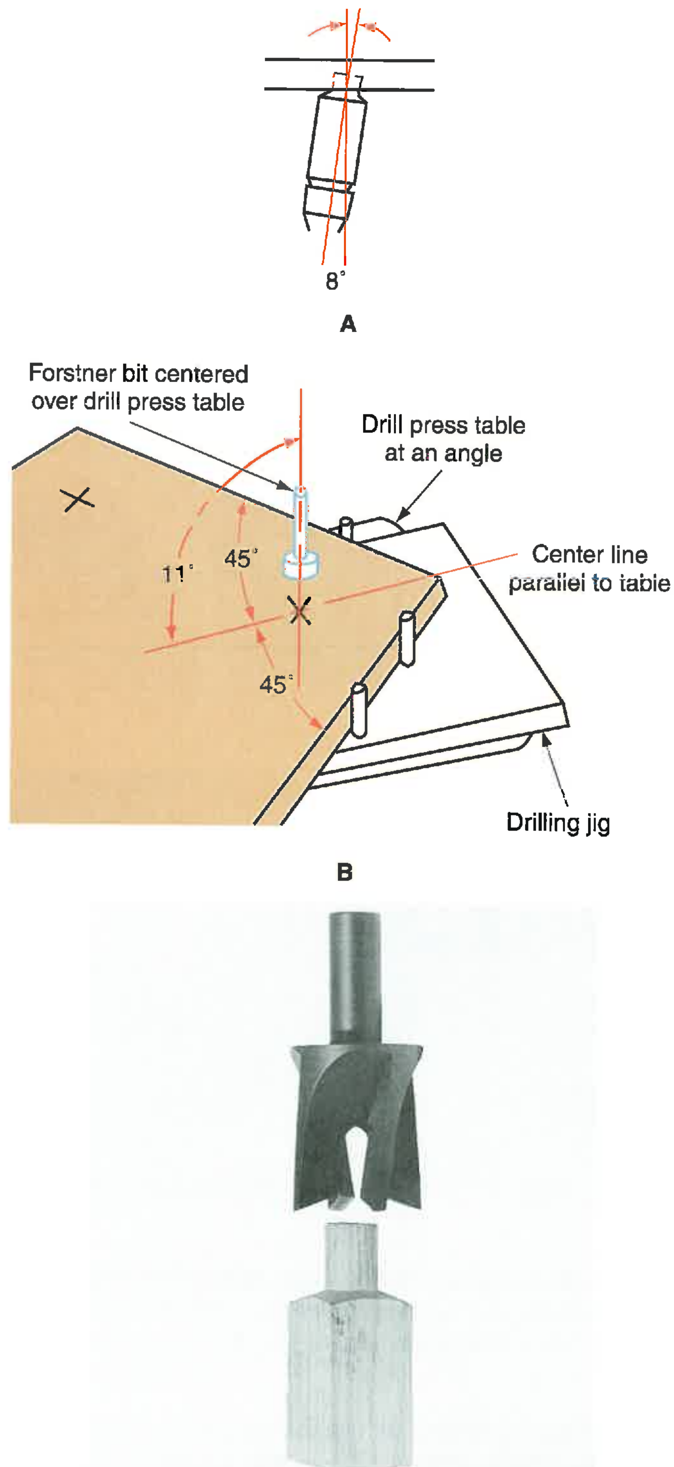
You can mount removable or permanent legs at equal work angles. Suppose you were making a valet chair, such as that shown in **Figure 40-11.** Using clinch nut plates to attach removable legs, select a plate type that will provide slanted legs. The shape of the clinch plate sets the angle, usually 8°. Screw a hanger bolt into a pilot hole drilled in the leg. Temporarily thread a cap nut on the machine screw end. Screw the hanger bolt into the leg with a socket wrench and remove the cap nut. Then thread the leg into the clinch nut plate.

Permanent legs at an angle are more difficult to make. Although dowel and mortise and tenon joints are common, you might choose a socket joint. This joint is made by shaping a round tenon on the leg using a tool similar to a plug cutter. See **Figure 40-12.** Drill the holes in the chair seat or tabletop at an angle, which is called the *work angle.* Use a T-bevel or protractor to set the angle of the drill press table. Make a fixture to hold the seat or top at the proper angles.

Select a Forstner bit for drilling the socket and drill the hole just smaller than the tenon. Then squeeze the tenon with pliers to compress the wood fibers. Moisture in the adhesive expands the compressed fibers of the tenon during assembly. This creates a strong joint.

### Unequal work angles

For some furniture styles, the front and back legs mount at different angles. This is typical with chairs. See **Figure 40-13.** Usually, the back legs are one piece that is curved slightly for stability.



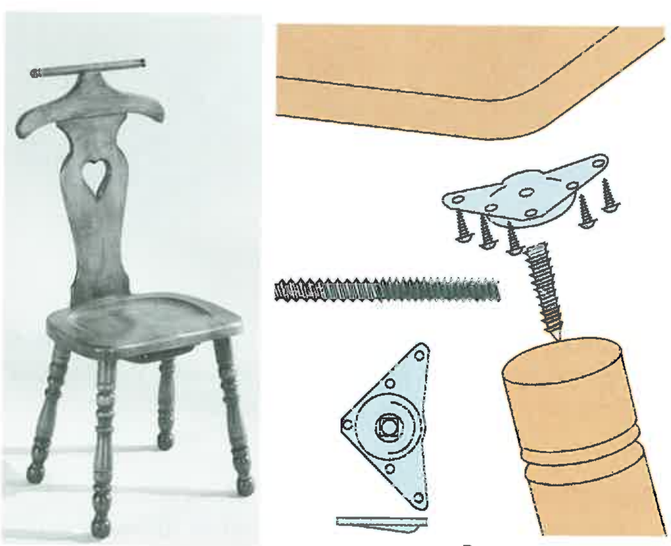




**Figure 40-11.** A—Valet chair with legs at an angle. *(Butler)* B—Select the proper shape clinch nut plate to attach the legs.

**Figure 40-12.** A—Typical angle for chair legs. B—Jig for drilling the chair seat. C—Making the tenon for socket joints requires a tool similar to a plug cutter. *(Woodcraft)*

### Mounting tripod legs

*Tripod legs* join a central pedestal with dowels, dovetail joints, or mechanical fasteners. See **Figure 40-14.** Refer to the assembly details in *Chapter 29* to attach legs with joinery. See **Figure 40-15.** Select mechanical fasteners to make the legs removable.

Removable tripod legs can be fastened with screws and insert nuts. See **Figure 40-16.** Align and drill two holes through the pedestal. The top hole should be a dowel size, such as 3/8" (10 mm). The lower hole should be a screw size, typically ¼" (6 mm). Then, align and mark the hole locations on each leg using dowel centers. Drill a blind hole in upper part of the leg for the dowel. Drill another blind hole large and deep enough to install an insert nut. Glue a dowel in the upper hole on the leg. Insert the machine screw through the pedestal and tighten it into the insert nut. Bond a plug over the screw head.

Make the surfaces match where the leg and pedestal meet. For a round pedestal, flatten the section where the leg attaches or contour the mating surface of the leg.

**Figure 40-13.** Example of a chair which has vertical front legs and angled back legs. *(Thomasville)*

**Figure 40-14.** Tripod legs for a clothes tree.

### Making legs

As mentioned before, selecting legs is a make-buy decision. Although it is easier to buy premade

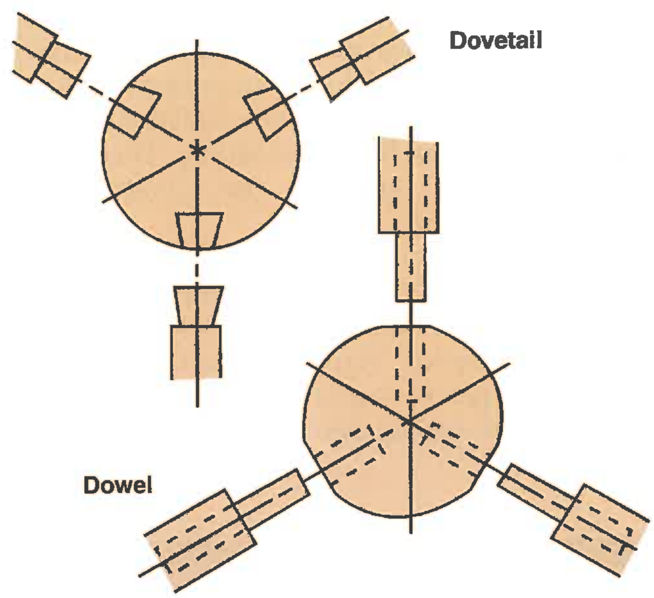



**Figure 40-15.** Typical wood joints for fastening tripod legs to a pedestal.

**Figure 40-16.** Place an insert nut and dowel in the leg. The screw travels through the pedestal and threads into the insert nut.

legs, you may find that some furniture styles require custom parts. Legs can be square, round, or shaped as well as straight or tapered.

## Round legs

Round legs are turned between centers on a lathe. Mount the top end of the leg at the headstock. When possible, select a long tool rest so that you do not have to reset it while turning. When making a number of matching legs, use the duplicator. Check your work on tapered or straight legs with a straightedge. Check contoured legs with a shaped template.

## Square legs

Square legs can be straight or tapered. Saw straight legs using the standard procedure for squaring stock. Make sure that you saw the leg 1/16"(2 mm) oversize to allow for surfacing.

Legs can be tapered on two or four sides. Two surface tapers are usually cut on the inside surfaces of the leg. Use a taper attachment and a rip blade. See **Figure 40-17.** Saw the two adjacent surfaces of all legs at one taper setting. Four-surface tapers are done much the same way. Cut two adjacent surfaces of all legs using the first taper setting. Then double the taper setting and saw the remaining two surfaces of each leg.

Legs often attach to aprons with dowel or mortise and tenon joints. Make these joints before tapering the legs. Start the taper below where the apron meets the leg. You can angle the apron end, but flat surfaces are easier to align and clamp for mortising and drilling. See **Figure 40-18.**

**Figure 40-17.** Make a taper jig to cut tapered legs. Let in a cleat to act as a push stick. The guard was removed to show the operation. (*Chuck Davis Cabinets*)

## Assembled legs

Assembled legs can be straight or tapered on two sides. They may be sawn to size before or after assembly. Install corner blocks for reinforcement when necessary. See **Figure 40-19.**

## Fluted or reeded legs

Fluting and reeding decorate legs and often make them match a particular cabinet style. ***Fluting*** is a series of equally spaced parallel grooves around the leg. ***Reeding*** is a series of narrow, equally spaced convex moldings. See **Figure 40-20.**

On round legs, fluting is done with a router or shaper accessory. See **Figure 40-21.** With a router accessory, the leg is held between centers and the

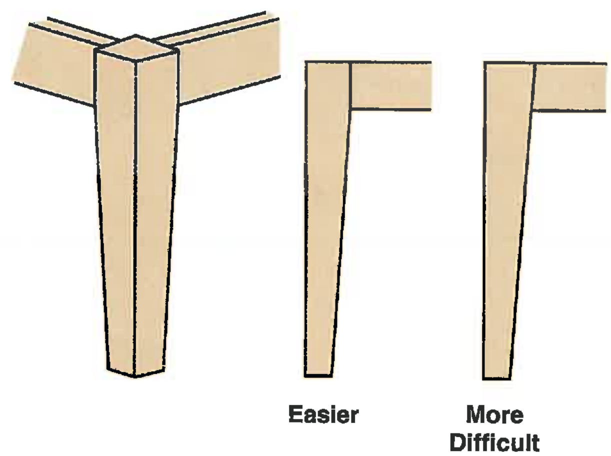



**Figure 40-18.** It is easier to join the apron to a square section of the leg rather than a tapered section.

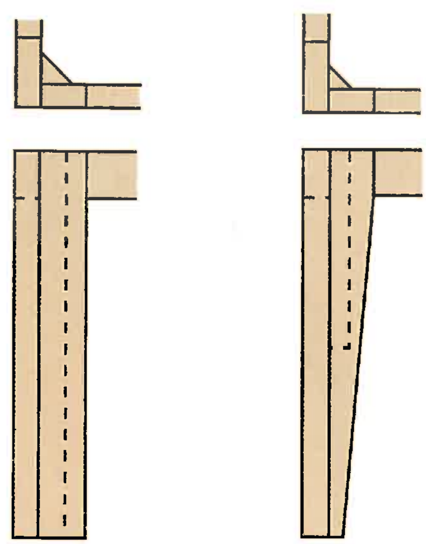


**Figure 40-19.** Assembled legs appear strong and are not as heavy as solid wood legs.

router slides over it. A shaper accessory slides in the table slot to move the leg past the cutter. For square legs, fluting is done on the shaper or table saw with a molding cutter.

To make reeds, shape a piece of excess material with a bead cutter. Then saw off and glue the reeds in place like molding.

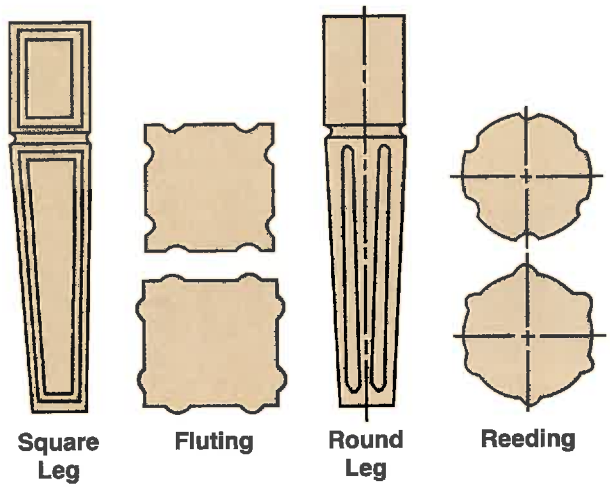



**Figure 40-20.** Elevation and section views of fluted and reeded legs.

## Cabriole legs

The ***cabriole leg*** is a distinguishing feature of *Queen Anne, French Provincial*, and other 18th century furniture. The shape varies according to the period style. In *French Provincial* furniture, the leg is slender, with more emphasis on the foot. See **Figure 40-22.** In *Queen Anne* furniture, the knee is bulky and the leg typically has additions called ears extending from each side. See **Figure 40-23.**

Legs that attach to rectangular tables have a square top. Those that attach to round tables have rabbets or mortises cut so that the leg fits flush with the apron. Prepare dowel holes or mortises before contouring the leg. Also, drill pilot holes for screws before shaping the leg, if possible.

Contouring cabriole legs is a challenging task. See **Figure 40-24** as you follow these steps. Begin with square stock and a template. Trace mirror images of the pattern on adjacent sides of the wood. After the first surface is cut, tape the excess back to the leg for support. Then saw the second surface. Curve the surface further by hand with Surform® tools, rasps, and files. Smooth the leg by hand or with an inflatable drum sander to avoid changing the shape.

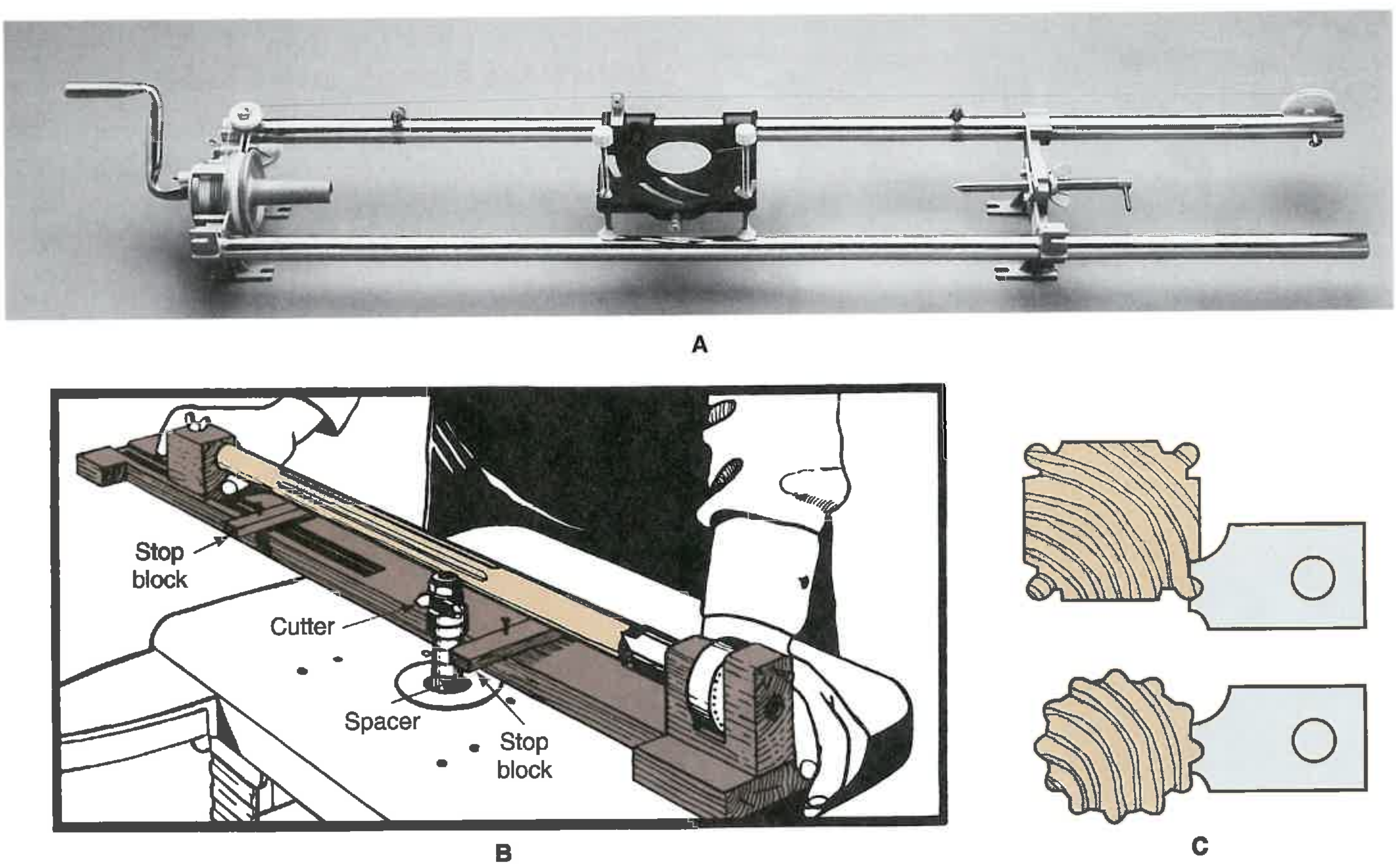



**Figure 40-21.** A—Router accessory for fluting legs. The leg is held between centers while the router passes overhead. B—Shaper accessory for fluting legs. The guard has been removed to show the operation. C—Details of cutting reeds on square and round legs. *(Woodcraft Supply Corp.)*

**Figure 40-22.** French Provincial cabriole legs. *(Bassett)*

**Figure 40-23.** Queen Anne cabriole legs.

## Stretchers, Rungs, and Shelves

Stretchers, rungs, and shelves strengthen table and chair supports. ***Stretchers*** extend diagonally or parallel to the tabletop between adjacent legs. ***Rungs*** connect stretchers. ***Shelves*** provide a storage area while reinforcing the legs.

Before cutting stretchers or rungs, assemble the legs and apron without adhesive. Check the rung or stretcher length, especially if the product has tapered or angled legs. Without accurate drill press setups, angled and turned stretchers, legs, and rungs can be a problem. At times, it may be easier to drill assembly holes before turning stretchers. Turn a small diameter stretcher with a steady rest behind the material.

### Stretchers

Stretchers may be round, square, or rectangular and fastened with dowels, mortise and tenon, or socket joints. See **Figure 40-25.** On tapered square legs, bevel the stretcher ends slightly to match the taper.

On round legs, flatten the area around the joint or contour the stretcher end for a good fit.

Diagonal stretchers are more difficult to fit. See **Figure 40-25C.** Cut an oblique lap joint where the

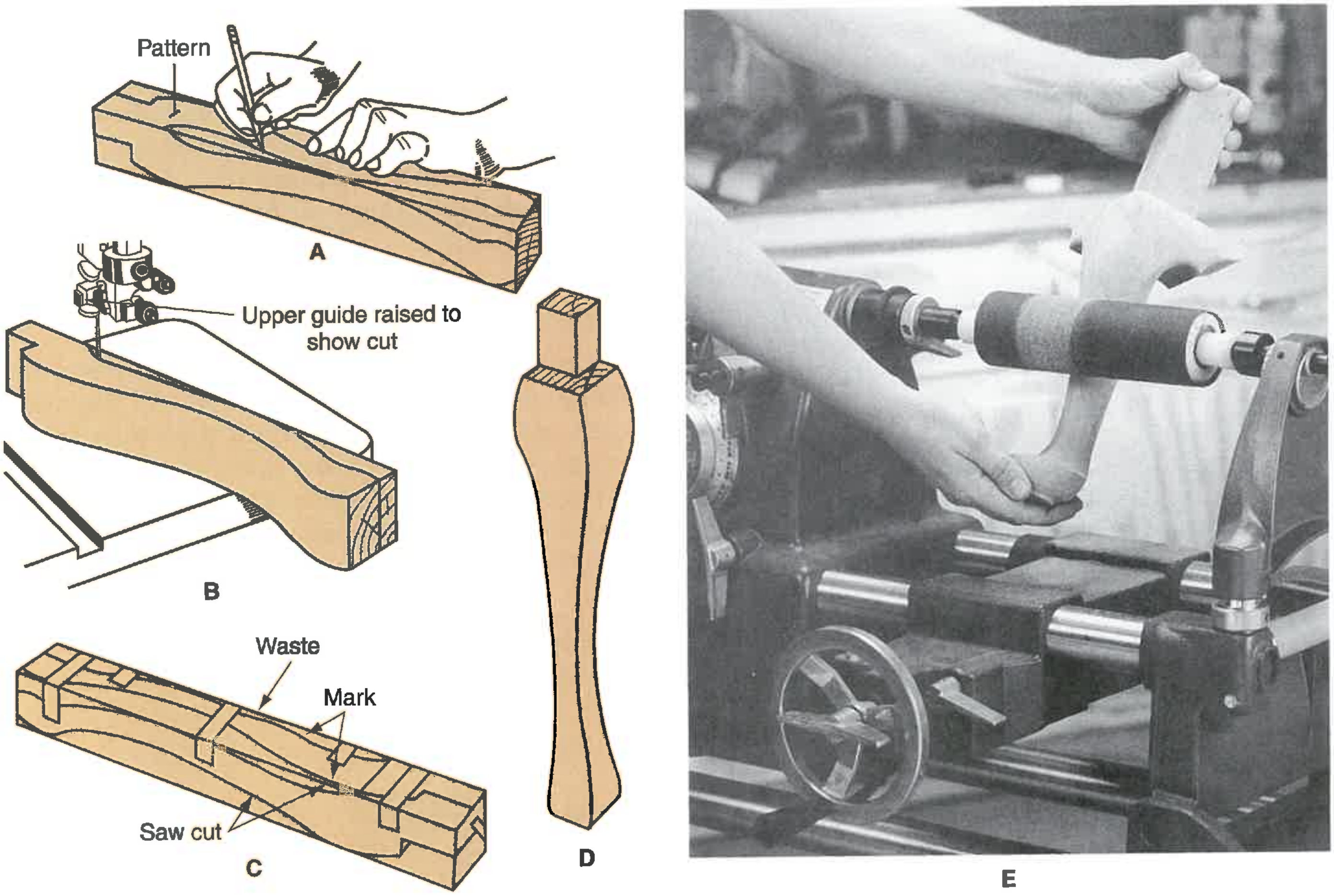



**Figure 40-24.** A—Marking stock using the pattern. B—Cut the first profile shape. C—Tape the waste back to the leg. D—The leg after cutting the second profile and removing the waste. E—Smoothing the final leg shape. *(Shopsmith)*

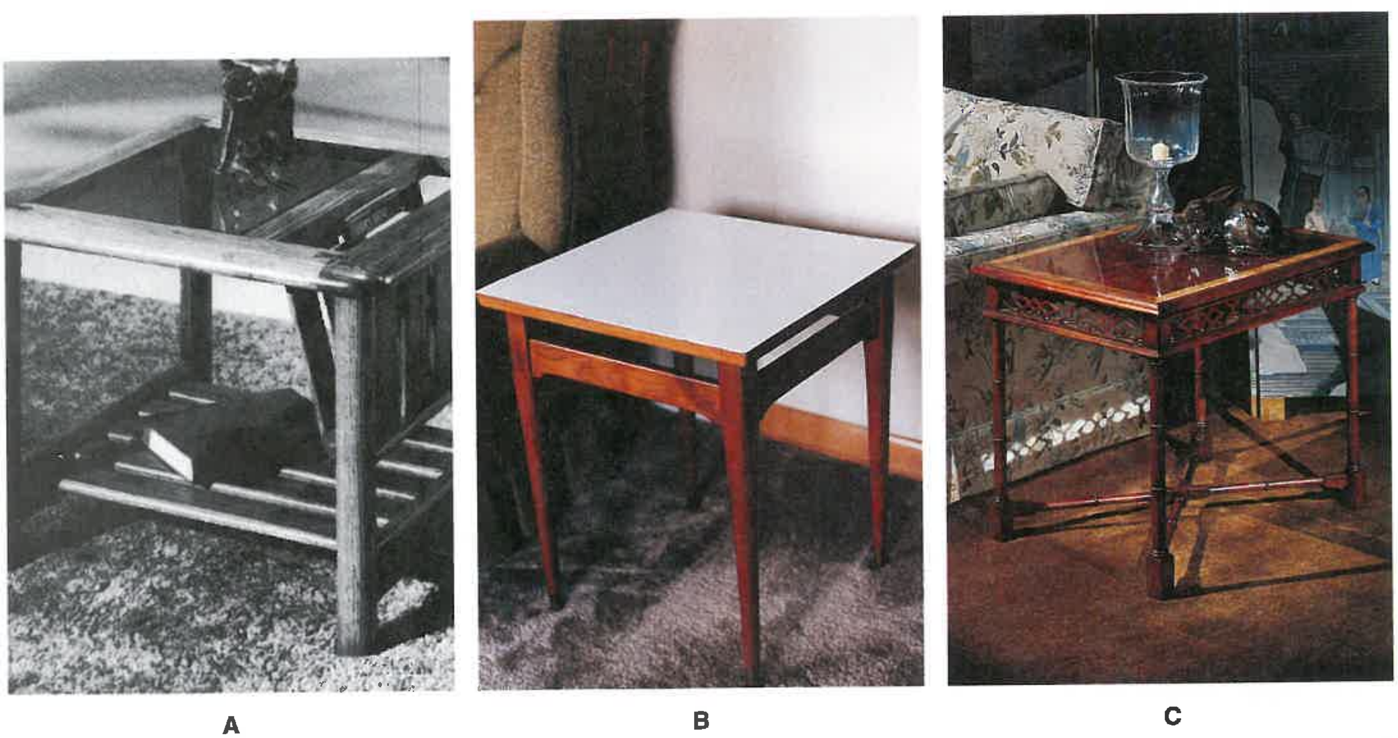



**Figure 40-25.** Stretchers. A—Between adjacent legs, with shelving. *(Mersman Tables)* B—On the upper portion of the legs. C—Diagonal, joined with a lap joint. *(Thomasville)*

stretchers cross. Round stretchers will likely fit into a center hub. Carefully measure the angles to drill holes for assembling the stretcher and legs.

## Rungs

Rungs, either round, square, or rectangular, fit between stretchers. They usually fasten with a dowellike socket joint. For greater strength, drive a brad in the underside of each joint to prevent twisting. A square tenon on the rung also prevents twisting.

## Shelves

Shelves, installed instead of stretchers and rungs, provide storage area and strength. See **Figure 40-26.** The shelf can be made of solid wood, a wood product, or a frame and panel assembly. In addition, you might groove or rabbet the stretchers to accept a lumber or wood product panel. Grooves control warpage better than rabbet joints. Cover particleboard and other wood product shelves with veneer or plastic laminate before inserting them in the frame. Cane also creates an attractive shelf.

Spindles can also support shelves for bookcases. A series of shelves and spindles are layered and assembled with dowel screws. See **Figure 40-27.**

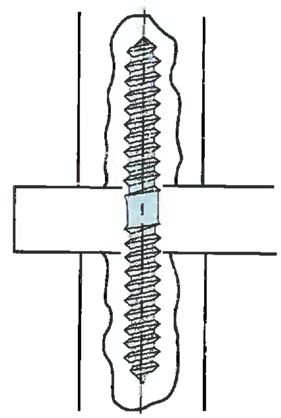
**Figure 40-26.** The shelves and dividers on this utility cart add strength as well as function.

## Posts

***Posts*** are similar to legs in shape and design, but longer. You usually see posts supporting beds. See **Figure 40-28.** A round post usually has a section left square where the rails connect. Some cabinetmakers refer to the two vertical supports for chair backs as posts.

## Plinths

Cases can rest directly on floors, legs, feet, or on plinths. See **Figure 40-29.** A lumber or manufactured wood product, the ***plinth*** may provide toe clearance on one or more sides. It may also set proud of the cabinet. Fasten it to the case with glue blocks, cleats, pocket joints, corner brace plates, or other fasteners.



A B

**Figure 40-27.** A—Bookcase made by assembling shelves and spindles. *(Butler)* B—Select dowel screws to connect the spindles.

**Figure 40-28.** Posts are frequently used instead of legs for bed assemblies. *(Thomasville)*

A plinth can be either vertical or tapered. Vertical plinths use the same corner joinery, fasteners, and assembly procedures as frames and bracket feet. Tapered plinths are much more complex.

Tapered plinths have corners that are cut at compound angles. This simply means that there are two angle settings to make before sawing the parts. The cuts can be made on either the table saw or radial arm saw.

**Figure 40-29.** Plinths are common supports for contemporary furniture. *(Dyrlund-Smith)*

## Table saw setup

There are few adjustments to make after the initial setup when tapering with the table saw. Three examples are shown for four- and six-sided pyramidlike tapered plinths. See the yellow shaded areas in **Figure 40-30** for the angle settings used in these examples.

The first example is a four-sided plinth assembled with butt joints at 5° angles. See **Figure 40-31.** Make a taper guide with one cutout (pass one) equal to the tilt angle and the second cutout (pass two) equal to double the tilt angle. Cut the components as shown. Compound settings are not required for butt joints.

The second example is a four-sided plinth assembled with compound miter joints. See **Figure 40-32.** To make the plinth sides at 5° angles, select the same taper guide used for the previous example. Also tilt the blade to a 44.75° angle.

The third example is a six-sided plinth assembled with compound miter joints. See **Figure 40-33.** To make the plinth sides with 10° angles requires the use of a miter gauge. Position the blade and miter gauge at the proper angles. Have a backup board clamped in position on the gauge. It should extend 4″ to 6″ (101 mm to 153 mm) beyond either end. First position the miter gauge in the right table slot. Make the first pass with the good face of the workpiece up and with the bottom of the base next to your fingers. For the next pass, move the miter

| Workpiece | 4-Sided Butt | | 4-Sided Miterd | | 6-Sided Miterd | | 8-Sided Miter | |
|---|---|---|---|---|---|---|---|---|
| Tilt Angle | Blade Angle | Overarm, Taper Guide, or Miter Gauge | Blade Angle | Overarm or Miter Gauge Left and Right | Blade Angle | Overarm or Miter Gauge Left and Right | Blade Angle | Overarm or Miter Gauge Left and Right |
| 5 | 1/2 | 5 | 44 3/4 | 5 | 29 3/4 | 2 1/2 | 22 1/4 | 2 |
| 10 | 1 1/2 | 9 3/4 | 44 1/4 | 9 3/4 | 29 1/2 | 5 1/2 | 22 | 4 |
| 15 | 3 3/4 | 14 1/2 | 43 1/4 | 14 1/2 | 29 | 8 1/4 | 21 1/2 | 6 |
| 20 | 6 1/4 | 18 3/4 | 41 3/4 | 18 3/4 | 28 1/4 | 11 | 21 | 8 |
| 25 | 10 | 23 | 40 | 23 | 27 1/4 | 13 1/2 | 20 1/4 | 10 |
| 30 | 14 1/2 | 26 1/2 | 37 3/4 | 26 1/2 | 26 | 16 | 19 1/2 | 11 3/4 |
| 35 | 19 1/2 | 29 3/4 | 35 1/4 | 29 3/4 | 24 1/2 | 18 1/4 | 18 1/4 | 13 1/4 |
| 40 | 24 1/2 | 32 3/4 | 32 1/2 | 32 3/4 | 22 3/4 | 20 1/4 | 17 | 15 |
| 45 | 30 | 35 1/4 | 30 | 35 1/4 | 21 | 22 1/4 | 15 3/4 | 16 1/4 |
| 50 | 36 | 37 1/2 | 27 | 37 1/2 | 19 | 23 3/4 | 14 1/4 | 17 1/2 |
| 55 | 42 | 39 1/4 | 24 | 39 1/4 | 16 3/4 | 25 1/4 | 12 1/2 | 18 3/4 |
| 60 | 48 | 41 | 21 | 41 | 14 1/2 | 26 1/2 | 11 | 19 3/4 |

**Figure 40-30.** Compound settings for sawing tapered plinths. Numbers represent degrees.

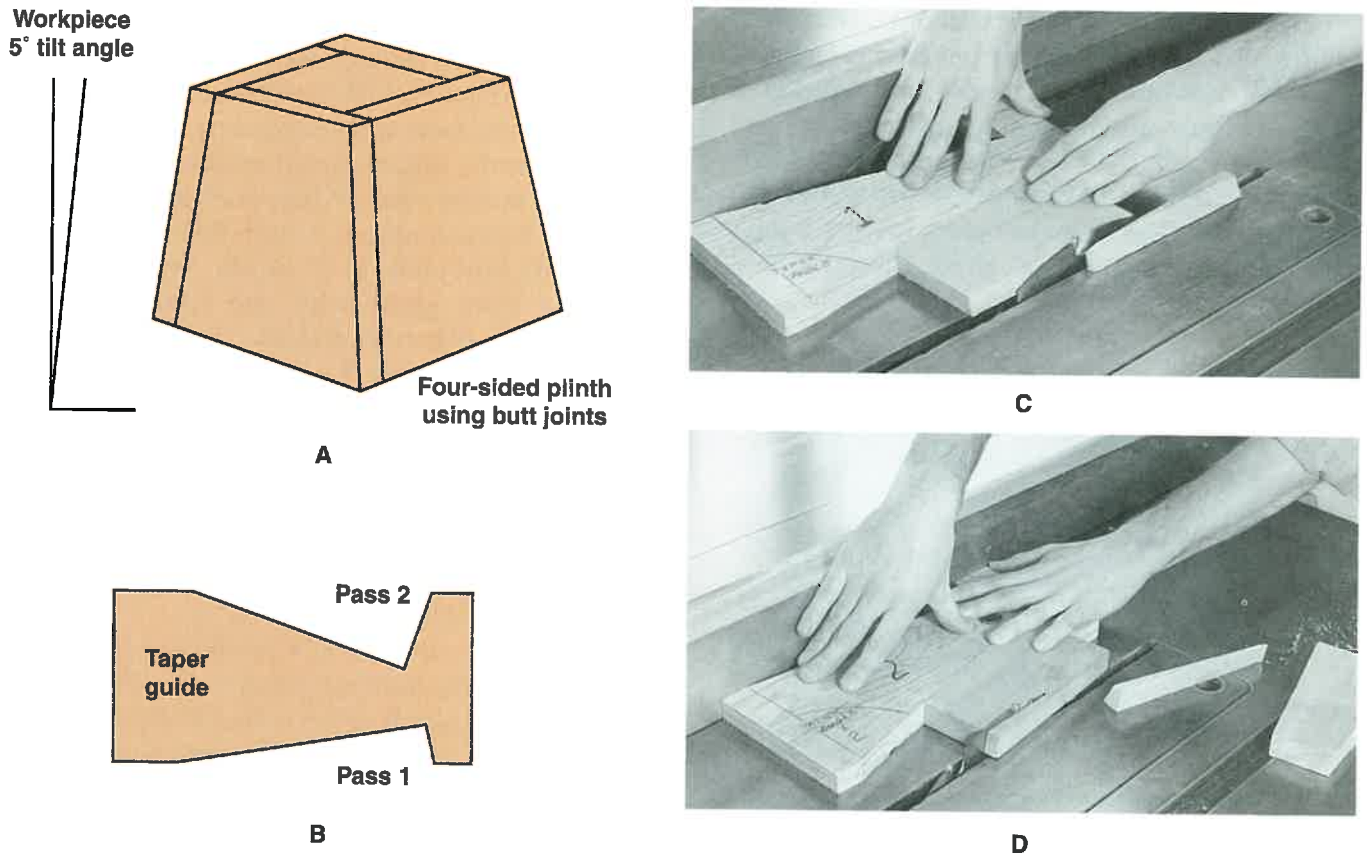



**Figure 40-31.** A—Four-sided plinth assembled with butt joints. B—The taper guide has 5 and 10° settings. C—Saw the first taper with the 5° guide. D—Saw the second taper with the 10° guide. The guard was removed to show the operation.

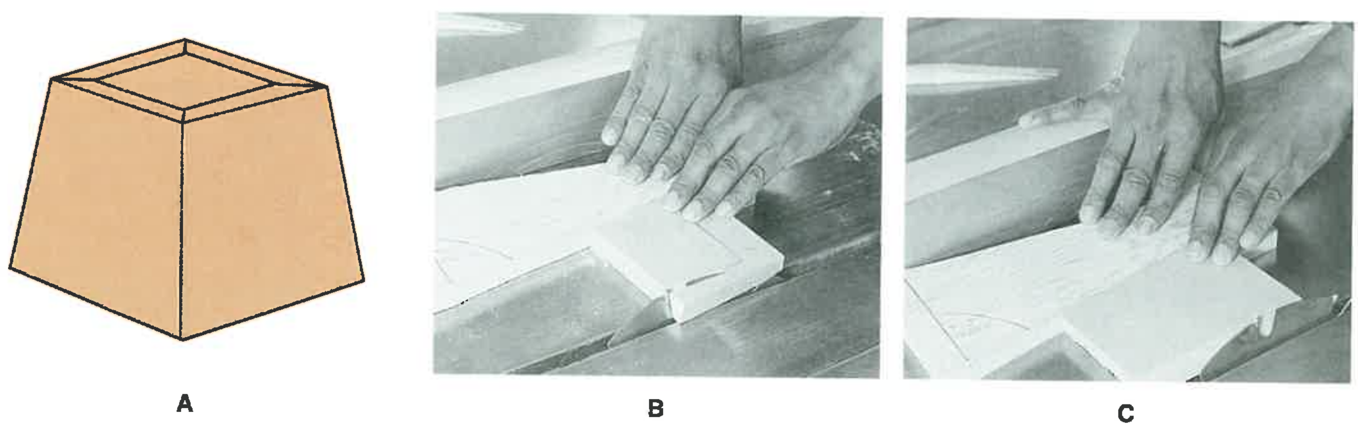



**Figure 40-32.** A—Four-sided plinth assembled with compound miter joints. B—Sawing pass one with the 5° taper guide, and with the blade at 44.75°. C—Sawing pass two using the 10° taper guide. The guard was removed to show the operation.

gauge to the left table slot. Position each workpiece with the good face down and have the bottom of the base against the gauge.

## Radial arm saw setup

With the radial arm saw, adjust the motor and overarm for every cut. Use setup steps shown in **Figure 40-30.** You must fit the motor and blade to the right for one pass and to the left for the other. You must also set the overarm at the required angle. For the first pass, tilt the saw to the left. For the second cut, tilt the saw to the right. Saw the parts with the good side up.

## Sides

Having the case sides on the floor is the simplest method of support. See **Figure 40-34.** This design also makes the product look stable. Occasionally, the sides are contoured to look like feet or legs.

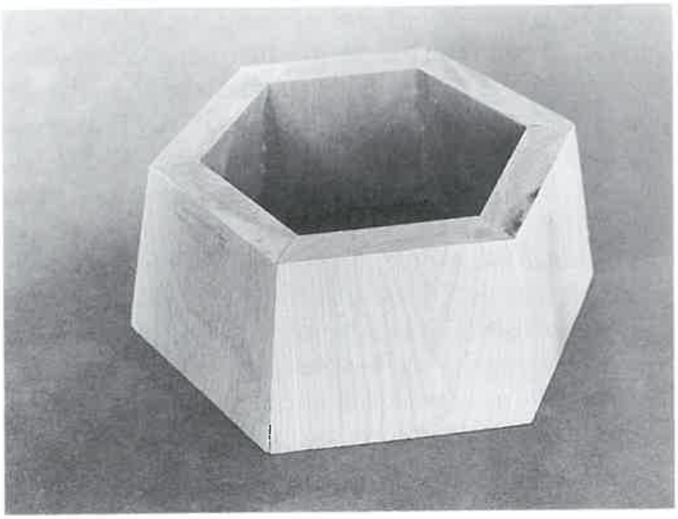





**Figure 40-33.** A—Six-sided plinth assembled with compound miter joints. B—Sawing pass one with the blade angle at 29.5° and the miter gauge at 5.5° in the right table slot. C—Sawing pass two with the miter gauge at 5.5° in the left table slot. The guard was removed to show the operation.

## Glides, Levelers, and Casters

Any part of a cabinet that contacts the floor should be protected. Otherwise, when you move the cabinet, the bottom wood surface can chip or splinter. To prevent this, install glides, levelers, ferrules, or casters.

*Glides* look like large round thumb tacks. See **Figure 40-35.** Insert glides having a nail point with a hammer. Glue those with a round tab into holes drilled in the bottom of the cabinet.

*Adjustable levelers* serve a dual function. See **Figure 40-36.** They protect the bottom of the cabinet and floor as well as level the cabinet. The leveler shown in the figure consists of a socket or plate and

**Figure 40-34.** The simplest form of support is the cabinet sides. Note that glides were inserted between the floor and cabinet at one end. The plinth at this end has access for plumbing connections. *(Adec)*

**Figure 40-35.** Shown are glides.

a bolt. The socket has internal threads and fits into a hole drilled in the cabinet bottom. The plate also has internal threads but fastens to the surface of the cabinet. The bolt, which has a swivel glide at the end, threads into the socket or plate. Make adjustments to the cabinet by turning the bolt.

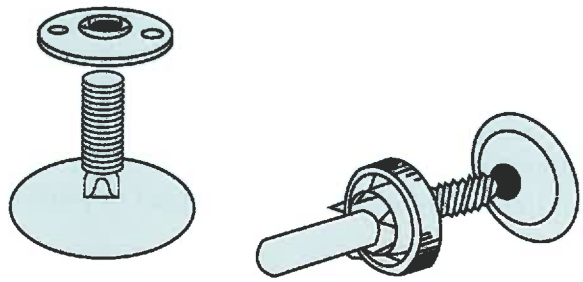



**Figure 40-36.** Two types of levelers and glides.

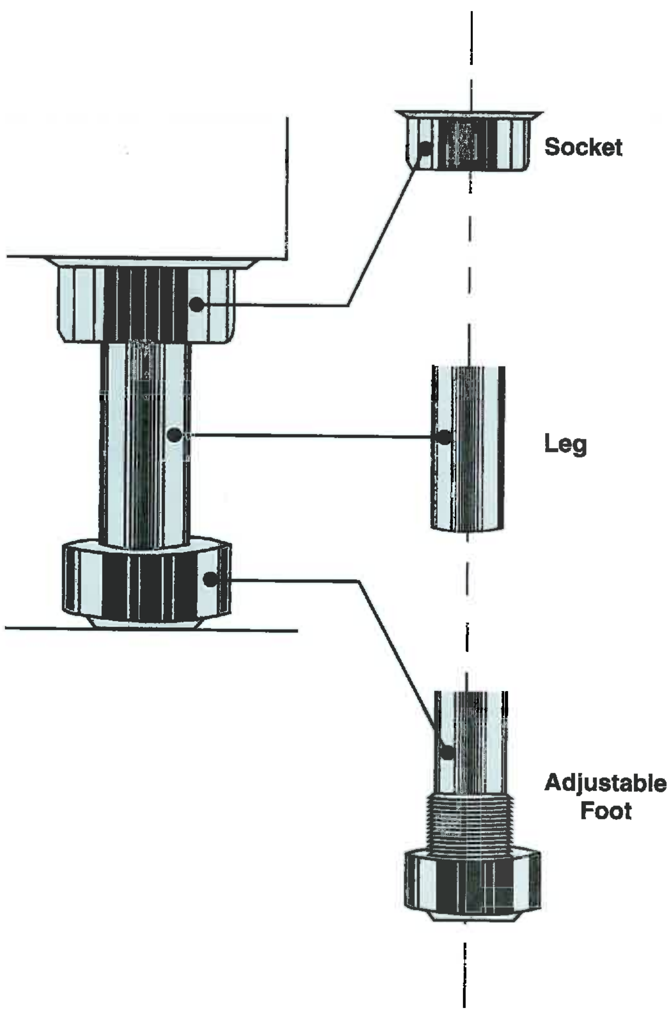
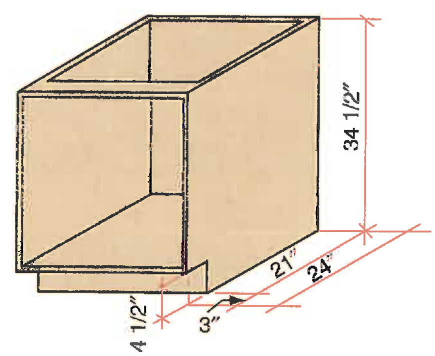



**Figure 40-37.** Cabinet levelers. Use the socket as a floor glide before cabinet is installed. *(Peter Meier, Inc.)*

With the development of the 32 mm System, a variety of manufacturers produce levelers specifically for the system. They consist of a metal or plastic socket that attaches to the cabinet bottom, a leg, and an adjustable foot. See **Figure 40-37.** For ease of installation, they may be adjusted from inside the cabinet or from below. This depends on your choice of socket. The socket, without the leg inserted, acts as a floor glide for handling and shipping. You insert the leg during installation. Snap-on toe-kick clips provide for placement of the toe-kick. The levelers save material and labor by eliminating the traditional notch at the bottom front of the cabinet. See **Figure 40-38.**

***Ferrules*** slip onto the ends of tapered round legs. See **Figure 40-39.** They usually have a swivel glide tip. The ferrule may fit friction tight or need a nail driven through it into the end of the leg.

***Casters*** make moving furniture easier. See **Figure 40-40.** There are two ways to attach the caster. Some you screw onto the support through a flange. Others need a socket sleeve inserted into a hole drilled in the bottom of the support. Then insert the stem of the caster into the sleeve.

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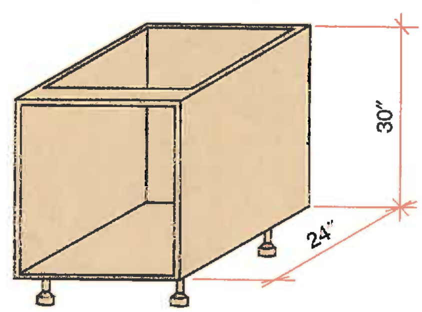



B

**Figure 40-38.** Panels do not have to be notched at lower front. A—The conventional construction will yield only four cabinet sides of a 4′ by 8′ (1219 mm by 2438 mm) sheet of hardwood veneered manufactured wood panel. B—Base leveler construction will yield six cabinet sides from the same material. *(Peter Meier, Inc.)*

**Figure 40-39.** Shown is a leg ferrule with a glide.

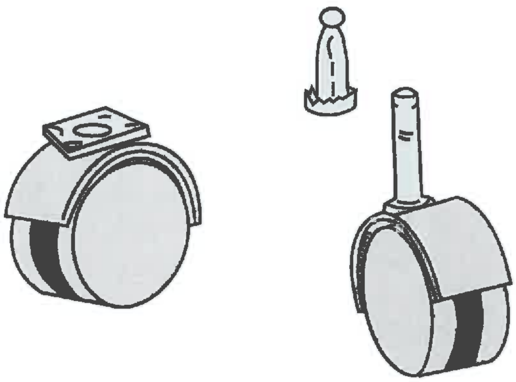


**Figure 40-40.** Shown are plate and socket sleeve casters.

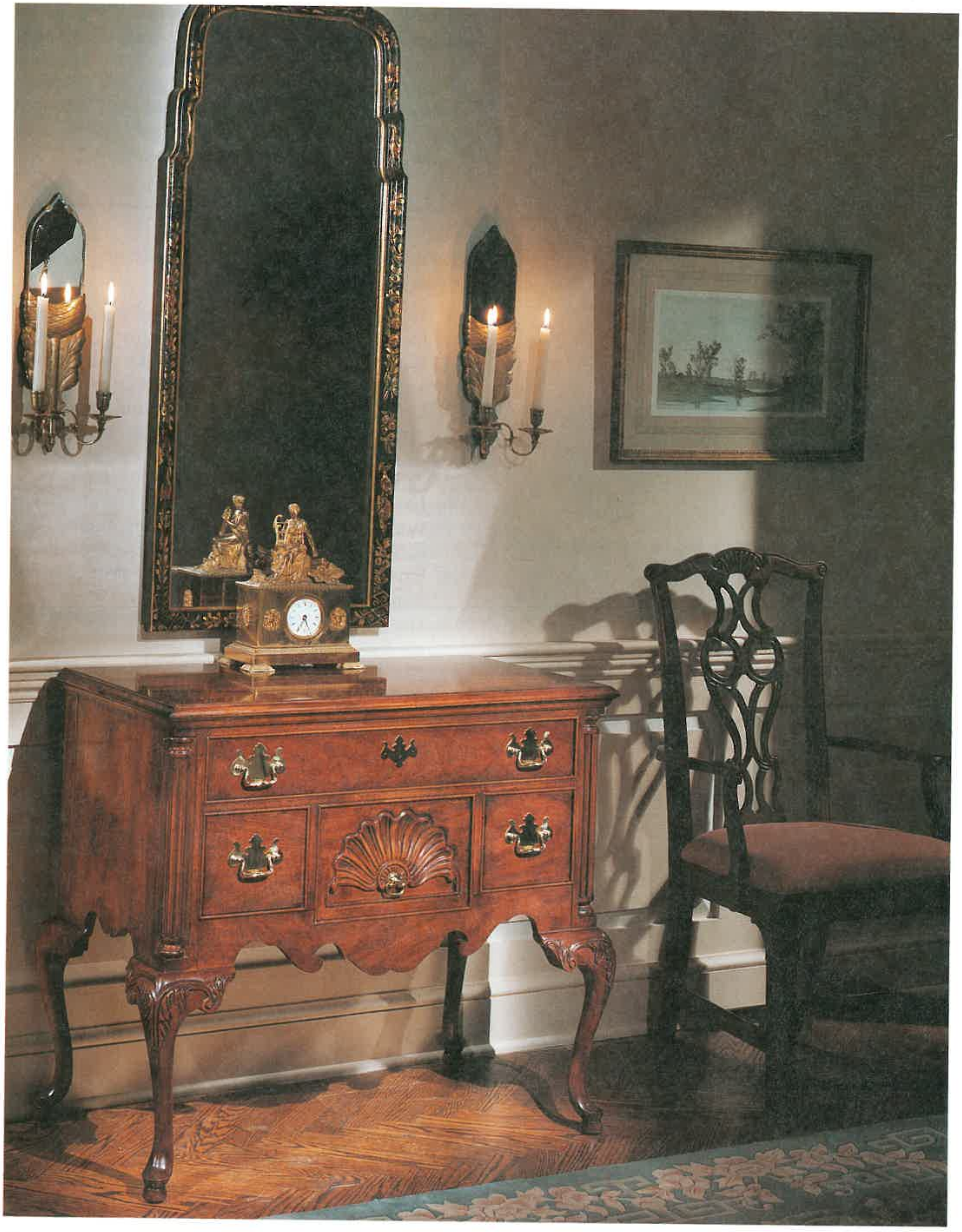
## Summary

Cabinet supports—feet, legs, posts, and plinths—raise casework and furniture above the floor. Feet are short supports under casework. You can use simple round and square lumber or create more complex assembled and shaped feet. Legs are longer supports for tables, chairs, and some casework. They can be round, square, straight, tapered, contoured, or a combination of shapes. Stretchers or shelves, fastened between legs, add strength and stability. Posts resemble legs, but are longer, and typically used as decorative bed rail supports. Plinths, or frames, provide toe clearance under cases.

## Test Your Knowledge

*Do not write in this text. Answer the following questions on a separate sheet of paper.*

1. To make a concave curve of an ogee bracket foot on the table saw involves a(n) _____ cut.
2. When might you choose to make custom legs rather than buying manufactured legs?
3. Explain the purpose of ferrules and glides.
4. The standard range of leg angles is _____° to _____°.
5. Tall cabinets with vertical legs often look _____.
6. List the four basic methods to mount legs vertically.
7. Why should you drill holes for angled legs before shaping the edges of chair seats?
8. Explain why two taper angles are needed to cut four-sided tapered legs.
9. How do socket and dowel joints differ? How are they alike?
10. Explain why the waste of the first pass is taped back on when making a cabriole leg.
11. What type of cutter should be used to cut flutes and reeds?



Shown is a Queen Anne style lowboy with the distinguishing feature of cabriole legs. *(Thomasville)*