Mechanical Fasteners

16

Objectives

After studying this chapter, you will be able to:

- Define the purpose for fasteners in cabinetmaking.
- List the applications of nails for fastening cabinetry.
- Describe the various types of screws and their uses.
- Select fasteners to attach cabinets to hollow and solid walls.
- Explain the convenience of ready-to-assemble cabinets.
- Select fasteners for assembling ready-to-assemble cabinets.

Important Terms

anchor
bolt
bolt and cam connector
brad
common nail
concave bolt connector
fastener
insert nut
Keku fastener
mechanical fastener
plug and socket connector
push-on fastener
screw
snap clip connector
staple
T-nut
tack
wedge pin connector
wire nail
wood screw

Cabinets may be assembled and installed with ***mechanical fasteners***. ***Fasteners*** include nails, staples, screws, anchors, bolts, and ready-to-assemble (RTA) fasteners. The type of fastener you select depends on the required strength of the joint. Threaded fasteners hold tighter than those without threads. RTA fasteners allow you to disassemble and reassemble cabinets easily. RTA fasteners also work well with manufactured panel products. Other fasteners provide readily removable access panels.

Fasteners are made of both metal and nonmetal materials. Metal fasteners are made of steel, aluminum, copper, or brass. Plastic fasteners are usually white or black. Plastic fasteners do not rust. Metal fasteners used in cabinets and furniture often are coated with paint or plated with another metal. Platings include brass, copper, chrome, zinc, and nickel. Steel fasteners may be galvanized (plated with zinc) to prevent rust. Other coatings include paint and lacquer which may be sprayed onto fasteners. Brass or copper fasteners may be used. However, these are more expensive than steel fasteners.

Unthreaded Fasteners

Unthreaded fasteners, such as nails and staples, are selected for less demanding purposes. They have less holding power than screws in some material. As a result, they are rarely used to assemble major parts of the cabinet. Nails are typically used to attach trim to the front of a cabinet. You can set nails below the surface of the trim and cover them with wood putty. Both nails and staples are used to attach cabinet backs.

The most common unthreaded fasteners are nails and staples. Corrugated fasteners, chevrons, and Skotch fasteners are also installed.

Nails

There are many types of nails. See **Figure 16-1.** Nails used for cabinetmaking include the following:

- ***Common nails.*** They are used in carpentry for framing. They are used where the appearance of the nail does not matter.

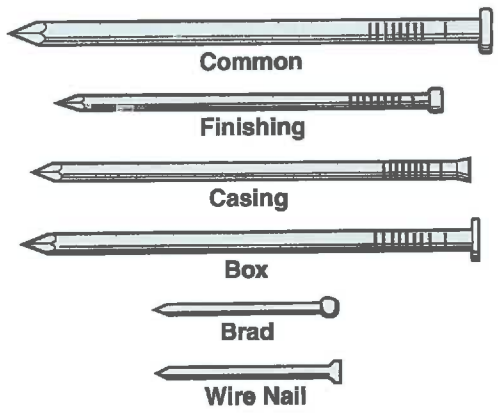


Figure 16-1. There are many nail sizes and head shapes for you to select. (*Continental Steel Corp.*)

- ***Box nails.*** They are similar to common nails, but thinner with smaller heads. They are less likely to split the lumber than common nails. They are used for light construction and are rarely used in cabinet assembly.
- ***Casing nails.*** They have cone shaped heads and are normally installed in architectural moldings (for example, door casings), where the head is driven below the surface with a nail set.
- ***Finishing nails.*** They have barrel shaped heads. Like casing nails, they are usually countersunk and covered with wood putty. However, they can be installed flush with the surface.
- ***Brads.*** They look like small finishing nails and are recommended for light assembly work. They are thinner, shorter, and smaller than finish nails.
- ***Wire nails.*** They are sized like brads, except they have flat heads. Like common or box nails, they are not set below the wood surface.

Nails for pnuematic fastening tools

Most cabinetmakers use nails that are driven by ***pneumatic fastening tools***, also called *air-powered nailers* or *nail guns*. These are fast, accurate, versatile tools. However, hammers are still used to drive nails. Nails that are intended to be driven with a hammer are packaged loose. Nails intended to be driven with nail guns are packaged in strips and coils. The strip or coil is loaded into the nail gun and driven one at a time until exhausted. Then another strip is loaded.

Nail guns are especially useful for driving finishing nails. Nails for use in these guns are available with a plastic coating. The coating is heated by the friction created by the staple's fast entry into the wood. The molten coating provides improved driving, and when cooled, enhanced holding power. The coating will bond the metal to the wood as it hardens like glue. Nails commonly used with nail guns may have ring-shank or screw-shank designs for added holding power. See **Figure 16-2**.

Nail sizes

Nails are measured by penny sizes and specific dimensions. Common, box, casing, and finishing nails are measured in penny size. The symbol for penny is ***d***. The penny size was a standard used in England that meant penny weight per hundred nails. Now the ***penny size*** refers to nail gauge and length. See **Figure 16-3**.

Brads and wire nails are measured by gauge and length. The wire gauge numbers range from 12 to 20. The larger the number, the thinner the nail. Lengths range from 3/8" to 1½" (9 mm to 38 mm). See **Figure 16-4**.

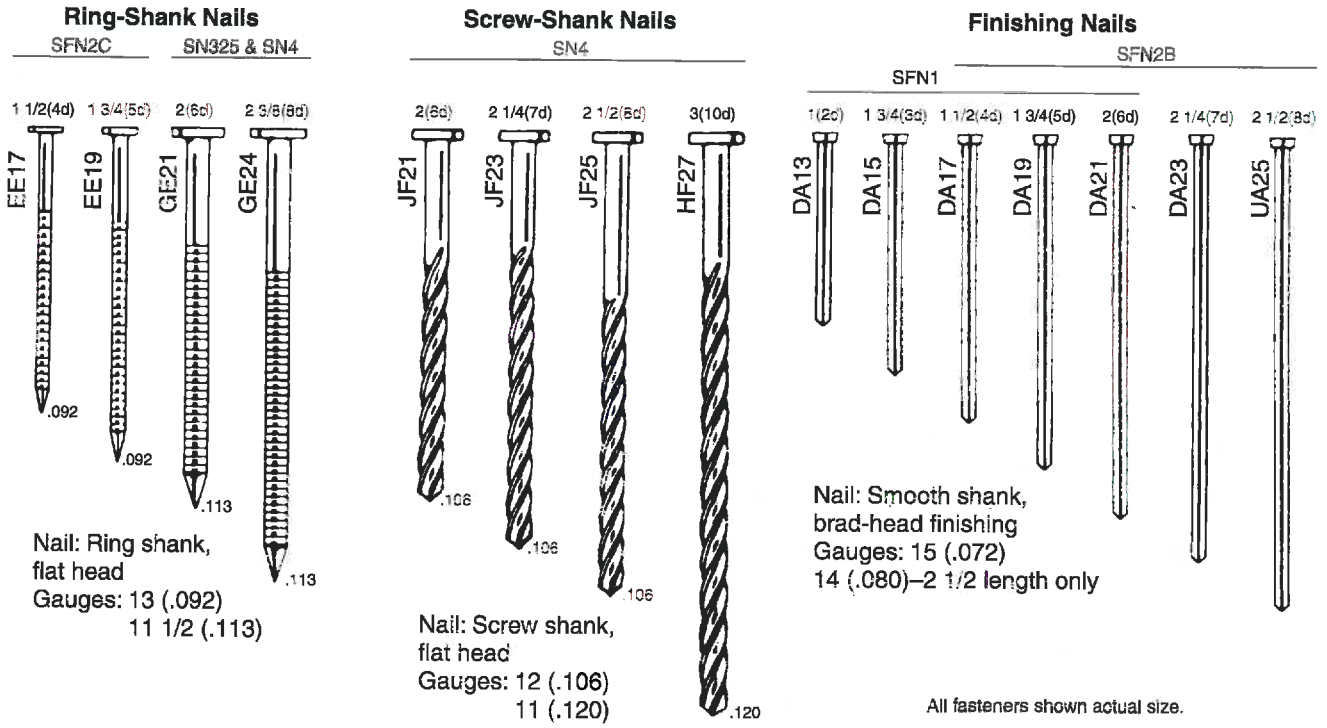


Figure 16-2. Popular sizes of ring-shank, screw-shank, and finishing nails used in pneumatic nail guns. (*Senco Products, Inc.*)

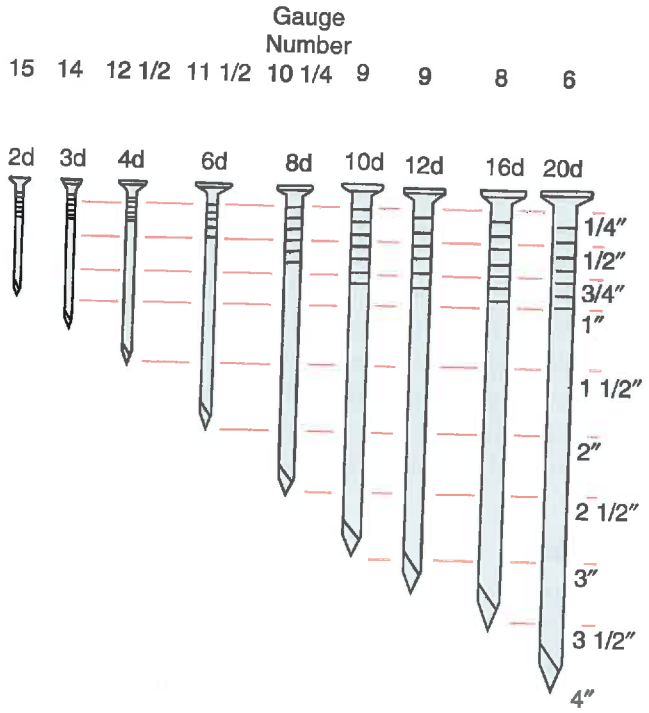


Figure 16-3. Nails are sized according to their length and gauge thickness of the shank. Size is indicated in pennies (*d*). (*Graves-Humphreys, Inc.*)

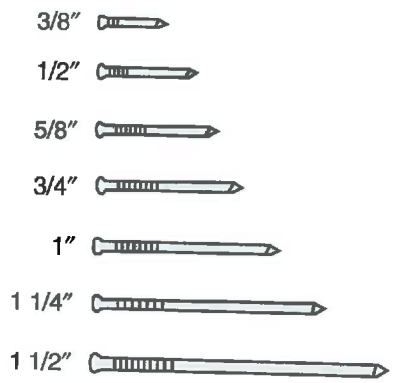


Figure 16-4. Common brad sizes. (*National Retail Hardware Assoc.*)

Fastening with nails

To fasten two workpieces with nails, it is important to select the correct size and type of nail. For best results, the length of the nail should be three times the thickness of the top workpiece. See **Figure 16-5**. Recommended nail types and sizes for plywood are given in **Figure 16-6**.

Nails are easy to drive into softer woods. The development of plastic coated nails for nail guns makes it easier to drive nails into hardwoods and virtually eliminates wood splitting. In harder woods when driving nails with a hammer, you might apply wax or soap to the nail. For very hard woods, drill a pilot hole slightly smaller than the diameter of the nail. See **Figure 16-7**.

The two methods of fastening with nails are straight nailing and toenailing. ***Straight nailing*** is driving the nail directly through the top workpiece into the base. Never drive two nails into the same

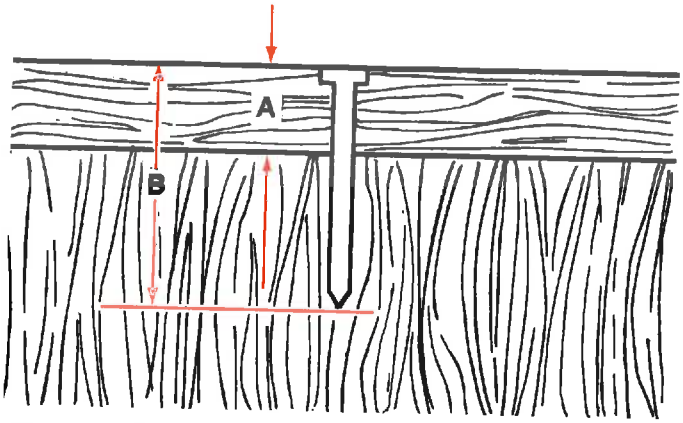


Figure 16-5. Generally, nails should be three times as long as the top workpiece, A. This assures that 2/3 of the nail is holding the base workpiece, B. (*National Retail Hardware Assoc.*)

Plywood Thickness	Type of Nail	Size
3/4"	Casing	6d
	Finishing	6d
5/8"	Finishing	6d-8d
1/2"	Finishing	4d-6d
3/8"	Finishing	3d-4d
1/4"	Brads	3/4"-1"
	Finishing	3d

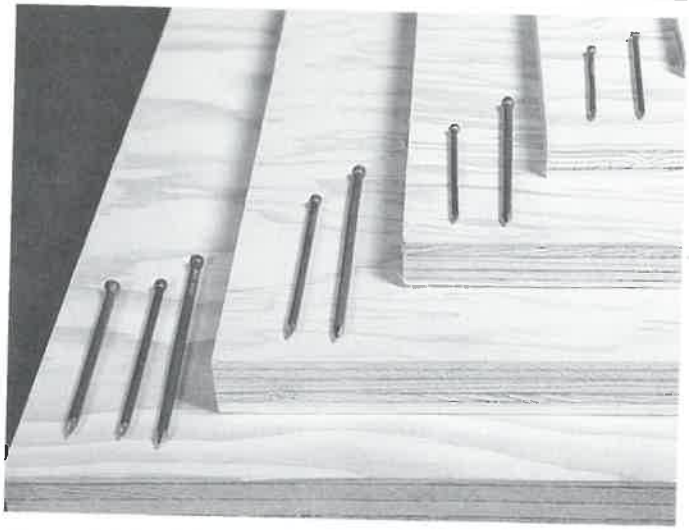


Figure 16-6. Nail types and sizes for plywood. (*National Retail Hardware Assoc., APA–The Engineered Wood Assoc.*)

grain line. The wood is likely to split. See **Figure 16-8**. ***Toenailing*** is used to fasten a T-joint. See **Figure 16-9**. When toenailing, first start driving the nail perpendicular to the workpiece about 1/8" (3 mm) deep. Then push it to a 30° angle and drive it the rest of the way.

Accurately place nails that will support heavy loads. Locate them so that the weight of the load tends to force them deeper. Nails can also be placed so that the load is supported by the shear angle of the nail. (The shear angle is across the nail.) Avoid driving nails where the load is likely to pull them out. See **Figure 16-10**.

When attaching wood trim or other visible materials, you may want to hide the nail. Use casing nails, finishing nails, or brads with a nail set for this purpose. The nail set has a small indent in the head, which centers the nail set. First, drive nail to within 1/8" (3 mm) of the surface. Then place the nail set on the nail head and strike it. Drive the nail just below the surface. Then fill the hole with wood putty.

Nails also can be concealed in the wood. With a utility knife, peel up a splinter of wood from the location where the nail is to be driven. See **Figure 16-11**. Once the nail is installed, glue the sliver back down.

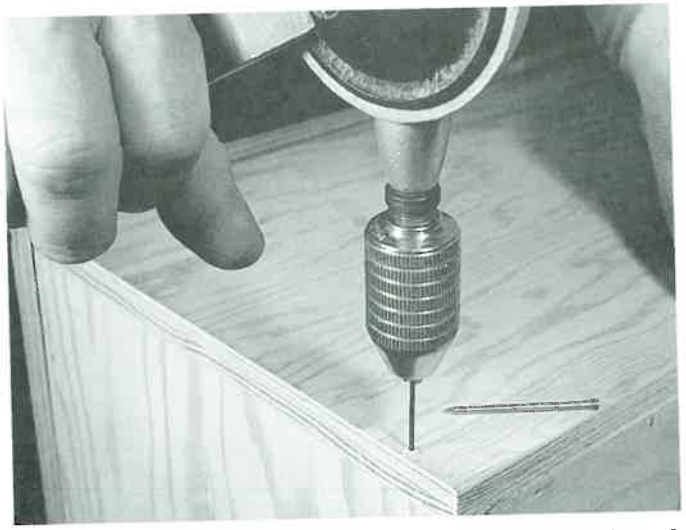


Figure 16-7. Drilling a pilot hole will prevent the board from splitting when driving nails.

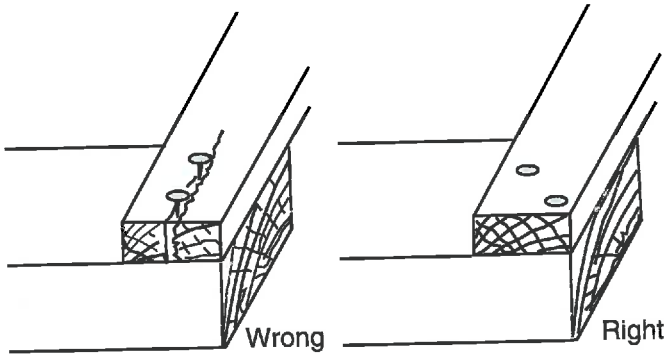


Figure 16-8. Never drive two nails in the same grain. Stagger them to reduce splitting.

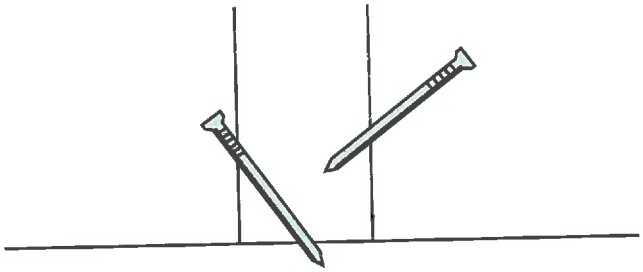


Figure 16-9. Toenailing is used when straight nailing cannot be done.

Staples

Staples appear like U-shaped nails. They are mostly installed in hidden areas, such as to attach cabinet backs and drawer bottoms. See **Figure 16-12**.

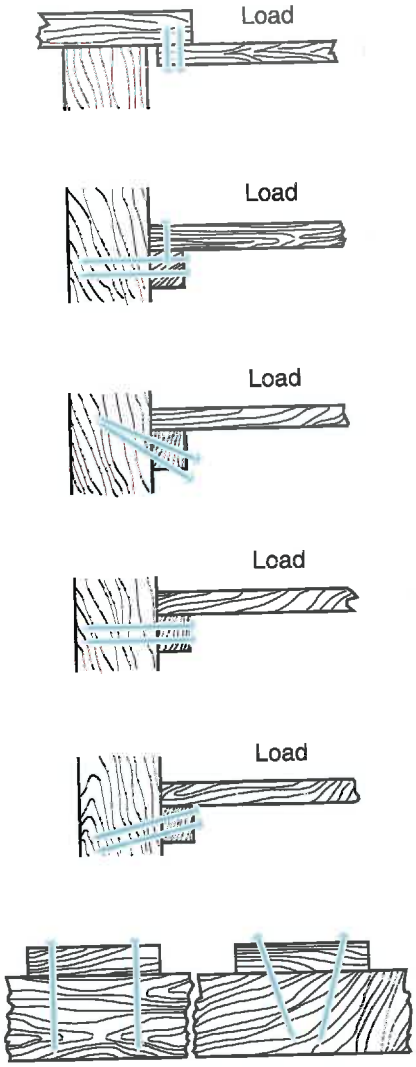


Figure 16-10. The angle at which nails are driven partly determines their holding power. (*Continental Steel Corp.*)

Staples are specified by crown width and leg length. Staple width for spring action staplers is given by a specification number, while the legs are ¼" to 9/16" (6 mm to 14 mm) long. Crown widths of staples used in pneumatic staple guns range from 3/16" to 1" (4 mm to 25 mm) with the leg lengths ranging from 5/32" to 2½" (4 mm to 63 mm). Cabinetmakers install most staples with pneumatic staple guns. Spring-action staple guns are often used for attaching upholstery materials and speaker grill cloth where softwoods are the substrate. See **Figure 16-13.** Spring-action staple guns may be used to attach low-voltage cable inside or to the back of wall cabinets. The staple is designed to curve over the cable.

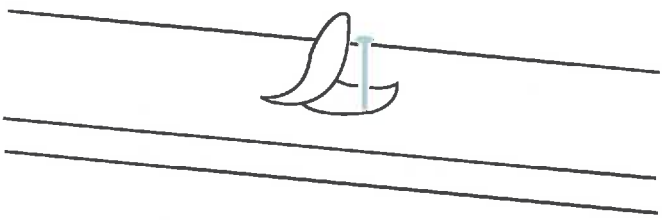


Figure 16-11. Nails can be concealed under a peeled-up wood shaving. (*National Retail Hardware Assoc.*)

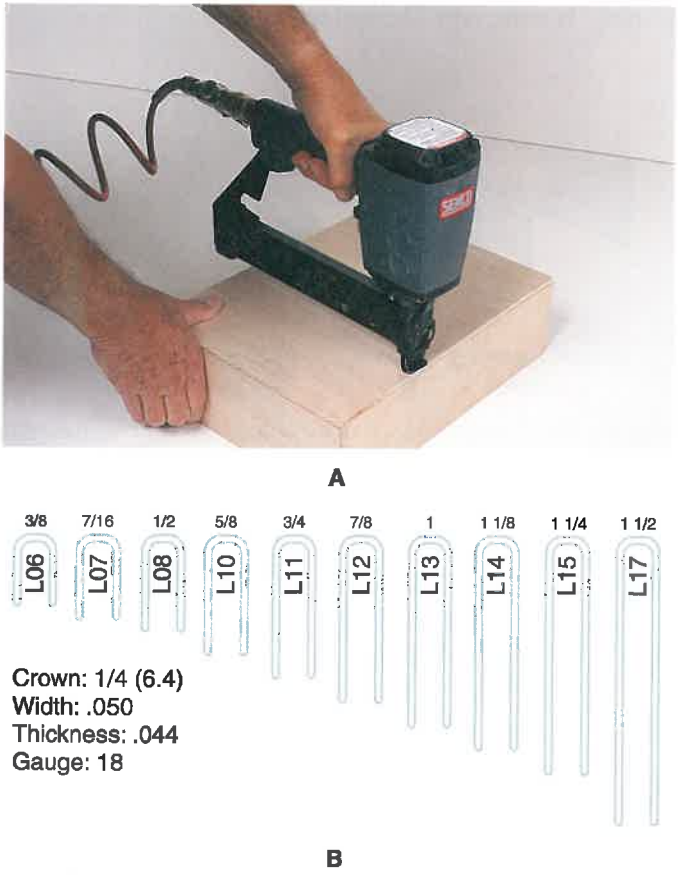


Figure 16-12. A—Staples are an effective fastener for utility grade drawer bottoms. (*Chuck Davis Cabinets*) B—Medium wire staples used in pneumatic staple guns. (*Senco Products, Inc.*)

For some applications, the staple should be flush with the surface. Sometimes the staple sticks up after using the staple gun to install it. This means the legs are too long for that material. If it penetrates the surface, the material is too soft or the legs are too short. See **Figure 16-14.** Pneumatic staple guns are designed to provide a consistent and appropriate countersink.

Staples for pneumatic staple guns are available with a plastic coating. Uncoated staples with added holding power include outward-flaring, self-crimping, and two-way splay staples. See **Figure 16-15.**

- ***Outward-flaring staples.*** They have chisel-like points beveled on the inside edges. As the staple is driven, the legs are forced to spread. This staple locks firmly in place so it does not pull out.
- ***Self-crimping staples.*** They work like outward-flaring staples. However, the staple legs are forced inward.
- ***Two-way splay staples.*** They are pointed so that one leg is forced forward, and the other backward when the staple is driven.

Figure 16-13. Spring-action staple guns are easy to use.

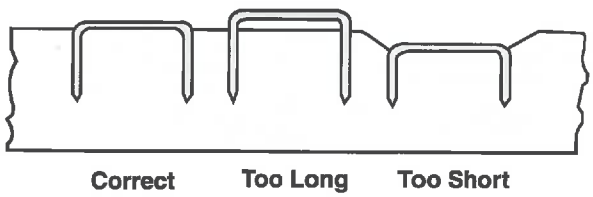


Figure 16-14. When driven, the staple should be flush with the wood.

Corrugated fasteners

Corrugated fasteners are sheet metal fasteners typically for miter joints in soft woods. See **Figure 16-16.** Lengths range from 3/8" to ¾" (9 mm to 19 mm). Width is given in numbers or corrugations. A size may be given as ¾" x 5 corrugations. The fastener is usually visible, although wood putty may be used to cover it.

Chevrons

Chevrons are angled fasteners. See **Figure 16-17.** They are ideal for picture frames and other products with miter joints. Each side is about 1" (25 mm) long. Chevrons penetrate 3/8" (9 mm) into the wood.

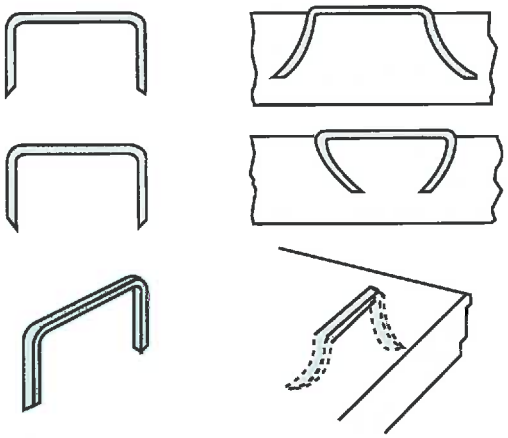


Figure 16-15. Special staples anchor themselves when driven. Top—Outward-flaring staple. Middle—Inward-crimping staple. Bottom—Two-way splay staple.

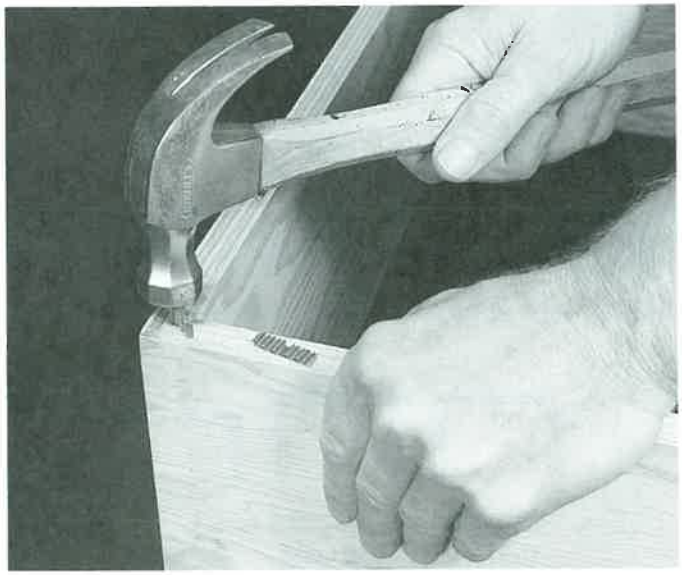


Figure 16-16. Corrugated fasteners typically fasten miter joints. (*APA–The Engineered Wood Assoc.*)

Skotch® fasteners

Skotch fasteners are eight prong staples that join parts without cutting or splintering wood fibers. See **Figure 16-18.** There are a variety of sizes, making them more versatile than chevrons. They are numbered from 0 to 3.

Clamp nails

Clamp nails are shaped pieces of steel. See **Figure 16-19.** Insert them into kerfs made in both workpieces to be joined. The kerf should be as wide as the thickness of the clamp nail web. Cut the kerfs accurately so that a perfect fit is obtained. As the clamp nail is driven, it aligns the joint. The tapered edges draw the two workpieces of wood together.

Clamp nails are sold in a variety of widths and lengths. Widths are designated by number. The number, placed over 16, tells the width. For example, a No. 6 clamp nail is 6/16" (3/8")mm wide. A No. 14 nail is 14/16" (7/8")mm wide. Lengths range from ½" to 5" (12mm to 127 mm).

A saw kerf is unnecessary when using pneumatic drivers. See **Figure 16-20.** With a 7/16" (11 mm) crown, Senclamp® is available in 5/16", 7/16", and 9/16" (7 mm, 11 mm, and 14 mm) lengths.

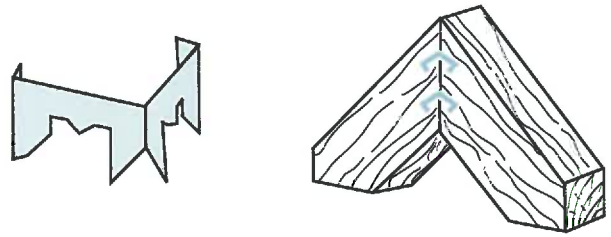
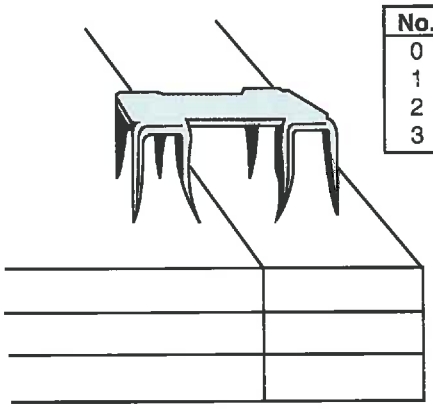


Figure 16-17. Chevrons work pieces together to make a tight joint.



No.	Size
0	3/8" x 1"
1	3/8" x 1 5/16"
2	1/2" x 1 11/16"
3	1/2" x 1 1/8"

Figure 16-18. Skotch fasteners have eight staple-like prongs. They are installed with a hammer.

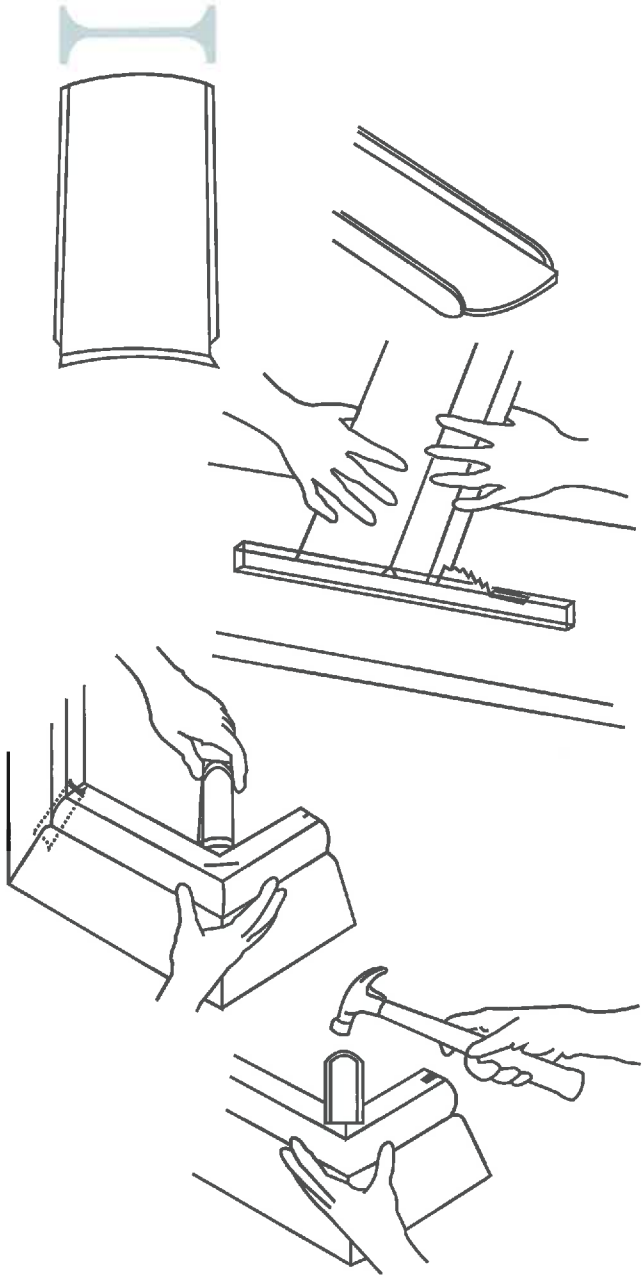


Figure 16-19. Drive clamp nails into aligned saw kerfs (slots). They are made before the nail is inserted. When driven, a clamp nail aligns the two workpieces as it draws them together. (*Wash Co.*)

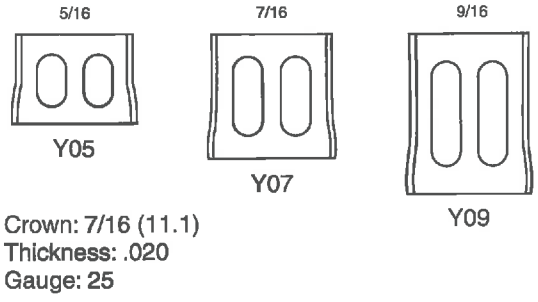


Figure 16-20. Clamp nails for air-powered drivers do not require saw kerfs. (*Senco Products, Inc.*)

Pins and tacks

Smaller nail-like fasteners with special uses include pins and tacks. See **Figure 16-21.** ***Escutcheon pins*** are small brass nails with round heads. They are for decorative purposes. Lengths range from ¼" to 1¼" (6 mm to 32 mm). Pin diameter is given in wire gauges. Pins for use with nail guns may be headless, have a slight head, or medium head. See **Figure 16-22.** They fasten light moldings. The medium head pin is similar to a brad. The slight head pin has a smaller head. It is easier to hide the holes left by these pins with wood putty.

Tacks are used primarily in upholstery. Some are meant to be hidden. These are designed to secure springs, wire, or cloth to a frame. Decorative tacks are those which are visible. Some have rounded heads made of brass or copper.

Threaded Fasteners

Threaded fasteners, such as screws and bolts, have more holding power than nails. They also permit disassembly and reassembly. Some fasteners

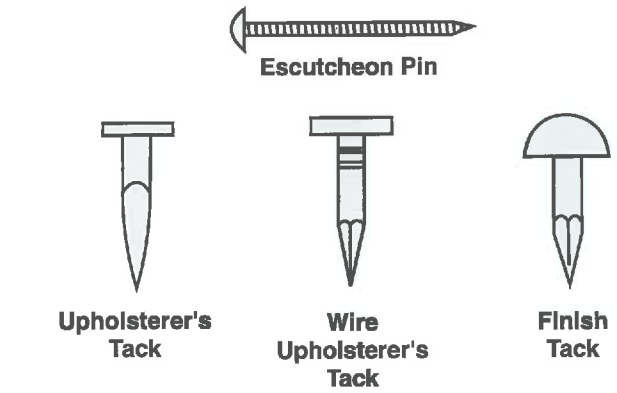


Figure 16-21. Tacks are typically used in upholstery to hold material or metal to a wood frame. Finish tacks and escutcheon pins are either brass or brass plated steel.

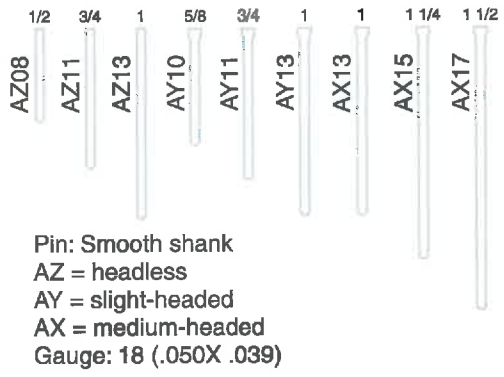


Figure 16-22. Pins for nail guns are similar to brads. (*Senco Products, Inc.*)

thread directly into lumber, wood products, metal, or plastic. Others pass through the workpiece and are secured with a nut or anchor.

Threaded fasteners are made of steel, brass, aluminum, and copper. They can be electroplated with zinc, chrome, or nickel. Painted finishes are also common. Those made of steel may be *blued* to prevent rust. Bluing involves heating the fastener to a certain temperature. The fastener is then dipped in oil, turning it dark blue. Unfinished steel screws are referred to as *bright*. When screws will be visible in the cabinet, use those that are finished.

There is a wide variety of head shapes for screws and bolts. See **Figure 16-23**. The head determines the type of screwdriver or wrench you should use. See **Figure 16-24**. Slotted head screws require flat blade screwdrivers. Recessed (Phillips) head screws require a Phillips screwdriver. Hex socket heads require an Allen wrench. Typical screw products used for cabinetry are wood screws, particleboard screws, face frame assembly screws, drywall screws, one-piece connectors, sheet metal screws, lag screws, cup and shoulder hooks, machine screws and stove bolts, cap screws and machine bolts, carriage bolts, and joint connector bolts.

Wood screws

Wood screws serve a wide range of general assembly purposes. They are the most used fastener in cabinetry.

Wood screws are specified by shank gauge, length, head shape, and finish. See **Figure 16-25**. Gauge numbers for screws differ from those for nails. As the gauge number increases, the diameter of the shank increases .013" (0.33 mm). See **Figure 16-26**. The size of the head also increases accordingly.

Screw length is measured from the tip of the threads to the top, middle, or bottom of the head. See **Figure 16-25**. Threads are cut on at least 2/3 the length of the shank.

Screws are sold singularly, in plastic packages, or by the box. Boxes may contain 50, 100, or 144 (one gross), or several thousand screws. To order screws, specify:

- 1 box—Catalog #1234-4, 1 ½ x No. 8—Flat Head Bright Slotted Wood Screws.

or

- 1 box—Catalog #4343-5, 1 ¼ x No. 8—Round Head—Nickel Plated Phillips Wood Screws.

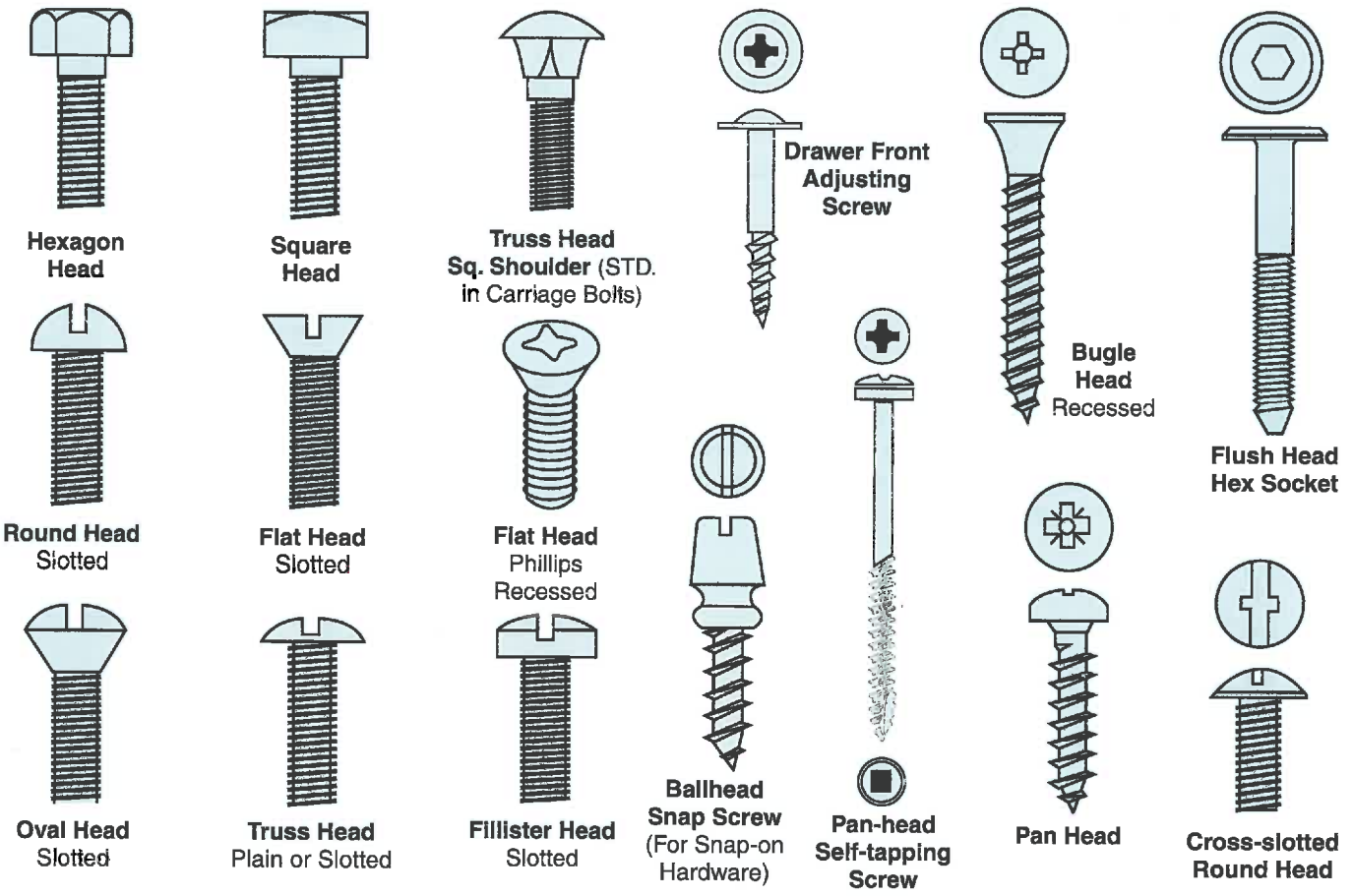
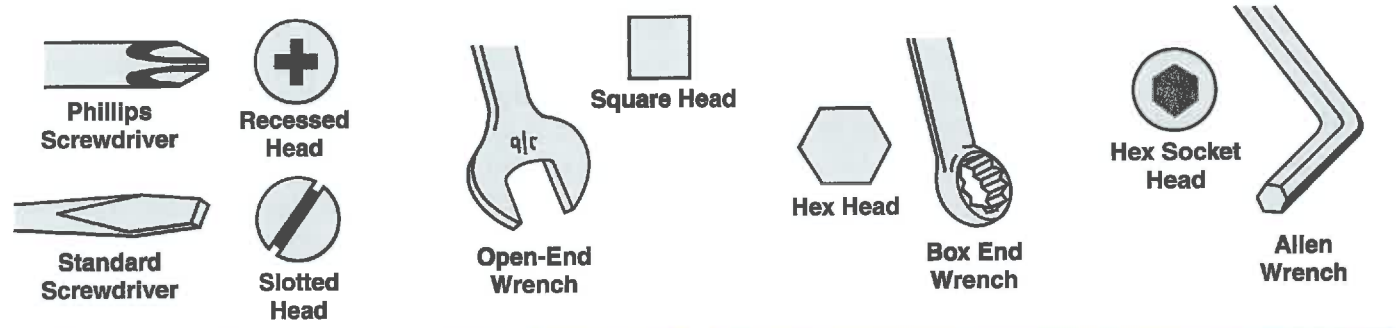


Figure 16-23. There are many head shapes for screws and bolts. The fastener you wish to use may be available with one or all of these head shapes. (*Liberty Hardware*)



A

B

Figure 16-24. A—Choose an appropriate tool for the head shape of the fastener. (*Parker Cable Corp.*) B—Screw bits and a portable drill make driving screws easier. (*Vermont American Tool Company*)

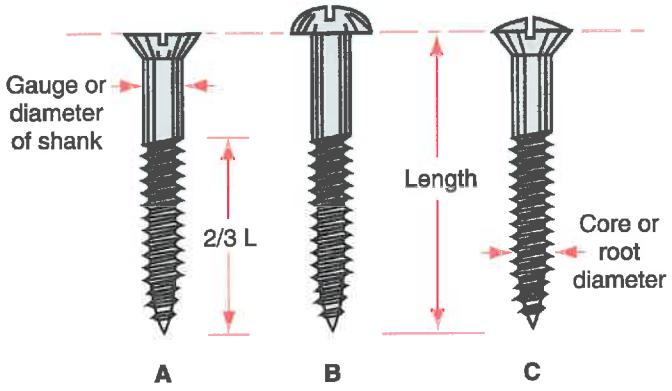


Figure 16-25. Select wood screws according to head shape, shank gauge, and length. (*Forest Products Laboratory*)

Installing wood screws

Several steps are involved when installing wood screws. These steps include selecting screws and screwdrivers, laying out holes, drilling holes, countersinking, counterboring, and driving screws.

Selecting screws and screwdrivers

Select screws at least three times the thickness of the workpiece you are fastening. This assures that all the threads will enter the base piece. Select the smallest gauge screw that will provide the required holding power. Generally smaller gauge screws are for thinner woods. Recommended screw sizes for plywood are given in **Figure 16-27**.

Gauge No.	0	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20
Diameter of Shank	.060	.073	.086	.099	.112	.125	.138	.151	.164	.177	.190	.203	.216	.242	.268	.294	.320
Head Size																	

Figure 16-26. These are the most common gauge sizes for screws. Head size increases with gauge numbers.

Select the proper screwdriver or wrench for the type of screw. The blade of a standard screwdriver should be as wide as the screw slot. See **Figure 16-28.** The blade of a Phillips screwdriver should fit snugly in the recessed head.

Laying out holes

Lay out and mark hole locations. Then, with a hammer, tap the tip of a nail or scratch awl on the layout mark. This small hole helps guide the drill.

Drilling holes

Two or more different holes are drilled when fastening wood with screws. See **Figure 16-29.** The first is the pilot hole. It is drilled through both workpieces the full length of the screw. Next, bore out the clearance hole in the upper workpiece. The clearance hole provides room for the shank of the screw.

If the holes are not drilled large or deep enough, the wood is apt to split. The size of the pilot hole is larger for hard, dense woods. This makes inserting the screw easier. Clearance and pilot hole sizes are given in **Figure 16-30.**

Multioperational bits may be used to drill pilot and clearance holes at the same time. They are sized according to the screw gauge and length. See **Figure 16-31.** Multioperational bits are called Screw-mater® drills by one manufacturer. In addition to pilot and clearance holes, they may also drill countersinks and counterbores.

Countersinking

Flat head screws and others with tapered heads require countersinking. A ***countersink*** is a drill bit with a cone-shaped tip. Use the countersink to enlarge the top of the clearance hole. See **Figure 16-32.** This allows the screw to be driven flush with the surface of the wood.

Counterboring

Counterboring allows the screw head to be below the surface of the wood. Drill pilot and clearance holes. Then drill the counterbore just larger than the screw head. Once the screw is inserted, cover the hole with a plug, a button, or wood putty.

Screw Selection Chart			
Plywood Thickness	Screw	Flat-Head Screws Length	Pilot Hole
3/4″	#8	1 1/2″	5/32″
5/8″	#8	1 1/4″	5/32″
1/2″	#6	1 1/4″	1/8″
3/8″	#6	1″	1/8″
1/4″	#4	3/4″	7/64″

Figure 16-27. Screw sizes for plywood. (*National Retail Hardware Assoc.*)

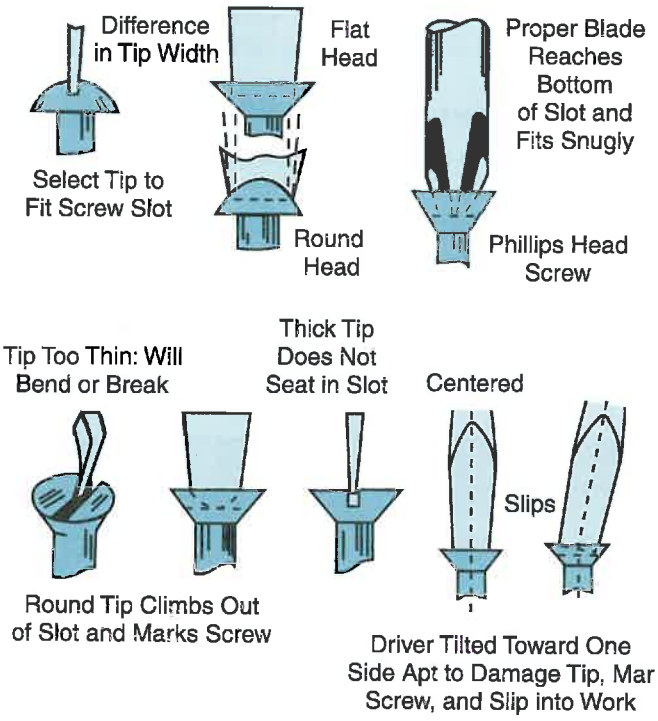


Figure 16-28. Choose a screwdriver that properly fits the screw head.

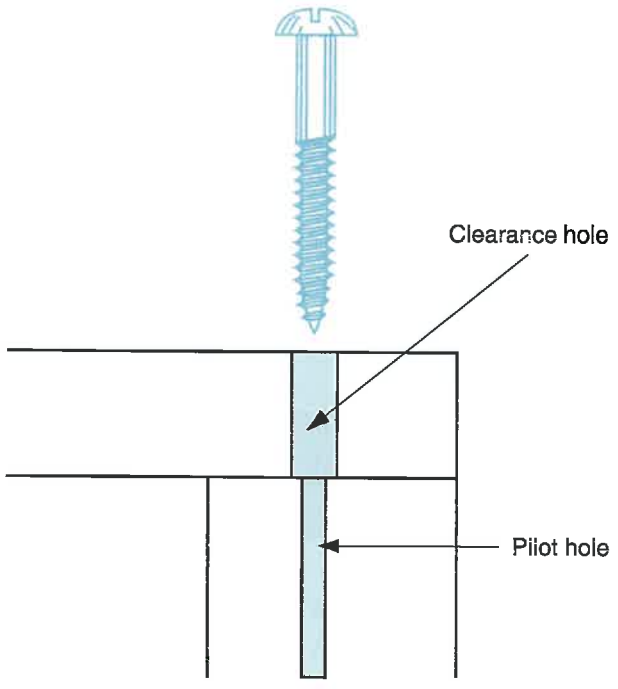


Figure 16-29. Drill pilot and clearance holes before the screw is inserted

Screw Gauge	0	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20
Clearance Hole Hard & Soft Wood	1/16	5/64	3/32	7/64	7/64	1/8	9/64	5/32	11/64	3/16	3/16	13/64	7/32	1/4	17/64	19/64	21/64
Pilot Hole Soft Wood	1/64	1/32	1/32	3/64	3/64	1/16	1/16	1/16	5/64	5/64	3/32	3/32	7/64	7/64	9/64	9/64	11/64
Pilot Hole Hard Wood	1/32	1/32	3/64	1/16	1/16	5/64	5/64	3/32	3/32	7/64	7/64	1/8	1/8	9/64	5/32	3/16	13/64

Figure 16-30. Clearance holes and pilot holes are sized according to the screw shank and core diameters.

Figure 16-31. Multioperational bits replace drilling three separate holes. (*Stanley*)

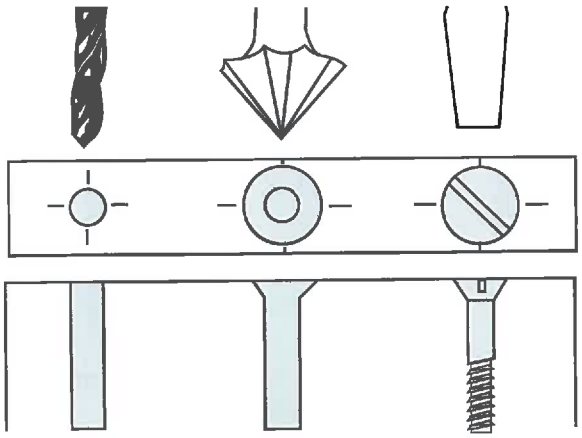


Figure 16-32. Countersinking permits flat head screws to be flush with the wood.

See **Figure 16-33**. Select the proper diameter counterbore for plugs and buttons so they will fit.

Driving screws

Drive screws in a clockwise direction by hand or with a screw gun. As the screw turns, the threads dig into the sides of the pilot hole. If the screw holes are drilled properly, you should be able to insert the screw with little effort. Be careful not to apply too much torque or the screw will break. This is especially true with aluminum or brass screws in dense material. Apply wax to the screw threads to make it easier to drive.

Particleboard screws

Particleboard screws are designed to hold better in weaker panel products, such as particleboard, composite panels, and waferboard. They have coarser threads than wood screws. See **Figure 16-34**. This allows for more wood fibers between threads. Particleboard screws may be used with lumber. However, they are more difficult to install in hard, dense woods.

Face frame assembly screws

Face frame assembly screws are specially designed for the construction of face frames. They are #6 pan head self-tapping screws. They are inserted in the pilot holes at the base of pockets cut in the back surface of the face frame components.

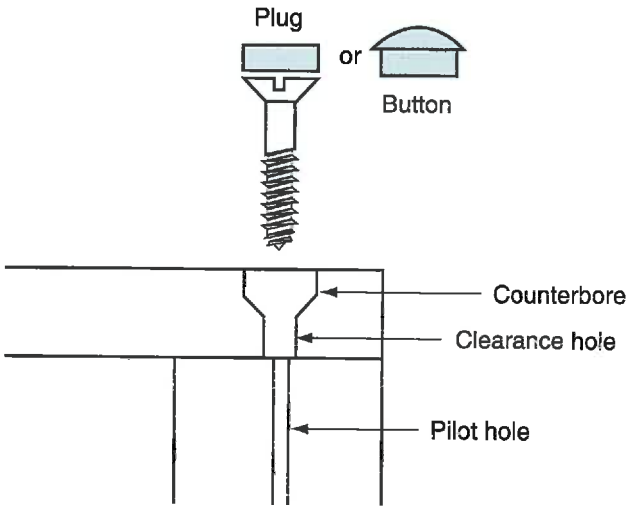


Figure 16-33. A plug or button covers the screw in a counterbored hole.

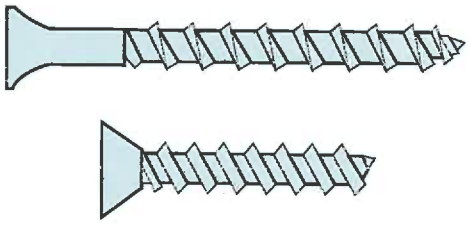


Figure 16-34. Particleboard screws have coarser threads than wood screws. They hold better in panels made of wood chips. (*Liberty Hardware*)

One-piece connectors

Screws with cylinder-shaped tips are typically called ***one-piece connectors*** or ***solo connectors***. They resemble particleboard screws because they have coarse threads. See **Figure 16-35A**. One-piece connectors have greater holding power than particleboard screws. In addition, they can also align the workpieces.

The screw fits through a clearance hole in the face workpiece. The cylinder-shaped tip then aligns the two workpieces. It centers in a pilot hole. See **Figure 16-35B**. Both holes must be drilled accurately. When installed, a one-piece connector fits flush with the surface of the wood. A cover cap may be inserted into the socket of the screw head to cover it.

Sheet metal screws

Sheet metal screws have threads up to the head. See **Figure 16-36**. They are ideal for joining metal to wood or wood to metal. Also use them in dense wood because they are made of hardened steel. They are recommended for panel products such as fiberboard.

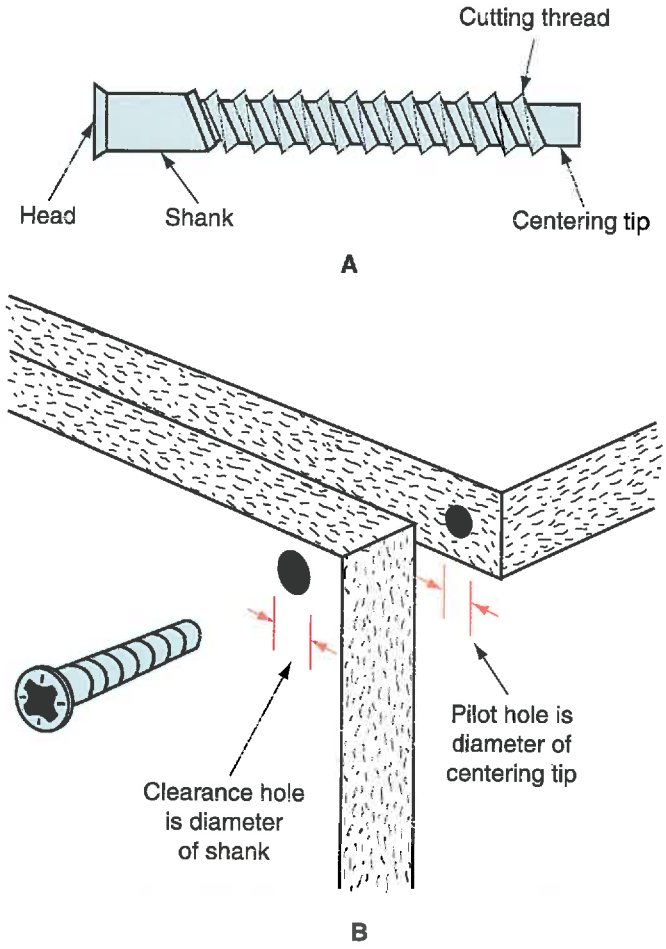


Figure 16-35. One-piece connectors align the components as they fasten them. (*Liberty Hardware*)

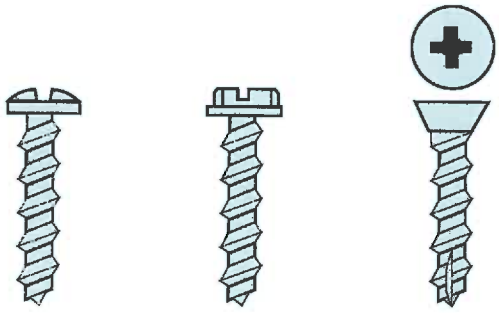


Figure 16-36. Sheet metal screws have threads their entire length. (*Liberty Hardware*)

Sheet metal screws are sized the same as wood screws. Head shapes are either round, flat, pan, oval, truss, or hex. The hex head often has a slot. It can be installed using a wrench or flat blade screwdriver.

Sheet metal screws also attach wood to sheet metal. For example, you might want wood paneling over sheet metal ductwork. Drill a pilot hole through the wood and sheet metal. Then bore the clearance hole in the wood.

Lag screws

Lag screws are installed where the joint requires great holding power. They are commonly used to assemble bunk beds and other large furniture. They are sized by the diameter of the shank and the length. The head may be square or hex shape. Drive the screw with a wrench or socket. See **Figure 16-37**.

Machine screws and stove bolts

Machine screws and *stove bolts* fit through clearance holes in both workpieces and are secured with a nut. They have limited use for cabinet work. Most are threaded the full length. See **Figure 16-38**. Head shapes and lengths vary like wood screws.

Machine screw and stove bolt threads are measured by the ***Unified and American Screw Thread Standard*** and the ***International Standards Organization (ISO) Metric Thread Standard.*** Unified and American Screw Threads include ***Unified National Coarse*** (***UNC***) and ***Unified National Fine*** (***UNF***) threads. The same diameter UNC screw has fewer threads per inch than an UNF screw. For example, a ¼" machine screw could have 20 UNC threads per inch or 28 UNF threads per inch. The specifications will be given as follows:

1/4"-20 UNC × 1½" (1/4" diameter, 20 Unified National Coarse threads per inch, 1½" long)

The diameter may also be given in screw gauge thickness as follows:

#8-32 × 1½"

ISO Metric threads are measured by diameter and millimeters per thread. M6 × 1 (6 mm shank size and 1.0 mm from thread to thread). M12 × 1.75 (12 mm shank size and 1.75 mm from thread to thread).

Truss head machine screws, sizes 8-32 and M4, are available with combination slots for use with either Philips or blade screwdrivers. You usually install knobs and pulls with them. False drawer fronts with adjusters are attached to the drawer box with them. The length of machine screws packaged with knobs and pulls is 1" (25 mm). These will fit ¾" (19 mm) thick material. A false drawer front and the drawer box usually total 1¼" (31 mm) and require a 1½" (38 mm) machine screw. Buy a supply that is longer and cut it to length; use bolt cutters like the ones in the head of an electrician's wire stripper and crimping tool.

Stove bolts are available in UNC threads. They are a poorer quality than machine screws due to their manufacturing process. However, they are less expensive and come with square nuts. Machine screws and nuts are sold separately. Select nuts that match the diameter and thread of the fastener.

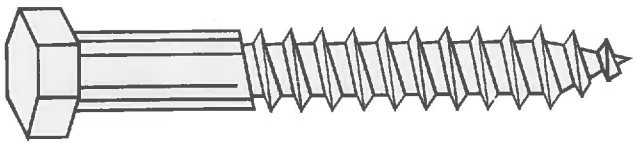


Figure 16-37. Lag screws may be up to 12" (305 mm) long. Use them where strength is essential.

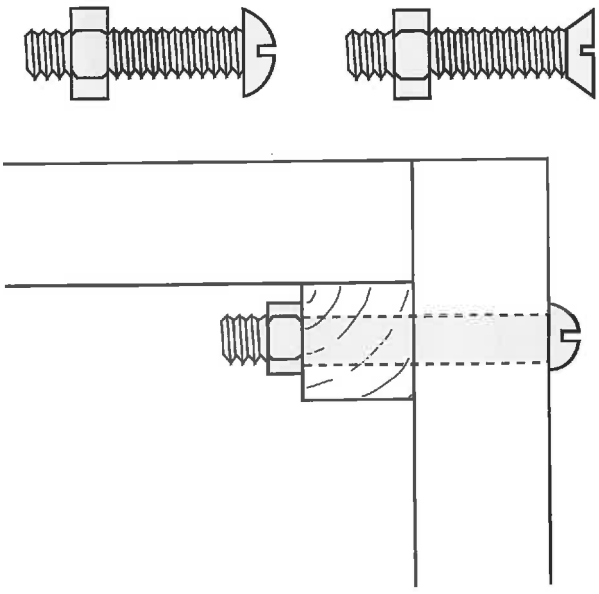


Figure 16-38. Machine screws and stove bolts may require nuts to fasten workpieces together. (*Liberty Hardware, Graves-Humphreys, Inc.*)

Cap screws and machine bolts

Cap screws and *machine bolts* are sized according to the Unified and American Thread Standard and ISO Metric Standard. Those 1½" (38 mm) or shorter are fully threaded. Longer fasteners have about 1½" (38 mm) of thread plus an unthreaded shank. Cap screws have hex heads. Machine bolts have square heads. See **Figure 16-39**. They are often electroplated with zinc chromate to prevent rust.

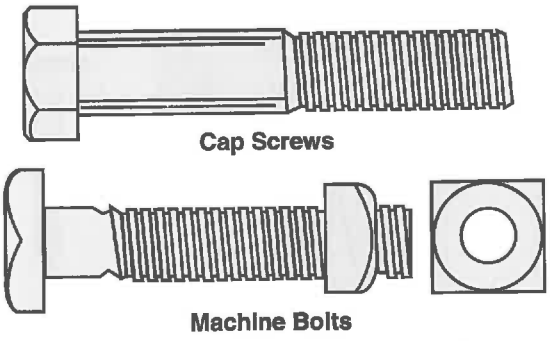


Figure 16-39. Cap screws and machine bolts are much alike. Cap screws have hex heads. Machine bolts have square heads. (*Graves-Humphreys*)

Carriage bolts

Carriage bolts have a truss head with a square shoulder. See **Figure 16-40**. Tightening the nut draws the shoulder into the wood and prevents the bolt from turning.

Carriage bolts are convenient fasteners for jigs and fixtures. They install and tighten easily. You do not have to hold the bolt with a wrench while tightening the nut. Using a wing nut instead of a hex or square nut simplifies securing the bolt. It can be tightened by hand.

Joint connector bolts

Joint connector bolts are made specifically for cabinetmaking. There are different styles of joint connector bolts to fit certain nuts. See **Figure 16-41**. The head of connector bolts is usually a hex socket. The socket permits the bolt to be fastened tighter than screws with slot or Phillips heads. The socket also allows the flat head to be nearly flush with the surface of the wood. A plastic cap covers the head. Conical head connector bolts are installed when the head must be flush or below the surface of the wood.

The shank of joint connector bolts may be enlarged for use with cap nuts. The clearance hole must be drilled large enough to accept the shank.

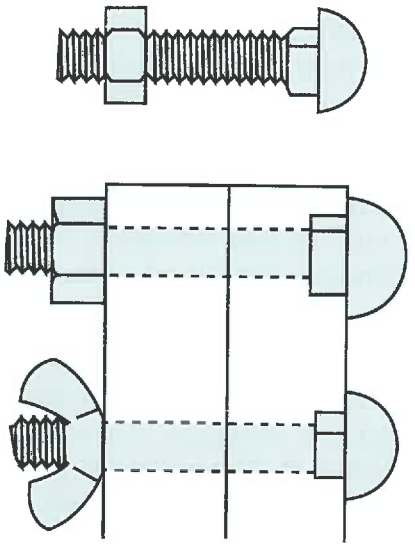


Figure 16-40. The square shoulder of a carriage bolt holds the bolt from turning in the wood. A wing nut can make installation and removal even easier.

Insert Nuts

Insert nuts are installed when frequent assembly and disassembly is desired. They are also used when wood screws lack holding power. The insert nut is installed in the base workpiece. A screw or bolt with NC threads fits into the nut to fasten the assembly. See **Figure 16-42**. Insert nuts are also available with metric threads.

There are several reasons for using insert nuts and machine screws instead of wood screws. Insert nuts rarely are taken out once driven; thus, they remain secure. Wood screws lose their holding power if the cabinet is taken apart many times. Each time a wood screw is installed, it cuts wood fibers around the pilot hole. If you are repairing furniture that has worn out screw holes, install insert nuts.

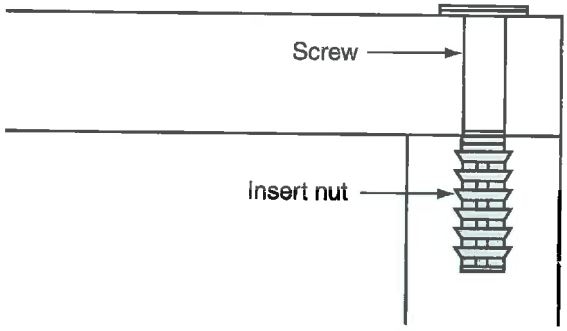


Figure 16-42. Insert nut with ridges that hold it secure. (*Liberty Hardware*)

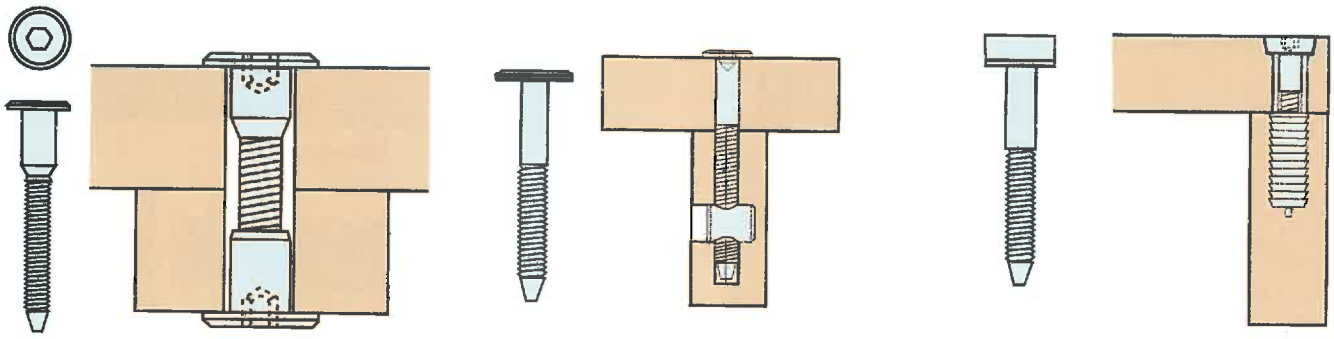


Figure 16-41. Joint connector bolts are designed specifically for cabinetmaking. Left—Bolt with enlarged shank used with cap nut. Middle—Bolt used with threaded metal cross dowel. Right—Cylindrical head bolt is flush with wood surface. Bolt is threaded into an insert nut. (*Liberty Hardware*)

You might also select insert nuts if the cabinet is fabricated from weak material, such as particleboard. Insert nuts have teeth for holding power. They may also be glued in place.

Insert nuts may be screw-in or knock-in types. See **Figure 16-43**. Knock-in insert nuts have teeth or ridges that dig into the wood once they are installed. Drill the proper size pilot hole. Then, use a hammer to drive in the nut. Some knock-in nuts are designed to be inserted with adhesive. They have gaps between ridges to permit glue flow. Apply an adhesive that bonds to both wood and metal.

Screw-in insert nuts have threads. Again, you must drill a pilot hole. Then use an Allen wrench to screw the nut into the workpiece.

T-Nuts

T-nuts are similar to insert nuts. They do not have to be held when fastening the bolt. They have prongs that hold in the wood. See **Figure 16-44**. To insert a T-nut, drill a hole for the barrel. Insert the T-nut barrel into the hole and hammer the nut to a fixed position. Insert the bolt from the opposite side and tighten it.

Anchors

Anchors are used to attach cabinetry where standard screws and bolts are ineffective. Toggle bolts attach cabinetry to hollow materials, such as gypsum walls and concrete blocks. Screw and bolt anchors attach cabinetry to solid materials, such as brick and concrete.

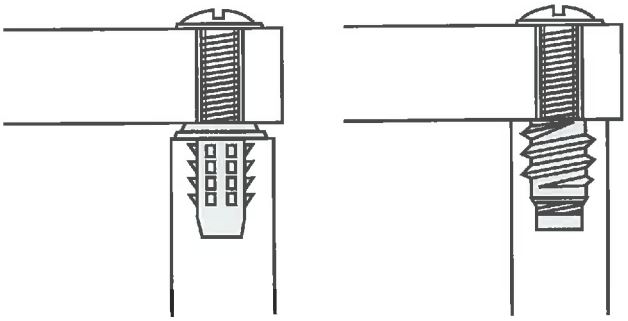


Figure 16-43. Insert nuts. Left—Knock-in type has teeth. Right—Screw-in type has threads. (*Liberty Hardware*)

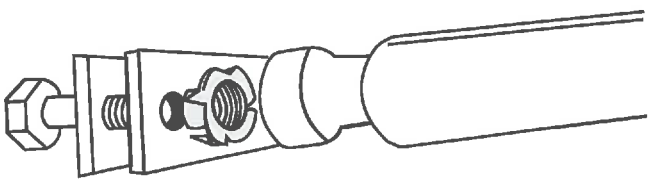


Figure 16-44. T-nuts hold secure with prongs.

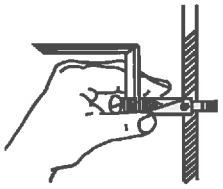
Toggle bolts

Toggle bolts include a stove bolt and toggle head. The toggle head spreads open when inserted through a clearance hole. See **Figure 16-45.** Install toggle bolts as follows:

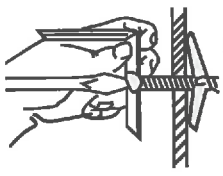
1. Assemble the toggle bolt through the cabinet's mounting holes. The head of the bolt will be on the inside of the cabinet; the toggle head is in back.
2. Drill the appropriate size clearance hole in the wall. The hole must be slightly larger than the diameter of the toggle head wings (when closed).
3. Align the cabinet and bolt assembly over the hole in the wall.
4. Push the toggle bolt through the hole until the wings spring open.
5. Tighten the bolt from the inside of the cabinet to secure the mount.

Screw and bolt anchors

Screw and bolt anchors attach cabinets and other fixtures to solid nonwood materials, such as poured concrete. The anchor is inserted into a hole drilled in the material. A screw or bolt is inserted through the cabinet or fixture, and threads into the anchor. As the screw is tightened, the anchor expands. It wedges against the side of the hole to secure the cabinet.



1. Insert bolt through item to be fastened, turn on wings, then fold wings completely back and insert through hole until wings spring open.



2. Pull back on assembly to hold wings against inside wall—this prevents the wings from spinning while tightening bolt. Turn bolt with screwdriver until firmly tightened.

Figure 16-45. Toggle bolts attach fixtures to hollow walls. (*The Rawlplug Co.*)

Screw anchors

Screw anchors are used with wood screws, sheet metal screws, or lag screws. Anchors may be made of fiber, metal (typically lead), or plastic (nylon). See **Figure 16-46**. Install screw anchors as follows:

1. Position the cabinet. Have mounting holes predrilled.
2. Mark the anchor positions on the wall through the mounting holes.
3. Drill holes the diameter of the anchor. For concrete or ceramic tile, use a carbide-tipped masonry bit.
4. Slide each anchor into its hole and tap it with a hammer. This will seat it. See **Figure 16-47A.**
5. Select the screw. Most anchors have the size of screw you should use marked on them.
6. Position the cabinet over the anchors.
7. Insert the screws through the mounting holes and tighten. See **Figure 16-47B.**

Bolt anchors

Bolt anchors have internal threads to receive a matching machine screw or bolt. See **Figure 16-48**. Insert the anchor using the procedure for screw anchors. Some bolt anchors must be pre-expanded in the hole with a setting tool.

Figure 16-46. Screw anchors may be made of lead. (*The Rawlplug Co.*)

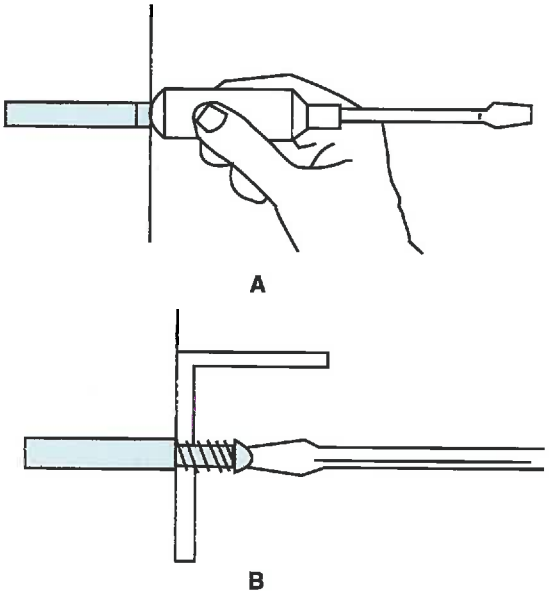


Figure 16-47. Installing screw anchors. A—Drill hole and tap in the screw anchor. B—Position fixture and insert screw. (*The Rawlplug Co.*)

One-piece anchors

One-piece anchors combine the anchor and fastener in one assembly. See **Figure 16-49**. One operation installs the anchor and secures the cabinet or fixture. Install one-piece anchors as follows:

1. Position cabinet against wall or surface. Mounting holes should have been drilled in the cabinet.
2. Drill a hole in the wall through each mount hole. Make holes the same size as the anchor.
3. Set the anchor in the hole and drive it with a hammer. The flange of the anchor will seat against the cabinet.

Light-duty plastic anchors

Light-duty plastic anchors work in any hollow or solid material. Various anchors for drywall, concrete, brick, and thin paneling are available. See **Figure 16-50**. Install the anchor as follows:

1. Drill a hole in the wall the size of a folded anchor. See **Figure 16-51A.**
2. Fold the anchor and insert it into the hole. Tap it flush with the wall. See **Figure 16-51B.**
3. For hollow walls, insert a nail to pop the anchor open. See **Figure 16-51C.**

Figure 16-48. Bolt anchors are prethreaded. (*The Rawlplug Co.*)

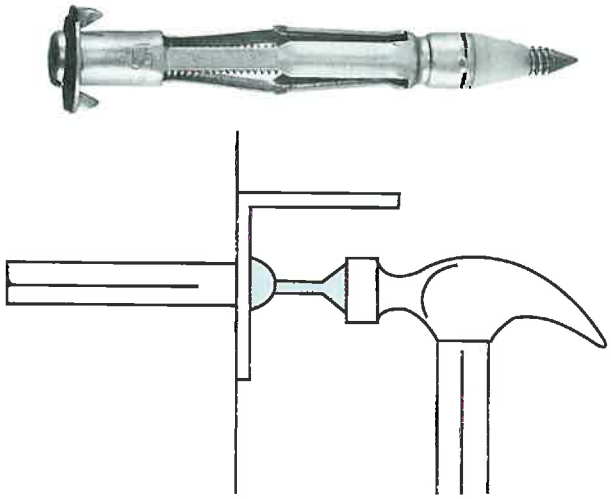


Figure 16-49. One piece anchors include the anchor and fastener in one assembly. (*The Rawlplug Co.*)

4. Place the cabinet or fixture over the anchor. See **Figure 16-51D**.
5. Insert the screw and tighten until the screw head is flush with the cabinet. See **Figure 16-51E**. Do not overtighten.

Repair Plates

Repair plates may be used to mend joints where other fasteners have weakened. If appearance is important, do not use them. These plates are made of galvanized steel and are seldom finished to blend with the appearance of the product. See **Figure 16-52.** Four types of repair plates are available.

Figure 16-50. Plastic anchors are fabricated for various wall thicknesses. (*Mechanical Plastics Corp., The Rawlplug Co.*)

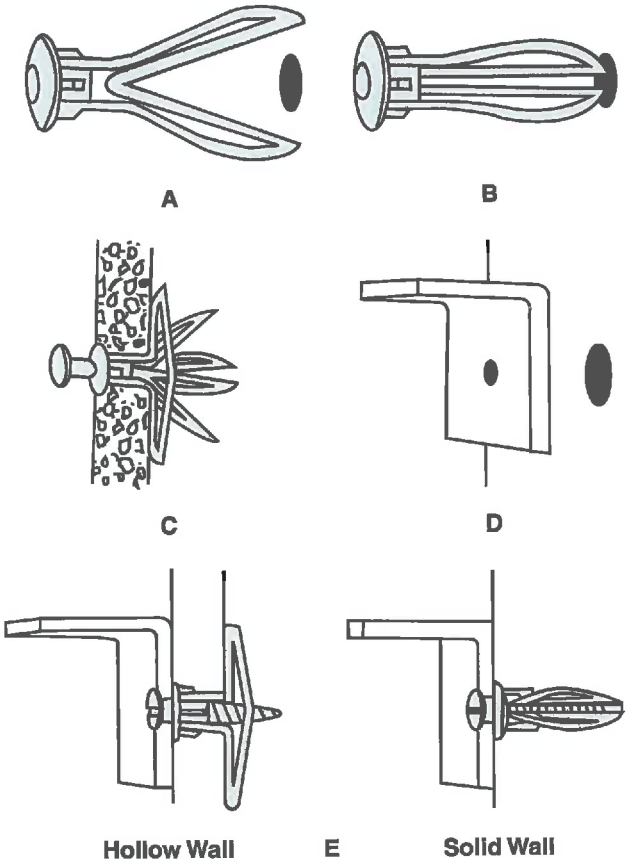


Figure 16-51. Installing plastic anchors. (*Mechanical Plastics Corp.*)

- Mending plates strengthen butt and lap joints.
- Flat corner irons strengthen frame corners. Typical uses are for door and window frames.
- Inside corner braces are installed under chair seats and tabletops to support weakening jointwork. They may also support shelves or cabinets.
- T-plates are attached to frames where rails and stiles meet.

Fasteners for Ready-to-Assemble Cabinets

Ready-to-assemble (*RTA*) cabinets are purchased as unassembled kits. As a small package or in pieces, the cabinet can fit through small doors and narrow stairways. The consumer then assembles the cabinet with RTA cabinet fasteners. The finished RTA cabinet looks no different from a wood cabinet assembled by a furniture manufacturer. See **Figure 16-53.**

RTA fasteners are suitable for both industry and the home woodworker. For industry, RTA fasteners eliminate labor for assembly. They also require minimal drilling and boring. Small cabinet shops and home woodworkers often install RTA fasteners. Most fasteners for RTA cabinetry are easy to install. They typically hold as well as screws or glue. However, they permit easy assembly and disassembly of the cabinet.

Many companies manufacture fasteners for RTA cabinetry. Various sizes and styles are available.

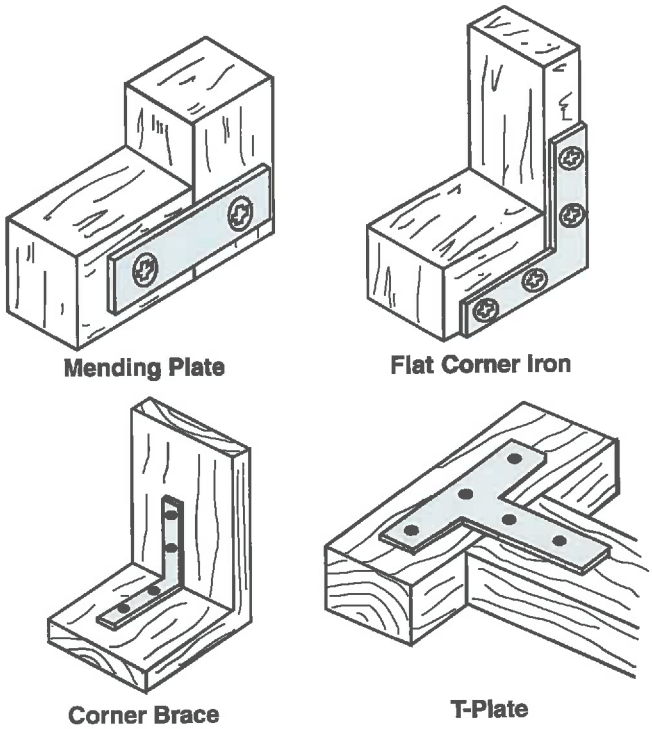


Figure 16-52. Repair plates. (*Liberty Hardware*)

Bolt and cam connectors

Bolt and cam connectors consist of a steel bolt with a special head, a steel or plastic cam, and a cover cap. The cam has a hollow side or interior to receive the bolt. Two types of bolt and cam connectors are available. One has a hollow casing, the other an eccentric cam. See **Figure 16-54**. Use bolt and cam connectors for cabinet corner and shelf assemblies.

To assemble the cabinet, first insert the bolts. Screw them into the sides of the cabinet at marked locations. Then insert cams in bored holes in components to be fastened. See **Figure 16-55**. To complete the assembly, fit the shelf (with cam) over the bolt. The hollow opening in the cam should be facing the bolt. Then turn the cam with a screwdriver (or possibly an Allen wrench) to draw the bolt and side panel into position. When all bolts and cams have been connected and tightened, cover the cams with plastic caps (provided by the manufacturer).

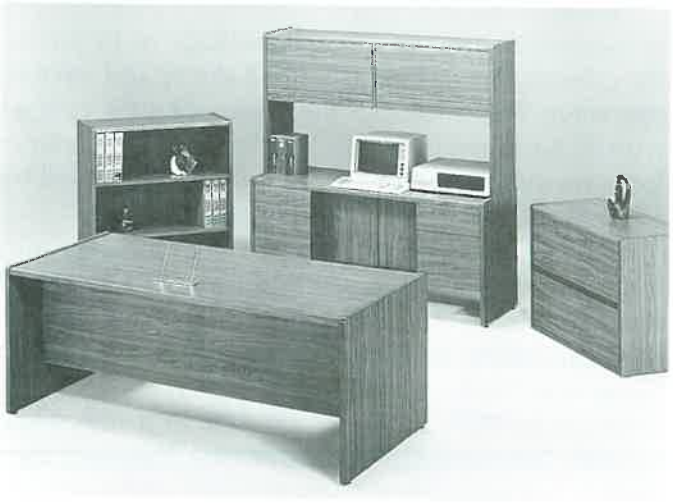


Figure 16-53. These are ready-to-assemble products. (*O'Sullivan Industries*)

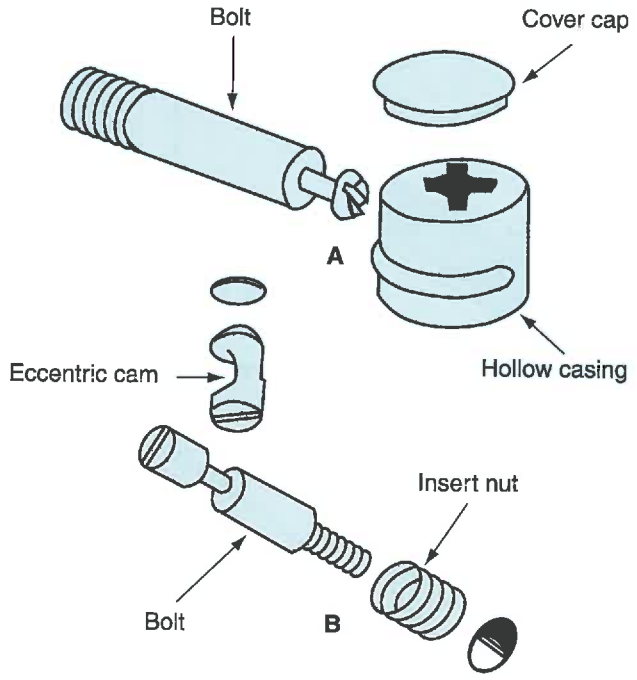


Figure 16-54. Bolt and cam connectors. A—Bolt and hollow casing. B—Bolt and eccentric cam. (*Liberty Hardware*)

Concave bolt connectors

Concave bolt connectors consist of three parts. These parts are a steel bolt with a concave hole in the shank, a collar, and a set screw. See **Figure 16-56.**

Concave bolt connectors are assembled in several steps. Insert the bolt into the side of the cabinet. The collar is placed in a predrilled hole in the workpiece to be fastened. To assemble the two components, position the concave bolt into the hole in the collar. A ball end set screw threads into the

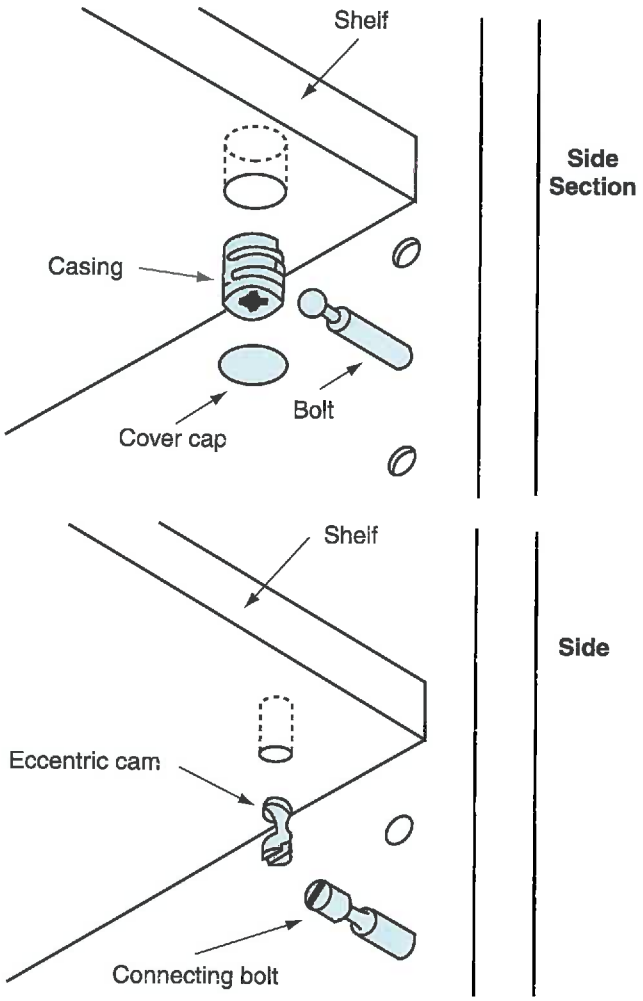


Figure 16-55. Diagram for assembling cabinets with bolt and cam connectors. Insert bolts into the cabinet sides. Place cams into workpieces to be fastened.

collar. When tightened, the set screw positions itself in the bolt hole. As the screw positions itself, it draws the bolt toward the collar. See **Figure 16-57**.

Wedge pin connectors

Wedge pin connectors are more visible than other RTA fasteners. They install quickly and can be used where appearance is not a factor. They consist of three pieces: two plastic mounts and a wedge pin. The mounts are connected to the two pieces of wood to be joined. One mount fits over the other. To fasten the two, a wedge pin is inserted through the fitted mounts. See **Figure 16-58**.

Plug and socket

Plug and socket connectors are designed for joints that require less holding power. The plug is screwed into one of the workpieces. The socket screws into the other. The two parts are pressed together to complete the assembly. See **Figure 16-59**.

Snap clips

Snap clips are used to attach the toe kick for cabinet bases. Attach clips to the toe kick. Insert bolts inside the base of the cabinet frame. The toe kick is pressed onto the frame. See **Figure 16-60**. Like plug and socket connectors, snap clips are made for joints requiring little strength.

Keku® suspension and press-fit fasteners

Keku suspension and press-fit fasteners allow subframes, soffits, and blind drawer fronts to be assembled in the workshop. Field installation is

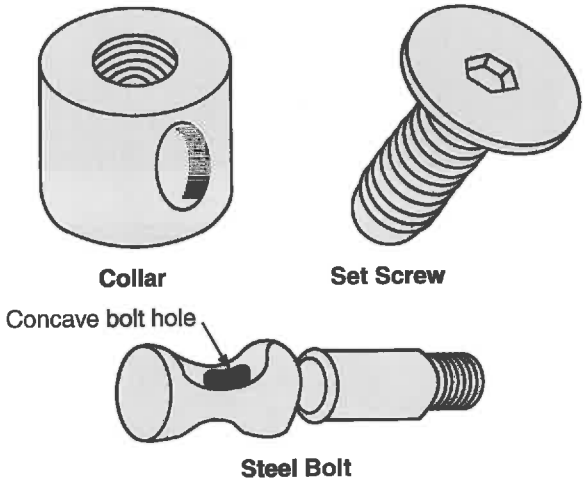


Figure 16-56. Parts of a concave bolt connector.

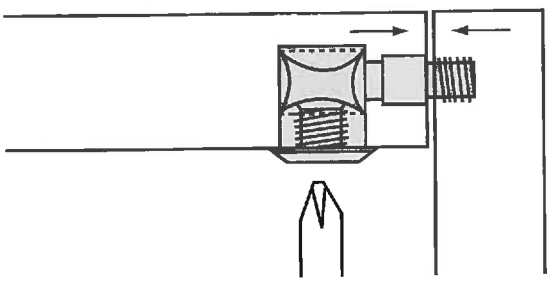


Figure 16-57. As set screw is tightened, it positions itself in bolt hole. This draws parts together. (*Liberty Hardware*)

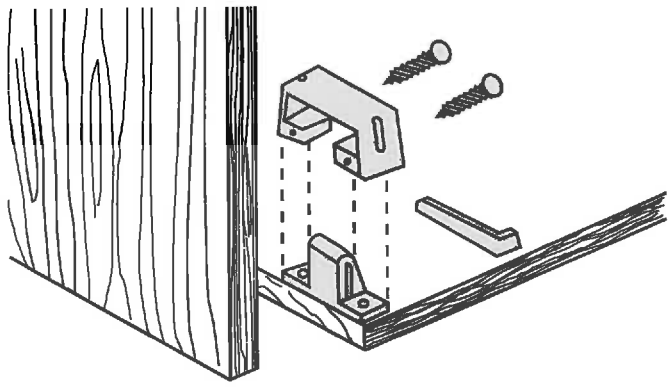


Figure 16-58. Wedge pin connectors include two plastic parts attached to the wood with screws. A pin is inserted through the two parts to hold the assembly together. (*Liberty Hardware*)

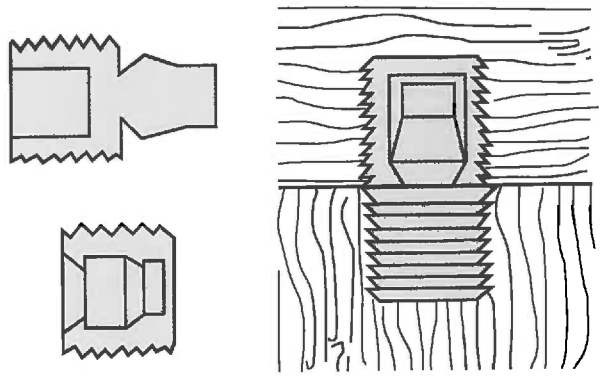


Figure 16-59. With plug and socket connectors, the two pieces are pressed together to complete the joint. (*Liberty Hardware*)

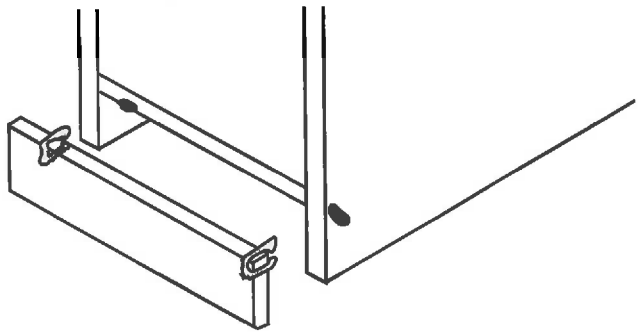


Figure 16-60. Snap clips are commonly used to attach toe kicks to the bottom of cabinets. (*Liberty Hardware*)

simplified and faster since the various elements are complete and ready to install. The elements only have to be fitted together. See **Figure 16-61.**

Keku fasteners are used for installing wall panels, wainscoting, and framed mirrors. They allow installation of removable access panels for radiators, air conditioning systems, spa motors and pumps, and other utilities. Suspension fasteners are used where there is room to slide the panel at least ¾" (19 mm) at the time of installation. First, build a frame to mount to the wall. The frame is similar to a cabinet face frame. Attach Keku frame components. Make the panel or mirror frame, place it face down on a worktable. Position the wall frame over the panel. Place Keku panel component over the frame component and fasten with screws. Install the frame on the wall and then hang the panel. ***Push-on fasteners*** are used where the frame element may be fastened to a side panel. See **Figure 16-62.**

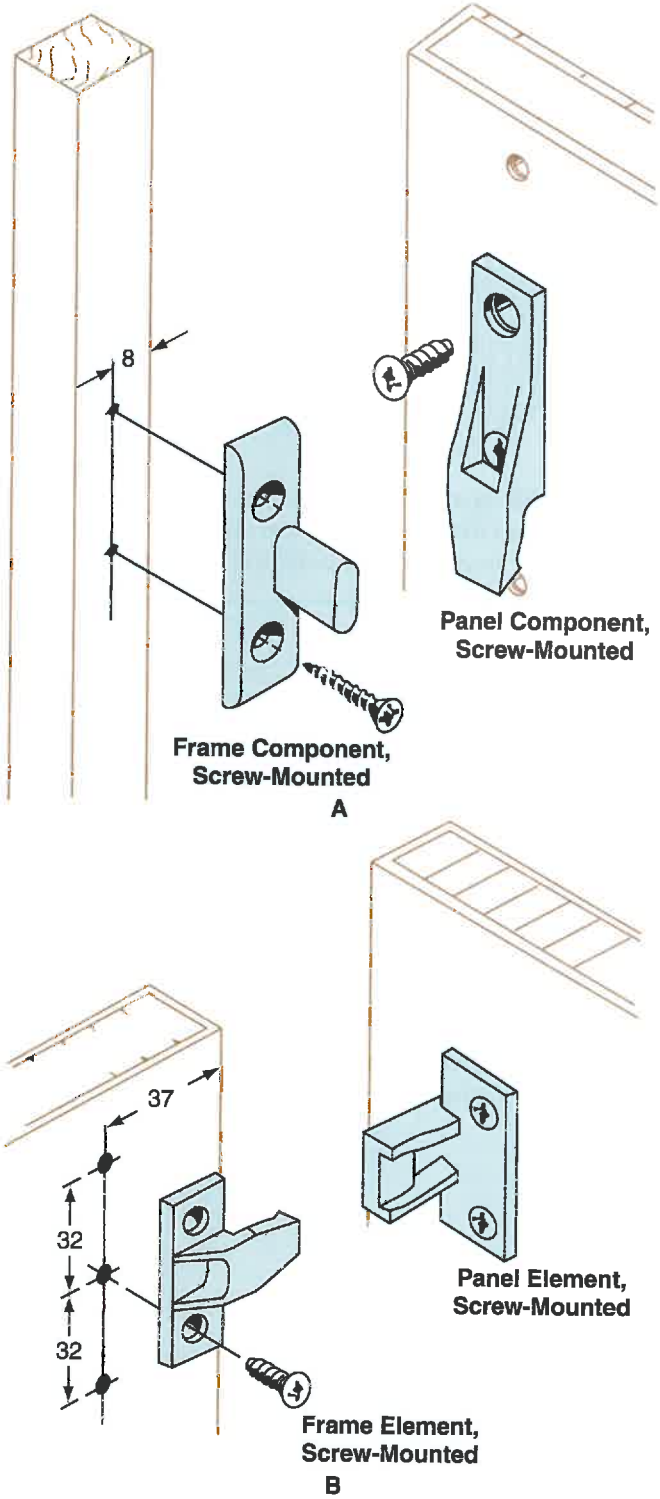
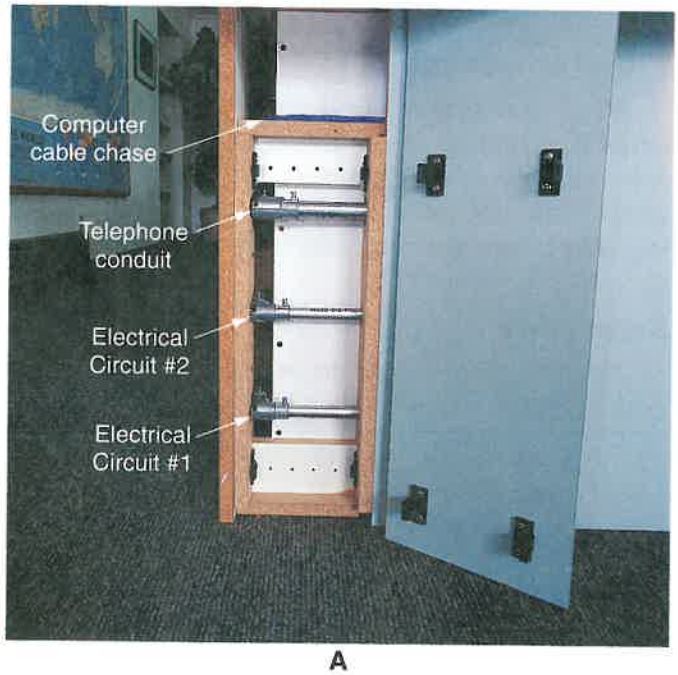
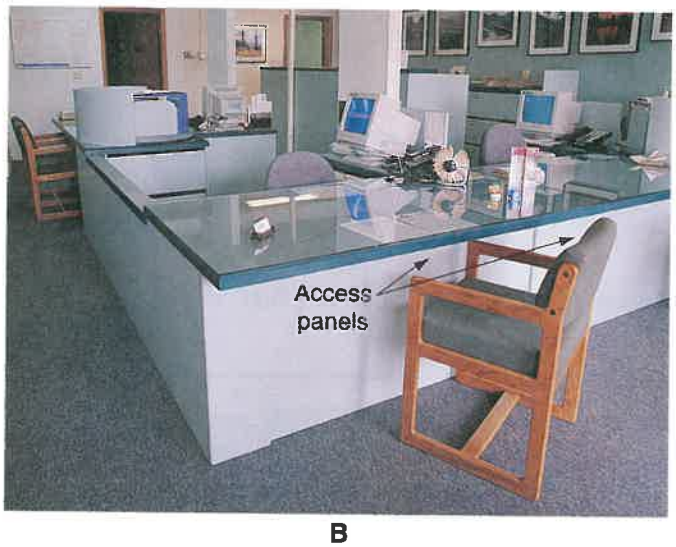


Figure 16-61. A—Keku suspension fastener. B—Keku press-fit fastener. (*Häfele America Co.*)



A



B

Figure 16-62. A—Computer, telephone, and electrical cable conduit passes through the panels below the countertop. Access panels allow installation or replacement of cables. B—Keku push-fit fasteners release the access panel for service. (*Newberg Travel*)

Summary

Mechanical fasteners include both metal and nonmetal joining devices. Many different styles are available and each may have a general or specific purpose. Wood screws are the most widely used threaded fastener. You will likely assemble cabinets and attach hardware with them. Some unthreaded fasteners are used. Nails and staples are inserted to attach cabinet backs. Casing nails are designed to attach trim; they can be set below the wood surface. Sheet metal fasteners, such as chevrons and corrugated fasteners, are excellent for fastening miter joints.

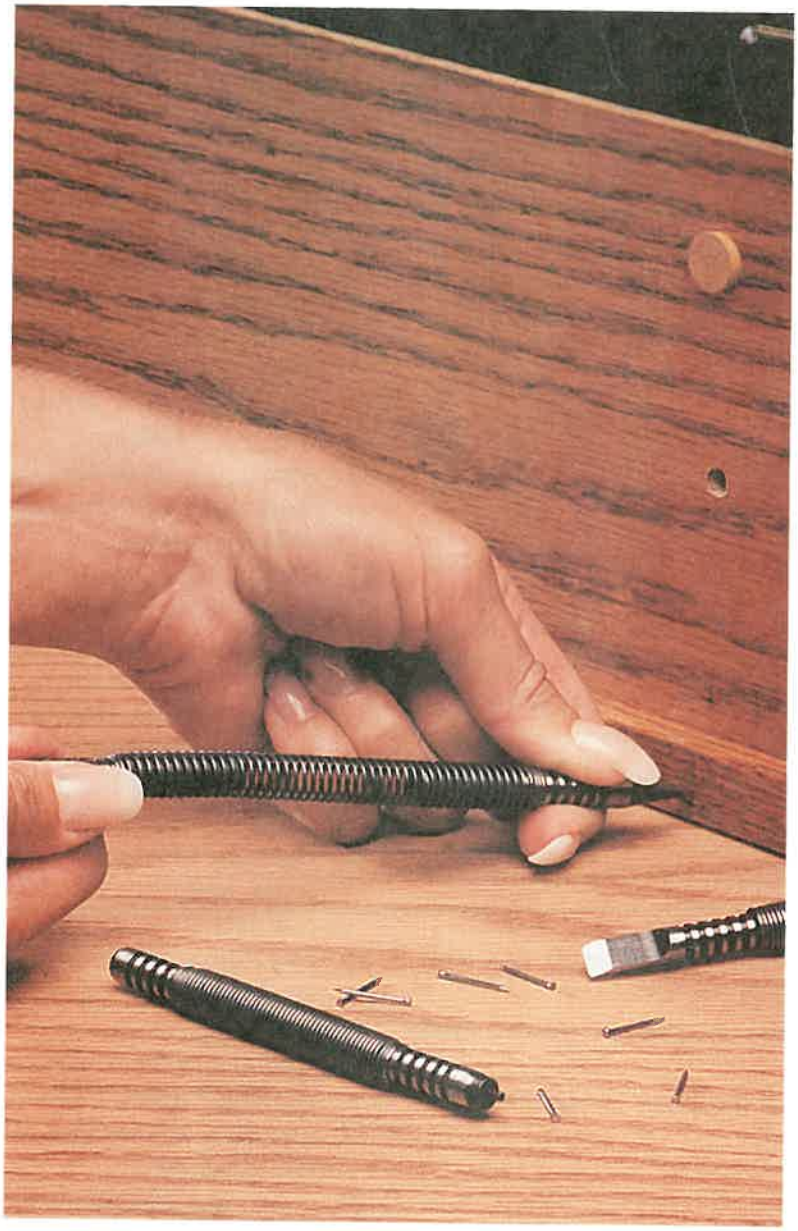
Anchors are used to attach cabinets to walls. They are designed for both hollow walls or concrete block, and solid concrete and brick.

RTA fasteners permit cabinets to be assembled and disassembled with ease. The joint strength does not decrease if the cabinet is disassembled many times. Bolt and cam connectors or concave bolt connectors are selected for strength. Snap clips or plug and socket connectors are chosen for quick release.

Test Your Knowledge

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

1. Describe the difference between brads and wire nails.
2. Why are nails that are used in nail guns coated with plastic?
3. The term penny and the letter d identify sizes for all nails except _____.
   a. box nails
   b. brads
   c. common nails
   d. finishing nails
4. A nail set is placed in the cone-shaped head of a(n) _____ nail to drive it below the surface of the wood.
5. How long should a nail be?
6. Two methods of nailing are _____ and _____.
7. _____ is a sheet metal fastener that can be installed only after making a saw kerf.
   a. Chevron
   b. Skotch fastener
   c. Corrugated fastener
   d. Clamp nail
8. List three finishes applied to screws. What term indicates that a screw has no finish applied to it?
9. What term indicates that a screw has no finish applied to it?
10. To install wood screws, you must drill _____ and _____ holes.
11. A(n) _____ is drilled in the wood to allow flathead and other tapered head screws to be flush with the wood.
12. Why might machine screws be selected to fasten dense woods?
13. The difference between cap screws and machine bolts is the _____.
    a. length of the thread
    b. shank diameter
    c. shape of the head
    d. threads per inch
14. Describe two features that make joint connector bolts specifically designed for assembling cabinets.
15. List two applications for insert nuts.
16. Anchors are used to attach cabinets to _____ and _____.
17. Explain why a consumer might choose to purchase ready-to-assemble (RTA) cabinets.
18. List two advantages RTA fasteners have over wood screws.
19. _____ is a fastener used for ready-to-assemble (RTA) cabinets and consist of a concave hole in the shank, a collar, and a set screw.
20. _____ are fasteners for ready-to-assemble (RTA) cabinets that are used to attach the toe kick for cabinet bases.



Shown here is a unique nail starter and setter for brads and finishing nails. (*Noxon Inc.*)

Hardware

17

Objectives

After studying this chapter, you will be able to:

- Select knobs and pulls for function and appearance.
- Install sliding doors.
- Choose hinges for wood and glass doors according to the style of cabinet.
- Explain various methods of mounting drawer hardware.
- Identify special purpose hardware for beds, desks, and folding tables.

Important Terms

bed rail
case front style
caster
catch
connector
face frame
furniture glide
furniture leveler
hinge
knobs
latch
pulls
shelf supports
slide guide
slides

Figure 17-1. The homeowner has many options when customizing their kitchen. The ceramic knobs and pulls illustrated above are available in a variety of colors. (*Amerock Corp.*)

Figure 17-2. Pulls and knobs may be made of brass. (*Amerock Corp.*)

Hardware serves many functions that add convenience to a cabinet. Hinges allow doors to swing open for easy access. Drawer slides provide smooth opening and closing drawers. Shelf rests support adjustable shelving.

Hardware can also enhance the appearance of the cabinet. There are many styles, materials, and finishes. Hidden hinges are typically steel that may be plated with nickel to prevent rust. Decorative hinges are painted or plated with another metal, such as brass. Pulls and knobs may be wood, metal, porcelain, glass, or several types of plastic. See **Figure 17-1.** Solid surface material knobs and pulls can match the countertops. Hardware may be brushed (slightly roughened) to reduce gloss, or it may be polished to increase the shine.

Pulls and Knobs

Pulls and ***knobs*** assist you when opening doors and drawers. A variety of styles are available. See **Figure 17-2.** You should select those that match the

cabinet style. Pulls are either flush mount or surface mount. Knobs are mounted on the surface.

Flush mount pulls

Flush mount pulls are level with the face of the door. Install them in sliding doors. See **Figure 17-3.** The doors pass each other with little clearance.

To install flush mount pulls, make a hole in the door using a router or drill. Press the pull into the hole or tap it with a mallet. See **Figure 17-4.** Most flush mount pulls are friction fit. Some may have screw holes. Others are best installed with adhesive.

Flush mount pulls for sliding glass doors are ground into the glass. These allow your fingers to move the door.

Figure 17-3. Flush mount pulls do not interfere with sliding doors.

Figure 17-4. Flush mount pulls are secured by friction, glue, and/or screws. (*APA - Engineered Wood Association*)

Surface mount pulls and knobs

Surface mount pulls and knobs are attached with screws from the back of the drawer front or door. Most wooden hardware is attached with wood screws. Some are fitted with insert nuts to accept machine screws. Metal and some plastic hardware is threaded for machine screws.

To install surface mount pulls and knobs, holes must be laid out and drilled accurately. The hardware is then attached. See **Figure 17-5.** Countersink the machine screw head when installing pulls and knobs on face frame cabinet doors to prevent scratching of the face frame. A decorative backplate is often placed between the door or drawer and the hardware. The backplate helps prevent scratches, dirt, and wear when you grasp the pull.

Bail pulls

Bail pulls include a backplate that supports a hinged pull. See **Figure 17-6.** The pull lays flat against

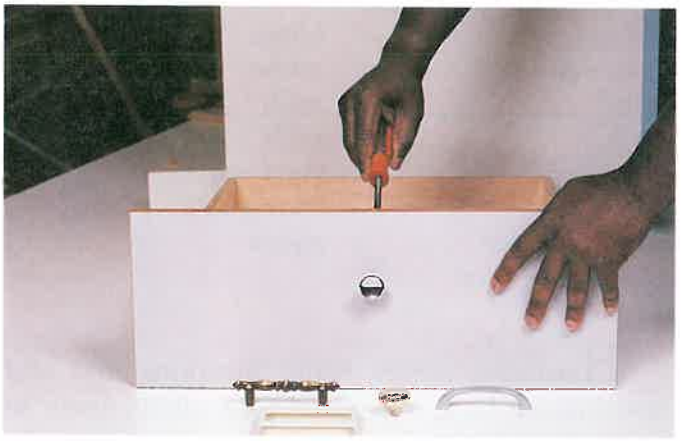


Figure 17-5. Surface mount pulls and knobs are attached from the inside of the drawer. (*Chuck Davis Cabinets*)

Figure 17-6. Polished metal bail pulls are decorative.

the backplate when not needed. Bail pulls are common on traditional and provincial furniture. Most are made of polished brass and are very decorative.

Ring pulls

Ring pulls include a ring that pivots in a backplate. See **Figure 17-7.** Flush mount ring pulls are chosen when the hardware needs to be below the surface. They are glued in place or attached with screws under the ring. Surface mount ring pulls typically have visible screw holes.

Door Hardware

Cabinet doors either slide past each other or swing open on hinges. Sliding doors allow access to only part of the cabinet opening. Hinged doors provide full access to the cabinet opening. However, hinged doors may be a safety hazard when left standing open. To reduce the width and weight of hinged doors, two doors are installed per opening. Door hardware includes tracks, hinges, catches, and latches.

Sliding door tracks

Sliding doors are supported and guided by metal or plastic tracks. The doors slide within about ¼" (6 mm) of each other, making flush mount pulls necessary.

Tracks come in pairs. See **Figure 17-8.** The upper track is attached to the top of the door opening. The lower track supports the weight of the doors. It contains ridges that prevent the entire edge of the door from seating in the track. This reduces friction that would prevent the door from sliding. Special roller hardware may be installed in tracks to ease movement of the door.

Figure 17-7. Ring pulls lay flat on the smooth flowing surface of this contemporary furniture. (*Bassett*)

The upper and lower tracks must be parallel. Locate and mark their locations. Attach the tracks with flat head screws.

Door measurements differ according to the style of track. Doors that slide without rollers are measured from the inside of the upper track to the top edge of the lower track. Reduce this measurement by 1/8" (3 mm) for clearance.

For doors on rollers, installation may be more involved. The doors typically must be bored or mortised to accept the roller assembly. See **Figure 17-9.** Follow the manufacturer's instructions for installation.

Hinges for wood doors

Hinges support doors and allow them to swing. Most hinges consist of two pieces of metal, called leaves, held together by a pin. The pins are either tight or loose. Loose pins allow you to remove the door quickly.

Other hinge styles include self closing, adjustable, and double action. ***Self closing hinges*** have a spring that prevents doors from standing open. ***Adjustable hinges*** have oblate mounting holes. These allow for door adjustment. As the hinge is mounted, it may be moved before the screw is tightly fastened. Another type of adjustable hinge, the concealed or ***"Euro-style" hinge,*** has adjusting screws on the arm for lateral and front to back adjustment. Another screw on the mounting plate provides vertical adjustment. ***Double action hinges*** permit doors to swing both inward and outward.

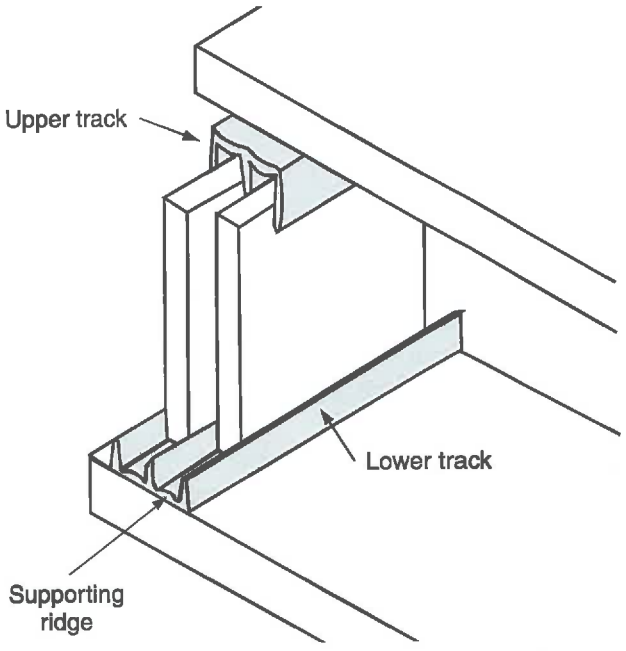


Figure 17-8. Upper and lower tracks must be parallel. The supporting ridges in the lower track reduce friction.

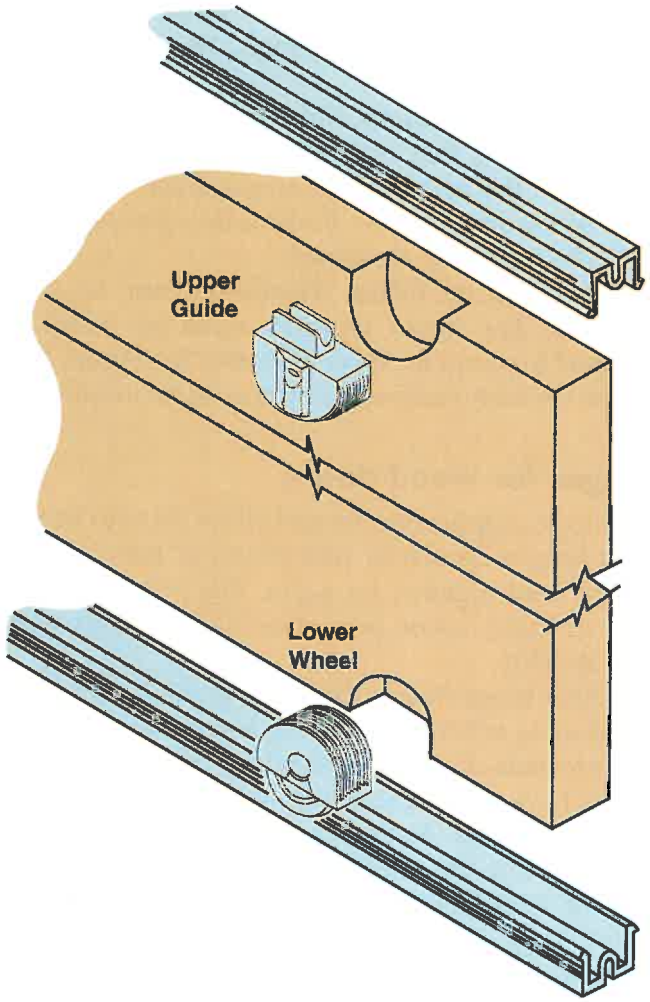


Figure 17-9. Roller type sliding door hardware may require mortising the doors. (*Liberty Hardware*)

Hinge surfaces may be brushed, polished, or textured. Many are plated with chrome, brass, or copper. Some have finish such as enamel, lacquer, or varnish applied to them.

Selecting door hinges

Select hinges to function properly in various cabinet styles. The cabinet front and door design plays a major role in how doors are mounted on the cabinet frame. This, in turn, affects which hinge is appropriate. See **Figure 17-10**. Common case front styles include:

- Flush front with face frame
- Flush front without face frame
- Flush overlay front
- Reveal overlay front (with or without face frame)
- Lip edge doors

You will notice that a face frame is part of several styles. A ***face frame*** is a solid wood border

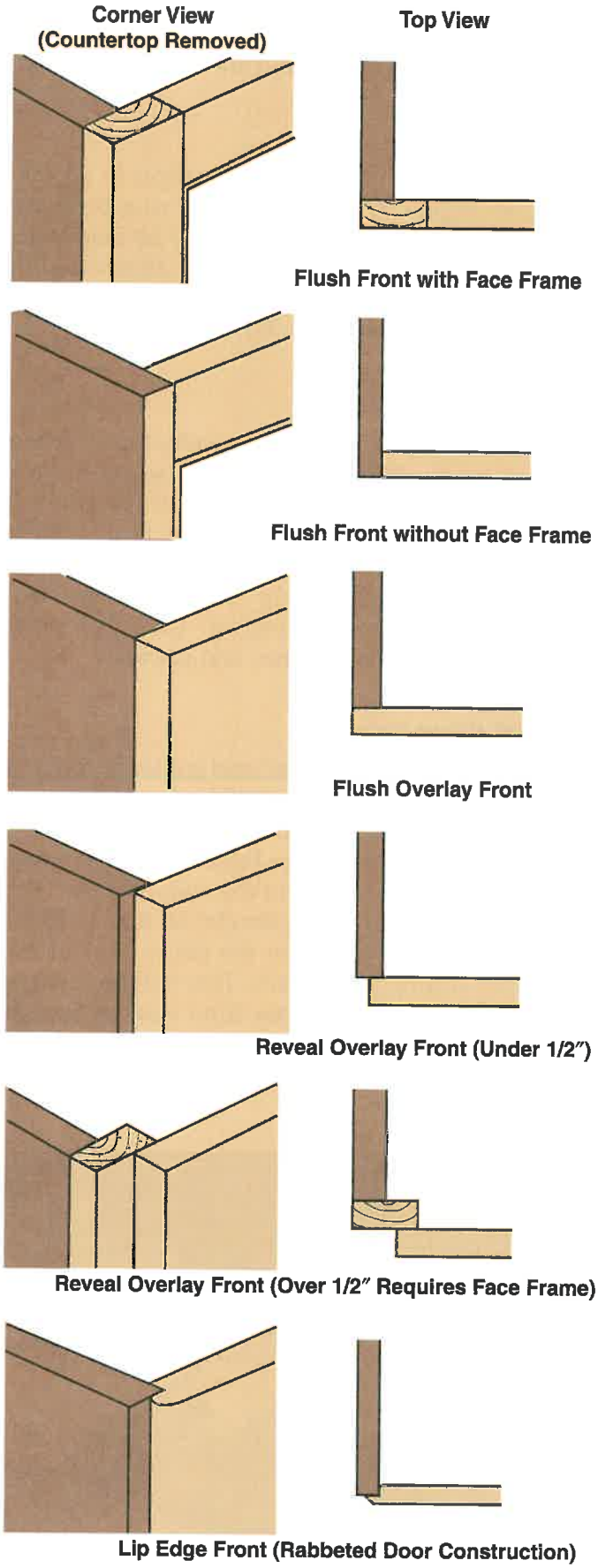


Figure 17-10. Flush and overlay doors are common on cabinets with and without face frames.

placed on the front of the cabinet assembly. It covers the edges of plywood or particleboard used to construct the case. Common face frame widths are 1½" to 2" (38 mm to 51 mm). With a face frame, the door cannot mount on the side of the cabinet; it must be attached to the side frame.

Examples of hinge types and their appropriate use are given in **Figure 17-11**. The number of hinges you install depends on hinge and type as well as the weight and height of the door. See **Figure 17-12**. Generally, two hinges per door are sufficient. When using three or more hinges, the pins must be in line, otherwise the door will not operate easily. This is called ***hinge bound***.

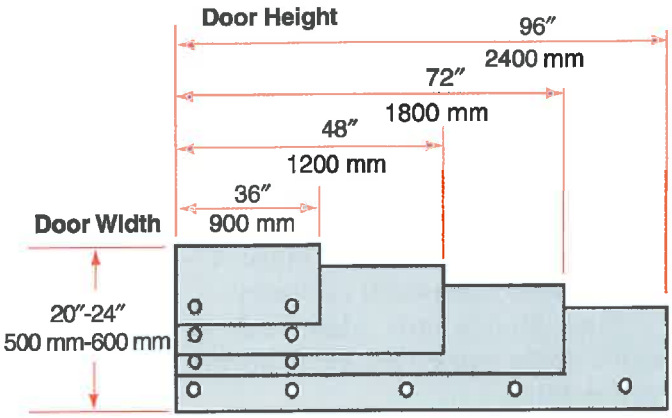


Figure 17-12. Install hinges according to door height and width. Most cabinet door widths are 24" (610 mm) or less.

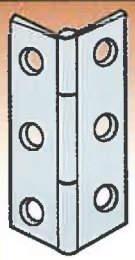
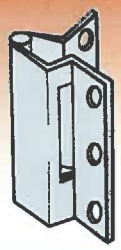
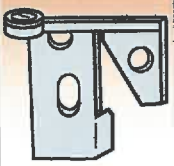
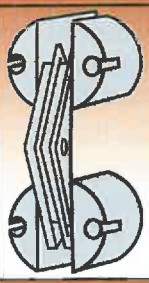
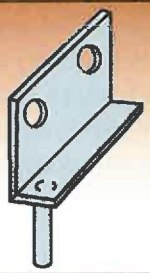
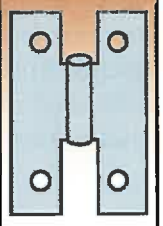
	Butt	Formed	Pivot	Invisible	European Style	Pin	Surface
Hinge Type							
Applications	Conventional Flush Front with Face Frame	Conventional Flush Front Reveal Overlay Flush Overlay	Reveal Overlay Flush Overlay	Conventional Flush with Face Frame	Reveal Overlay Flush Overlay Conventional Flush without Face Frame	Conventional Flush Front	Conventional Flush Front with Face Frame
Strength	High	Very High	Moderate	Low	Moderate	Moderate	High
Concealed when Closed	No	No	Semi	Yes	Yes	Yes	No
Requires Mortising	Yes	Occasionally	Usually	Yes	Yes	Yes	No
Cost of Hinge	Low	Moderate	Low	High	High	Low	Low
Ease of Installation (cost)	Moderate	Easy	Moderate	Difficult	Very Easy	Easy	Easy
Adjustment after Installation	No	Slight	Slight	No	Yes	Slight	No
Degree of Motion	95°	95°–180°	180°	180°	90°–170°	180°	95°–120°
Automatic Closing	No	Optional	No	Optional	Optional	No	No
Remarks	Door requires hardwood edge			Door requires hardwood edge	1. Specify degree of opening 2. No catch required		

Figure 17-11. Hinge applications and features.

Butt hinges

Butt hinges have two leaves connected by a pin. The leaves fold face to face when installed in the door. The two types of butt hinges are mortised or nonmortised.

Mortised butt hinges are placed in routed or chiseled gains in the door and cabinet frame to conceal the hinge. See **Figure 17-13.** They are designed for flush front cabinetry.

Butt hinges are identified by length and width. Some named by width are broad, middle, or narrow butts.

Mortised butt hinges may be swaged, nonswaged, or fully swaged. These are classified by how the two leaves form around the pin. The amount of swage determines how close the two leaves fit together. See **Figure 17-14.** It also determines if the pin is between or to one side of the closed leaves.

Nonmortised butt hinges are designed for flush overlay fronts or reveal overlay fronts with face frames. The outer leaf is attached to the frame. The inner leaf is attached to the back of the door. See **Figure 17-15.** This metal used in these hinges is thin. Therefore, the hinge is not as strong. However, they are installed quicker.

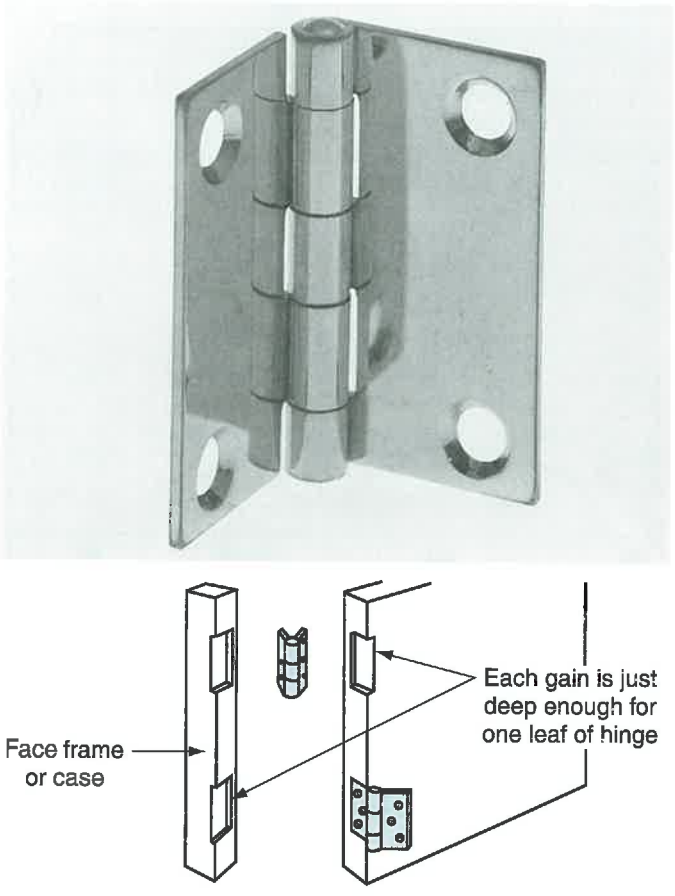


Figure 17-13. Install mortised butt hinges in gains cut in both the door and cabinet frame.

Formed hinges

Formed hinges are made for flush overlay, lip edge, and reveal overlay doors. One leaf is bent to fit around the frame. The other leaf may be flat or bent and attaches to the back of the door. See **Figure 17-16.** Some

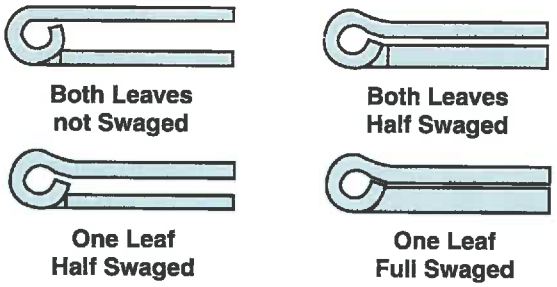
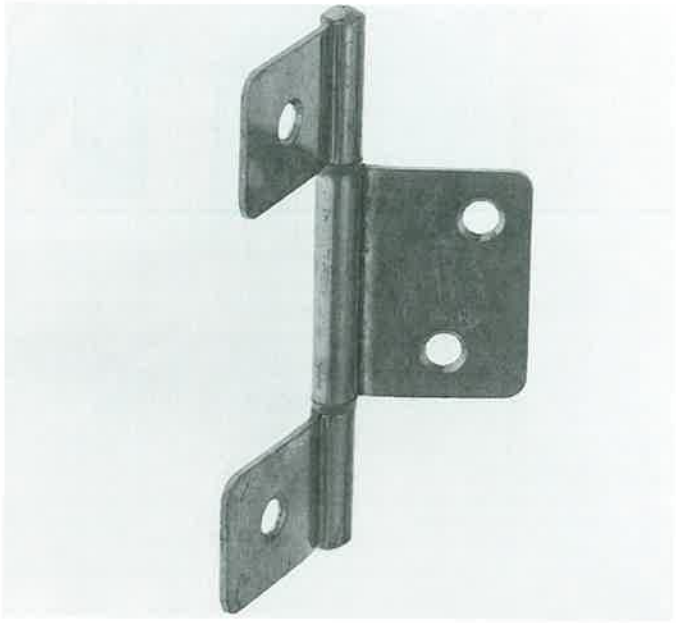


Figure 17-14. Swage determines pin location and how tightly the two hinge leaves close. No swage leaves a space between the door and frame.



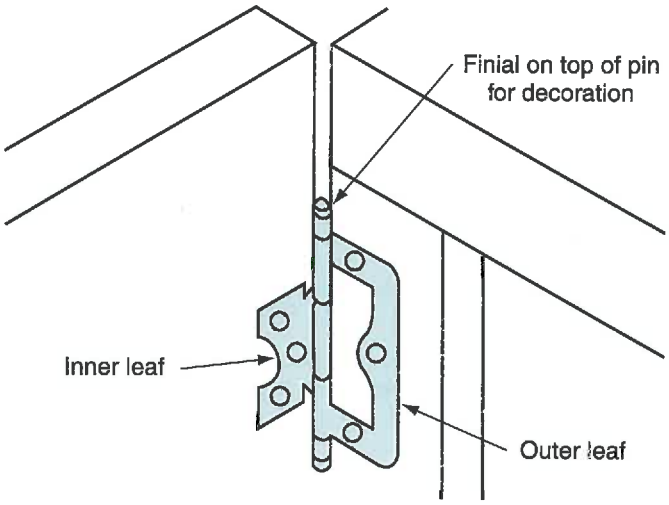


Figure 17-15. Nonmortised hinges do not require a gain.

hinge styles have finials attached to the top and bottom of the hinge pins for decoration. Formed hinges are also called ***bent hinges*** and ***wrap-around hinges***.

Formed hinges for lip edge doors

Lip edge doors require specially formed hinges. Each leaf has two bends. The two bends fit in the rabbeted edge of the door. The hinge is attached to the cabinet side or face frame and door back. See **Figure 17-17.**

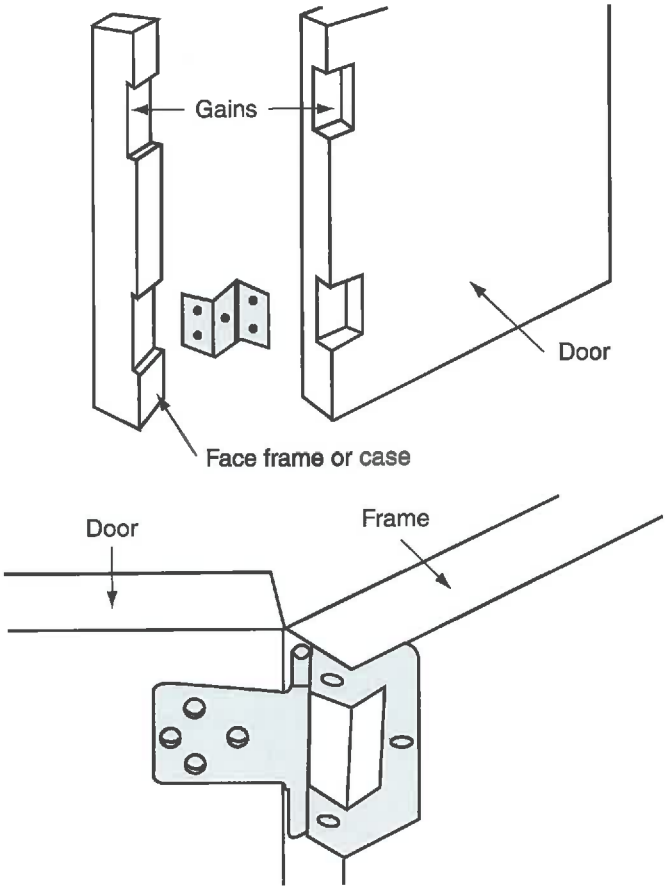


Figure 17-16. Formed hinges wrap around the frame. Typically they are more secure than a butt hinge. Top—Mortised formed hinges are placed in gains. (*The Woodworker's Store*) Bottom—Nonmortised formed hinge resembles nonmortised butt hinge. (*Liberty Hardware*)

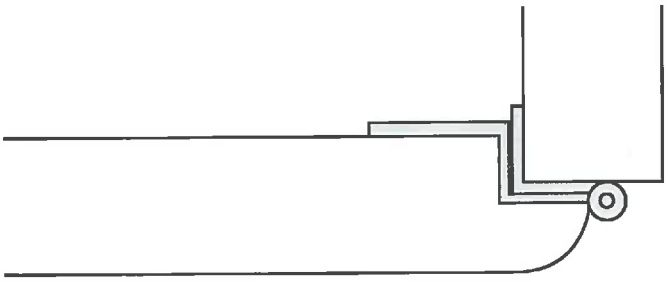


Figure 17-17. Formed hinges for lip doors have two bends in the door leaf and one in the frame leaf. (*Liberty Hardware*)

Semiconcealed formed hinges

Semiconcealed hinges are made for reveal overlay doors. The visible part of the hinge is attached to the front of cabinet. It typically is textured and finished in chrome, brass, copper plating, or black paint. The hidden leaf is attached to the back side of the door. See **Figure 17-18.**

Surface hinges

Surface hinges have "H" or "HL" shapes and attach directly to the front of the cabinet. See **Figure 17-19.** They are designed for either conventional flush front or

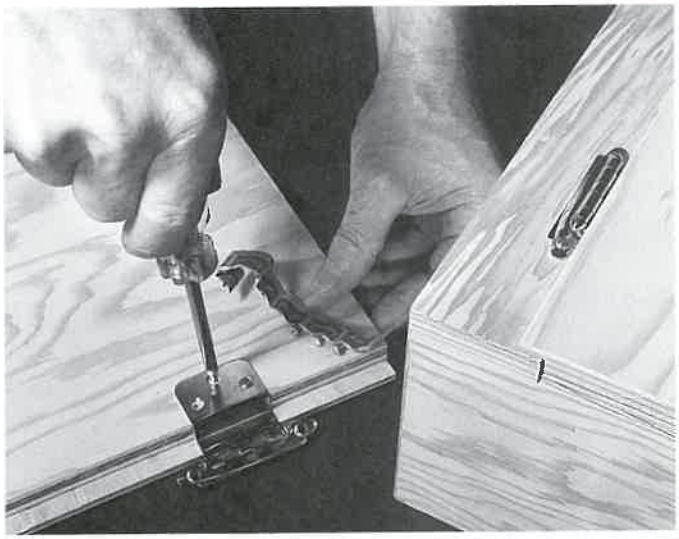


Figure 17-18. One leaf of semiconcealed formed hinges is decorative and installed on the cabinet surface. This one is used with a lip edge door. (*APA-The Engineered Wood Association*)

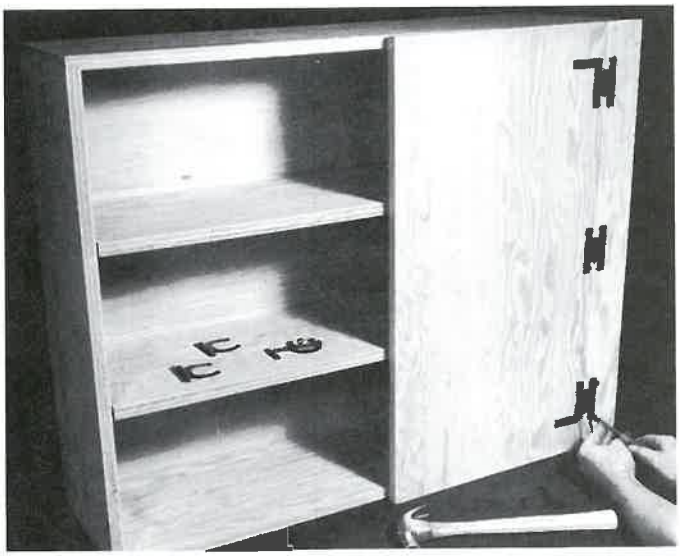


Figure 17-19. "H" and "HL" surface hinges are used on flush and some lip front cabinets. (*APA-The Engineered Wood Association*)

overlay front cabinetry. Overlay surface hinges have a 3/8" or 3/4" (10 mm or 19 mm) outset. Surface hinges are finished and often textured for decoration. "HL" hinges have an extra decorative leg.

Pivot hinges

Pivot hinges consist of two plates riveted together. A nylon washer is placed between the two plates to reduce friction when opening the door. Pivot hinges are used for flush overlay and reveal overlay fronts. Some have a wraparound support that fastens on the inside of the cabinet. When installed, only a narrow edge of the hinge can be seen.

The top and bottom of the door may be mortised when installing pivot hinges. See **Figure 17-20**. A kerf must be cut in the door if a middle hinge is to be installed.

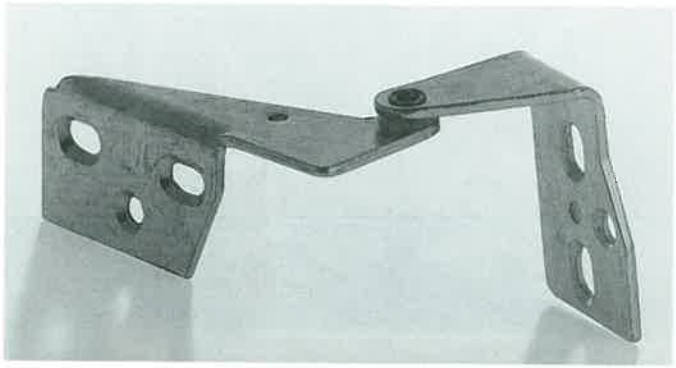


Figure 17-20. These doors are mortised for pivot hinges. (*APA-The Engineered Wood Association*)

Pin hinges

Pin hinges fit into holes drilled in the top and bottom inside surfaces of the cabinet. A nylon washer fits into the holes to prevent the hinge pin from wearing the wood. See **Figure 17-21**. The door is attached after the hinges have been fitted in the holes. Pin hinges are installed in flush front cabinets.

Invisible hinges

Invisible hinges consist of two metal cylinders with a lever mechanism between them. The two cylinders are inserted into holes bored in the edge of both door and side or frame. See **Figure 17-22**. To fully fasten the hinge, you must tighten the screws in the end of each cylinder. The screw forces the cylinder to expand. Some invisible hinges have two flanges per cylinder. This hinge can be mounted with wood screws. Once installed, and with the door closed, the hinge is hidden. The hinge can be seen only when the door is opened.

Invisible hinges are used for flush front cabinets, both with and without frames. Sizes begin at 3/8" (9 mm).

Concealed hinges

Concealed hinges, also called ***Euro-style hinges***, allow the door to be aligned accurately after it is installed. Set screws move the door up-and-down, in-and-out, and side-to-side. They are installed in reveal overlay, flush overlay, and flush fronts. Some models may be installed in lip doors. When the door is closed, the Euro-style hinge is not visible.

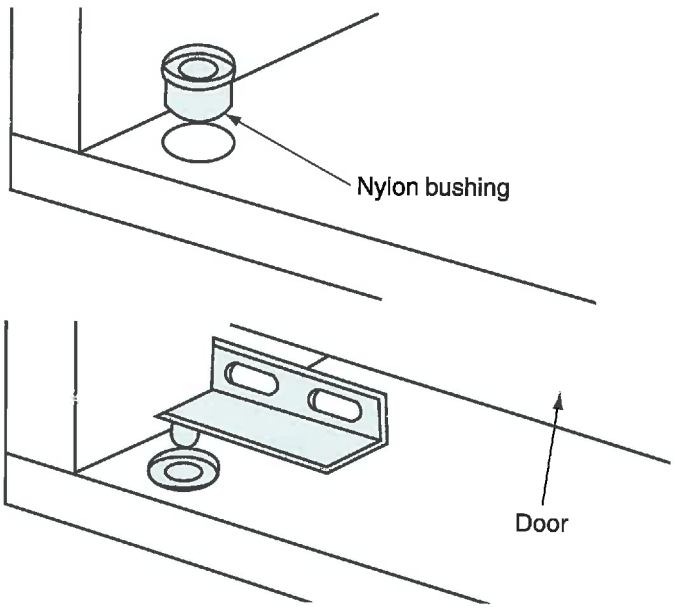


Figure 17-21. Pin hinges rotate in a nylon bushing. The door is secured from the back of the hinge.

Euro-style hinges consist of an arm and a mounting plate. The mounting plate is connected to the cabinet side. The arm is attached to the door. The arm has a *cup* that is inserted into a mounting hole. The cup is attached to the door with screws, plastic dowels, and various quick mount systems. See **Figure 17-23.** The arm then slides over the mounting plate and is fastened.

Once the arm is attached to the mounting plate, it can be adjusted. Several machine screws allow for up to 3/16" (4 mm) of overlay, depth, and height adjustment. See **Figure 17-24.**

These hinges and mounting plates come in many different styles to meet your needs. Full overlay, half overlay, inset, twin half overlay, and twin inset combinations are available. Angled

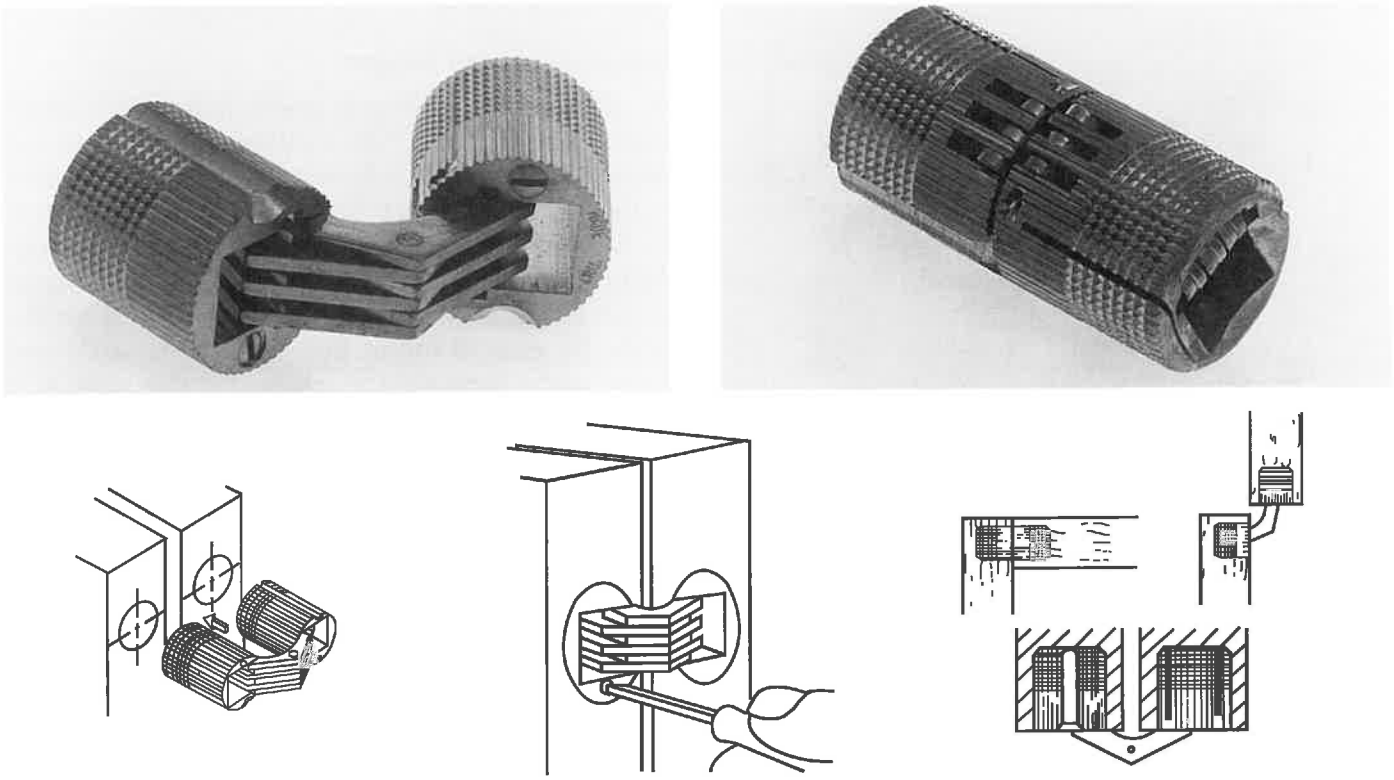


Figure 17-22. Left—Invisible hinges are inserted into mortised holes. (*Liberty Hardware*) Middle—Secure the hinges with screws. Right—Invisible hinges allow for 180° of motion. (*The Woodworker's Store*)

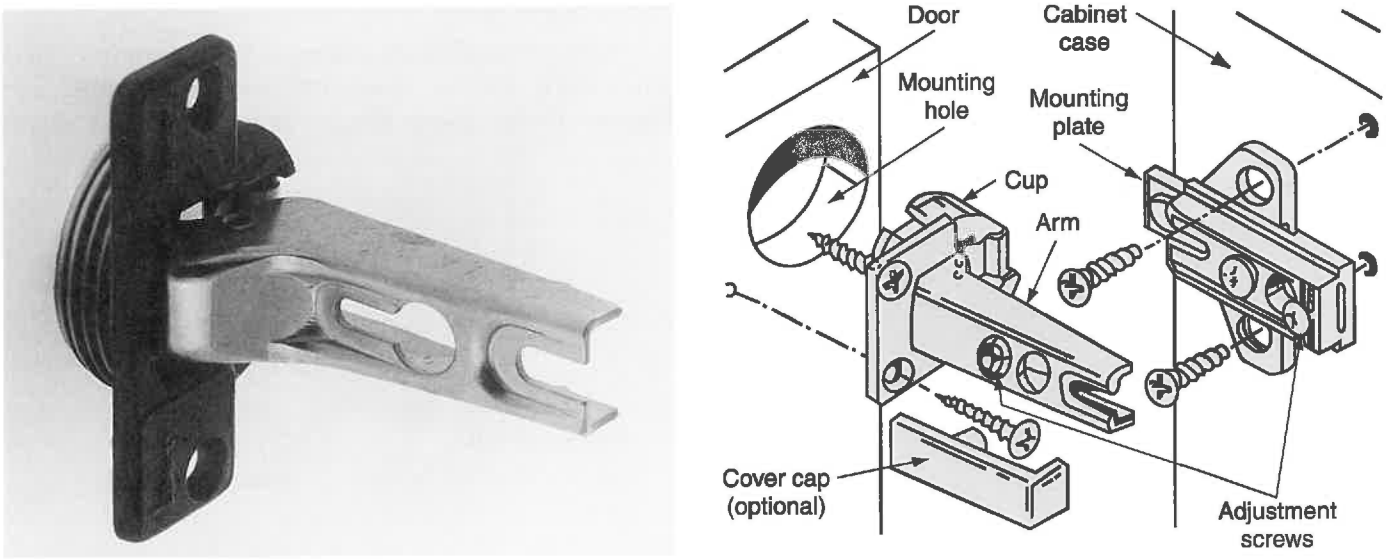


Figure 17-23. Components and mounting diagram of a Euro-style hinge. (*Häfele America Co.*)

hinges and mounting plates and variable angle mounting plates enable any cabinet angle from -45° to +70° to be built.

Continuous hinges

Continuous hinges resemble a very long butt hinge, and are often referred to as ***piano hinges***. They are described by certain features shown in **Figure 17-25**. Hinge lengths are available in 1′ to 6′ (305 mm to 1829 mm) lengths. However, continuous hinge is also available in a 100′ (30.5 m) coil. Cut the length you need with a hacksaw. Then file away the sharp edges and saw marks.

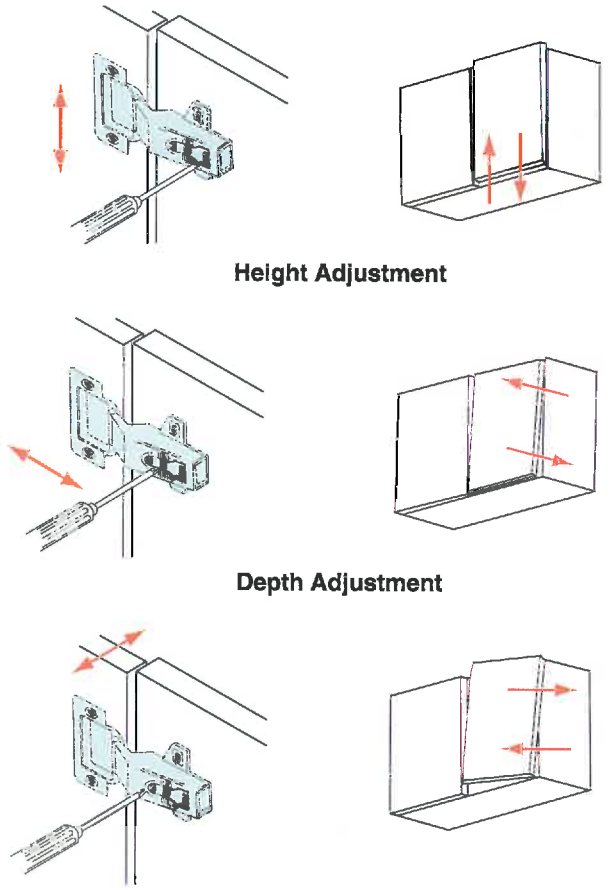


Figure 17-24. Concealed hinges allow for three-way door adjustment.

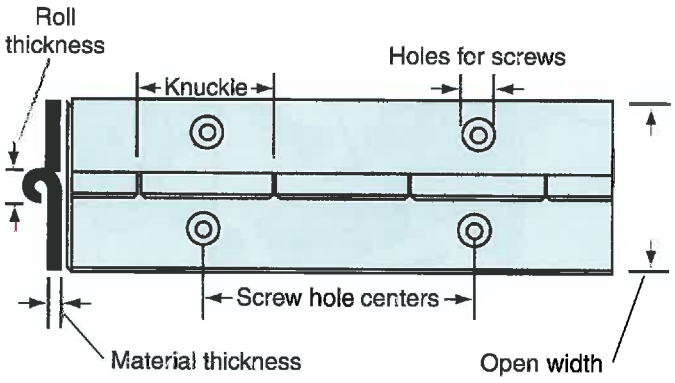


Figure 17-25. A continuous hinge is specified according to certain standard dimensions. (*Häfele America Co.*)

Hinges for glass doors

Hinges for glass doors may hold the glass by friction or screws. For some screw mounted hinges, glass drilling may be necessary. Three glass hinge styles are pin, side mount, and Euro-style.

Glass door pin hinge

Glass door pin hinges resemble those for wood doors. See **Figure 17-26**. Drilling the glass is not required. You drill a hole inside the top and bottom surfaces of the cabinet. Then press a nylon bushing in the hole. Hinges are mounted in the bushings first. Then, the glass is inserted into the U-shaped hinge leaf that has one or two set screws on the back. Be sure to locate the rubber (press-on) and metal pads between the glass and the screws. It prevents the glass from slipping. It also prevents glass breakage when the screws are tightened. Turn the screws only snug enough to keep the glass from slipping out of place.

Side mounted glass door hinge

Side mounted glass door hinges are attached on the insides of the cabinet with screws. See **Figure 17-27**.

The glass fits into the U-shaped hinge. A screw and pad holds the glass in place. Side mounted glass hinges may be adjustable. The mounting holes are oblate. This permits the hinge to be moved before the screws are fully tightened.

Euro-style glass door hinges

Euro-style glass door hinges resemble concealed Euro-style hinges used for wooden doors. See **Figure 17-28**. These hinges are suitable for sheet

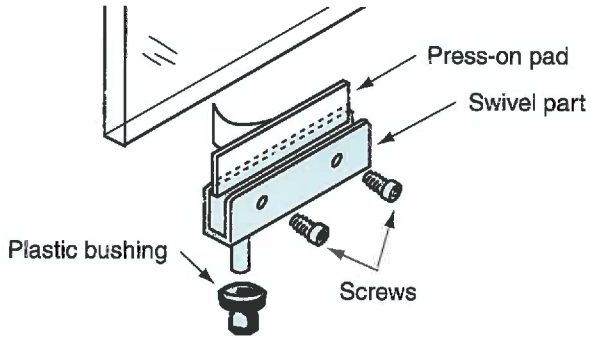


Figure 17-26. Glass is held in a glass door pin hinge by two set screws. (*Häfele America Co.*)

glass or plastic. Thickness can vary from 3/16" to ¼" (5 mm to 6 mm). The mounting plate is screwed into the side of the cabinet. The arm attaches the glass to the mounting plate. A hole must be bored in the glass. The cup part of the arm fits through the glass. Mounting screws are inserted from the back side of the glass, through the hole, and into a front plate. As the screws are tightened, the front plate draws against the arm, holding the glass between the two.

Use untempered glass only with these hinges. Boring must be done in glass that is considered soft. Otherwise, the corners of the glass would melt away because of the high temperatures.

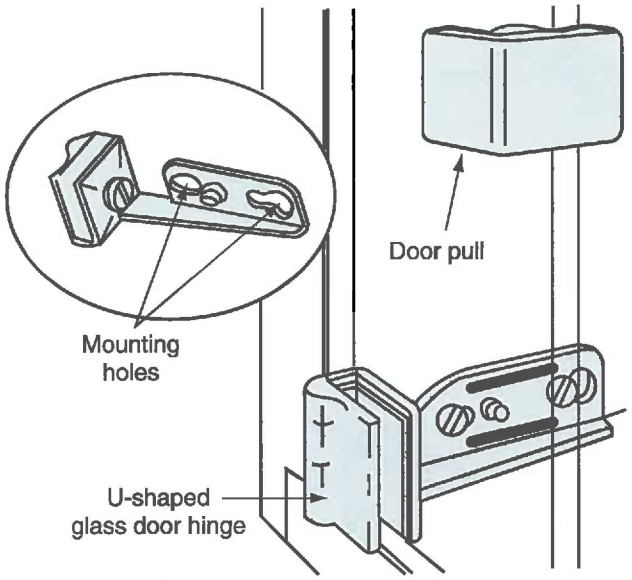


Figure 17-27. Oblate mounting holes make glass door hinges adjustable. (*The Woodworker's Store*)

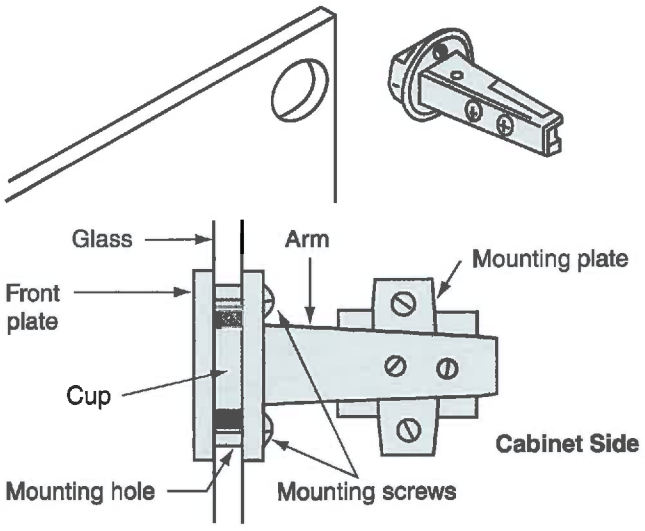


Figure 17-28. Euro-style glass door hinges require bored mounting holes. (*Häfele America Co.*)

Pulls for glass doors

Pulls for glass doors typically slip around the edge of the glass. See **Figure 17-29**. Some are held in place by friction. Others are secured with a set screw.

Hinged door catches

Catches keep doors closed either mechanically or by magnetism. Catches are two-part assemblies. A catch mounts on the cabinet. A strike is fastened to the door. The strike fits into the catch when the door is closed.

Friction catch

A friction catch consists of a bent spring steel catch and a ball head screw used as a strike. See **Figure 17-30**. As the door closes, the ball head is wedged in the catch.

Roller catches

There are single and double roller catches. Single roller catches have one roller and a hook shaped strike. Double roller catches have two rollers and a spear or round shaped strike. See **Figure 17-31**.

Bullet catch

A bullet catch consists of a bullet shaped, spring operated catch. It mounts into a hole drilled in the edge of the cabinet face or in the door. The strike is cup shaped. See **Figure 17-32**.

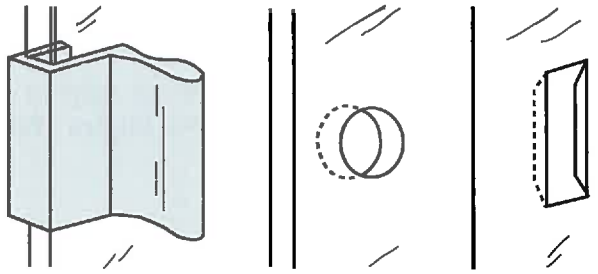


Figure 17-29. Glass door pulls may slip on. They can also be drilled or ground into the glass.

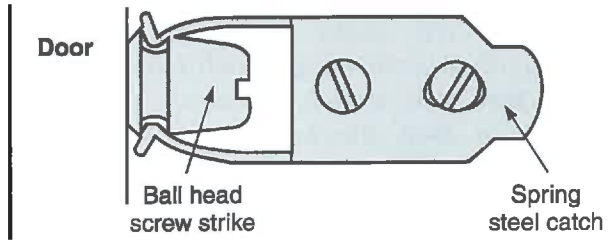


Figure 17-30. There are no moving parts on a friction catch.

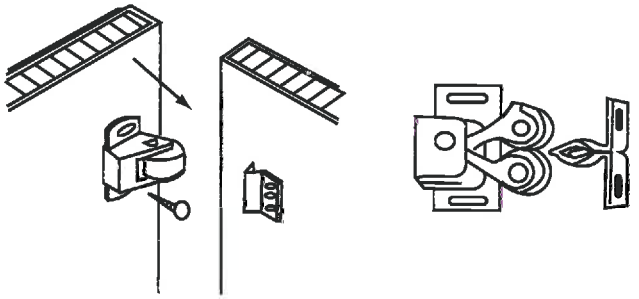


Figure 17-31. Roller catches. Left—Single roller catch. (*Häfele America Co.*) Right—Double roller catch. (*The Woodworker's Store*)

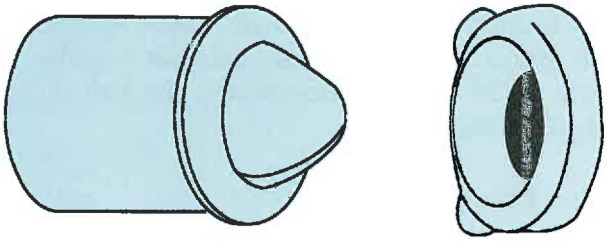


Figure 17-32. Bullet catch. (*The Woodworker's Store*)

Elbow catch

An elbow catch hooks onto the strike. A spring action lever is pushed to release the catch. See **Figure 17-33.**

Ball catch

This catch consists of two springloaded balls with a strike between them. See **Figure 17-34.**

Magnetic catch

A magnetic catch has a permanent magnet that attracts a flat, plated steel strike. See **Figure 17-35.**

Spring catch

A spring catch includes a spring arm with a roller. When the door is closed, the roller seats in a concave strike. See **Figure 17-36.**

Latches

Latches are slight variations of catches. When the door is closed, the latch works as a catch to hold the door closed. However, if you press on the door face, the latch springs outward to open the door. Doors with latches do not require pulls since the hardware opens the door as well as holds it closed. Two types of latches are push and magnetic.

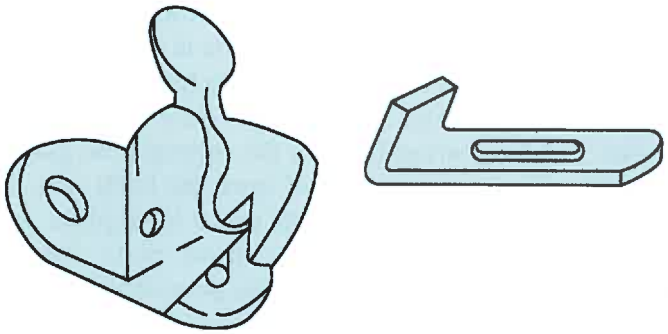


Figure 17-33. An elbow catch hooks onto a bent strike. (*The Woodworker's Store*)

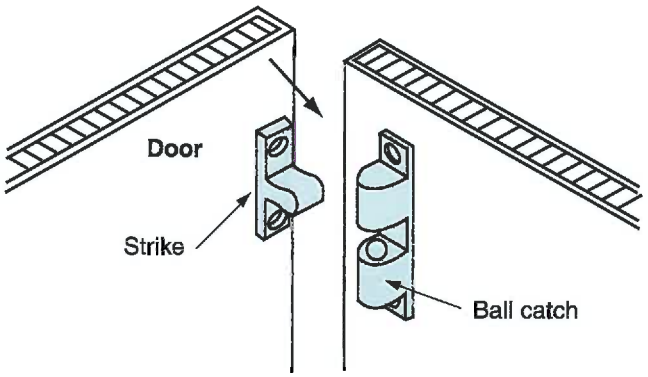


Figure 17-34. Ball catch. (*Häfele America Co.*)

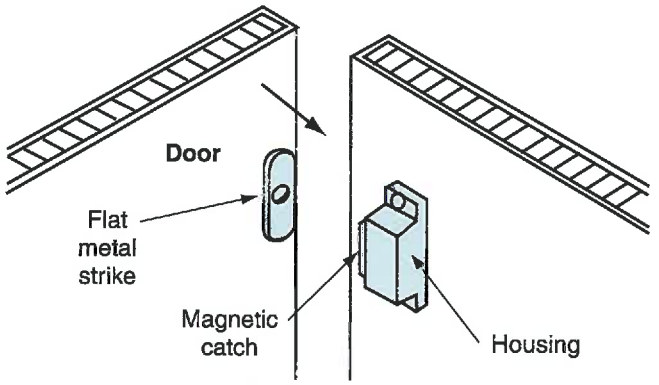


Figure 17-35. A magnetic catch includes a permanent magnet catch and flat, metal strike. (*Häfele America Co.*)

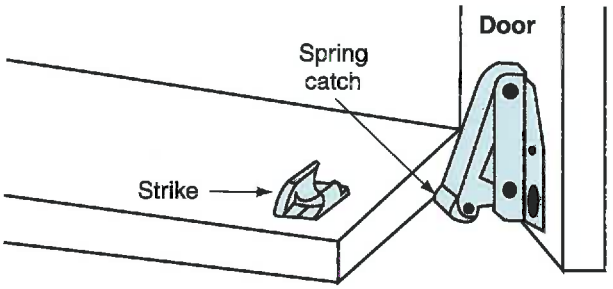


Figure 17-36. Spring catch.

Push latch

A push latch has a clawlike mechanism that grips the strike as the door is closed. See **Figure 17-37.** The claws release when you press against the door.

Magnetic touch latches

Magnetic touch latches hold the door closed with a permanent magnet. See **Figure 17-38.** The magnet is mounted in a spring mechanism. A slight push on the door trips the mechanism and forces open the door.

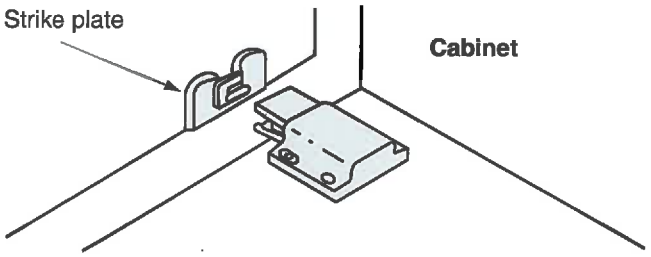


Figure 17-37. A push latch grips the strike when the door is closed. Pushing the door again releases the latch. (*Häfele America Co.*)

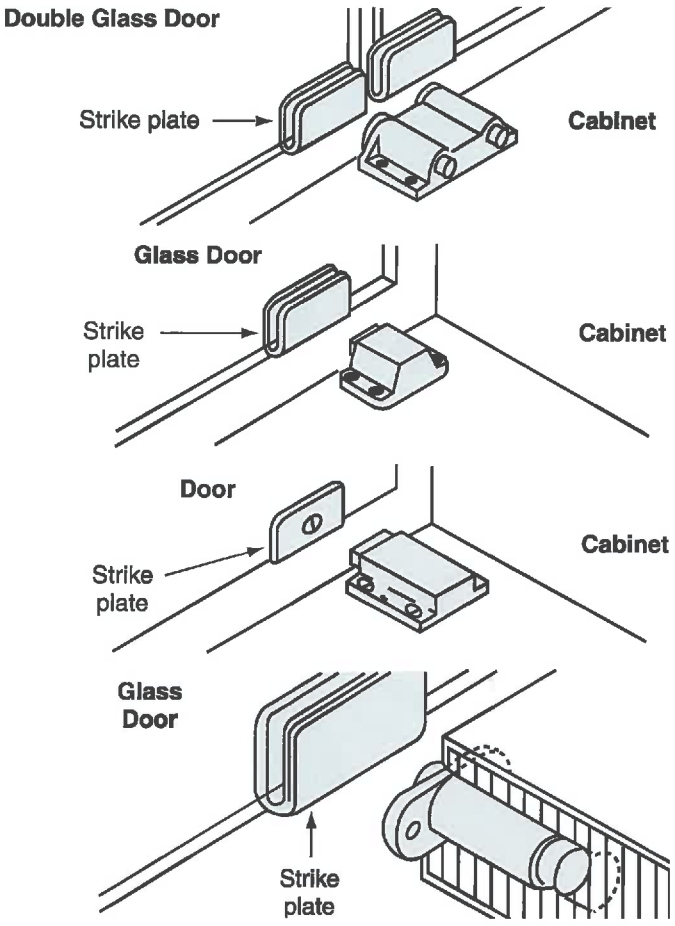


Figure 17-38. Various types of magnetic touch latches. (*Häfele America Co.*)

Drawer Hardware

Drawer hardware includes pulls, knobs, and slides. Matching pull or knob styles should be installed on both the drawer faces and doors. Drawer slides allow you to pull out a drawer with ease. Most slides move on plastic rollers or ball bearings.

Slide extension

Drawer slides may be standard, full extension, or full extension with over travel. With ***standard slides***, all but 4" to 6" (102 mm to 152 mm) of the drawer body extends out of the cabinet. ***Full extension slides*** permit the entire drawer body to extend out for easy access. Some full extension slides will feature an over extension capacity. They are often used for file drawers. By extending beyond the cabinet 1" to 1½" (25 mm to 38 mm) hanging file folders can easily be removed. Be cautious when designing freestanding cabinets with full extension and telescoping slides. A heavily loaded drawer could easily tip over the cabinet. No problem exists with cabinets fastened to the wall. A freestanding file cabinet with two, three, or four drawers may be fitted with mechanical anti-tip devices. These devices permit only one drawer at a time to be open.

Capacity

Load capacity of a drawer slide refers to how much weight it can hold. Two ratings are used; static and dynamic. Static ratings are based on short term edge loading when the drawer is extended halfway. Dynamic ratings are based on the ability of the slide to move a load throughout 100,000 open and close cycles. Categories are as follows:

- ***Light duty (residential slide).*** 50 pound (22.7 kg) static load capacity.
- ***Medium duty (commercial slide).*** 75 pound (34 kg) static load capacity.
- ***Heavy duty.*** 100 pound (45.4 kg) static load capacity.
- ***Special extra heavy duty.*** Greater than 100 pound (45.4 kg) static load capacity.

Mounts

Drawer slides are most often mounted on the side of the cabinet. See **Figure 17-39.** Each slide consists of two tracks. The tracks are separated by rollers or ball bearings to ease movement. One track is attached to the inside of the cabinet and is called the ***cabinet track***. The other mounts to the outside of the drawer and is called the ***drawer track***.

Other styles include top mount, bottom mount, and single track. ***Top mount slides*** are commonly used on under-the-counter drawers. ***Bottom mount slides*** are used with both drawers and pull-out shelves. Bottom mount slides are usually telescoping. See **Figure 17-40.** One common single track device is the single track and ***tri-roller slide.*** See **Figure 17-41**. Slide guides are used with wooden single track slides. See **Figure 17-42.**

Shelf Supports

Shelf supports are small sized rods, brackets, or flat spoons that hold shelves. Supports are inserted into the sides of the cabinet. Different styles are available. See **Figure 17-43.**

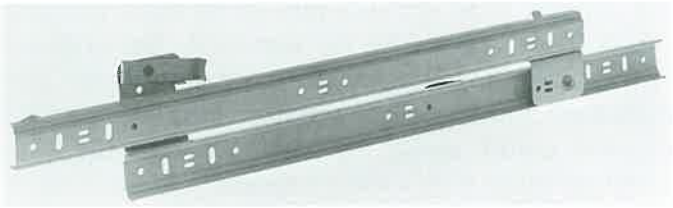


Figure 17-39. Most side mount drawer slides consist of two tracks. The forward roller, located on the cabinet track, supports the weight of the drawer. The rear roller, located on the drawer track, prevents the drawer from tipping forward when it is extended.

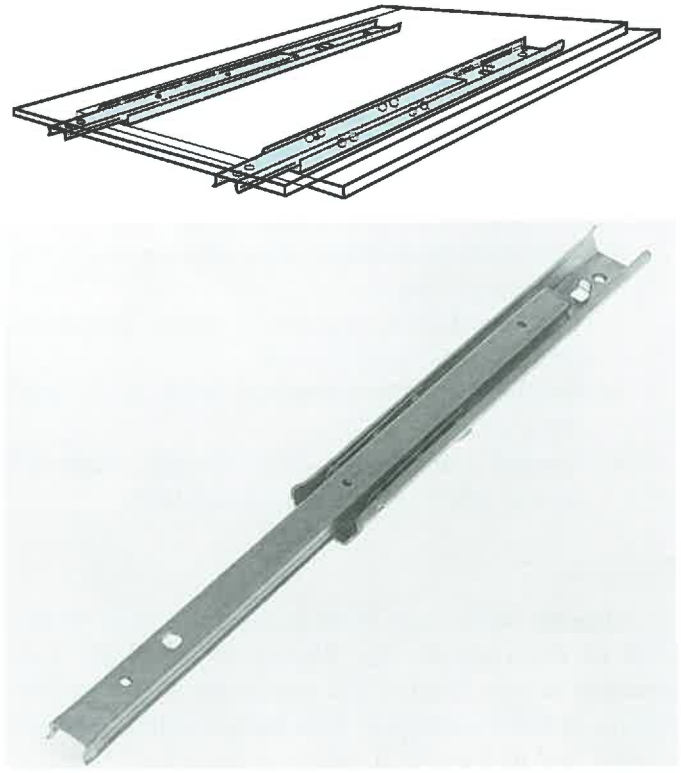


Figure 17-40. Bottom mount slides are commonly used for pull-out shelves. (*Liberty Hardware*)

Typically shelf supports are inserted into evenly spaced holes drilled in the cabinet side. The more holes you drill, the greater the possible shelf adjustments. See **Figure 17-44**. Line boring machines provide accurate spacing of holes. Heavy wooden shelves, common in wall units, may be supported with two-part fasteners. See **Figure 17-45A**. When the shelf is installed, the inclined contact surfaces of the two elements pull the shelf tightly against the side panel. See **Figure 17-45B**.

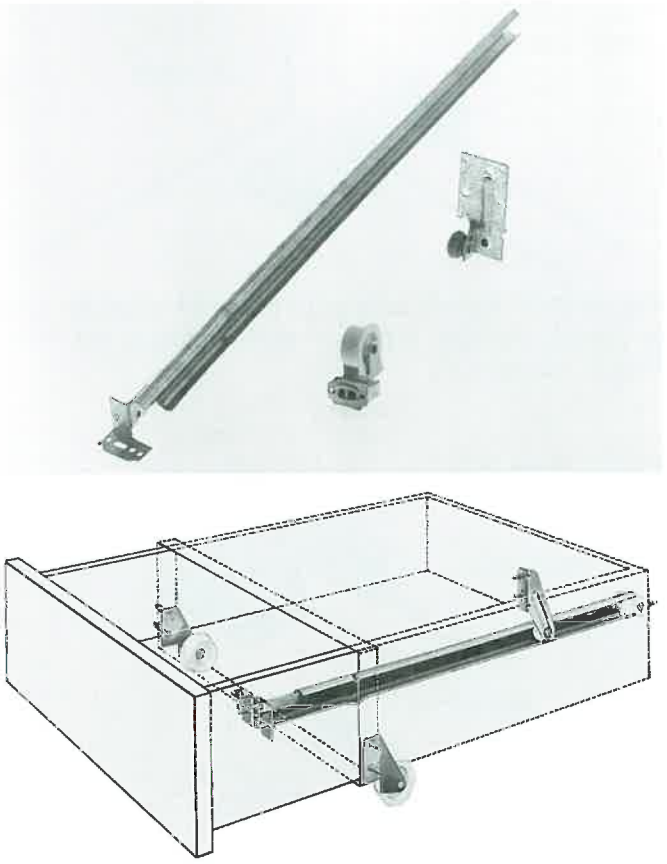


Figure 17-41. Single track and tri-roller slides are more complicated than standard side mount slides. (*National Lock*)

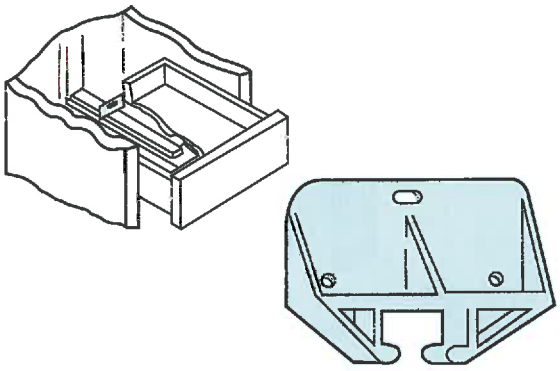


Figure 17-42. Plastic slide glides prevent wood-to-wood contact. (*The Woodworker's Store*)

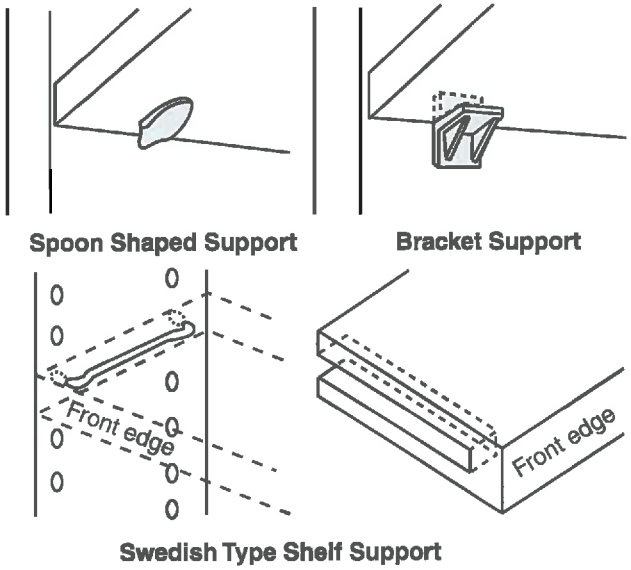


Figure 17-43. Four types of shelf supports. (*Häfele America Co.*)

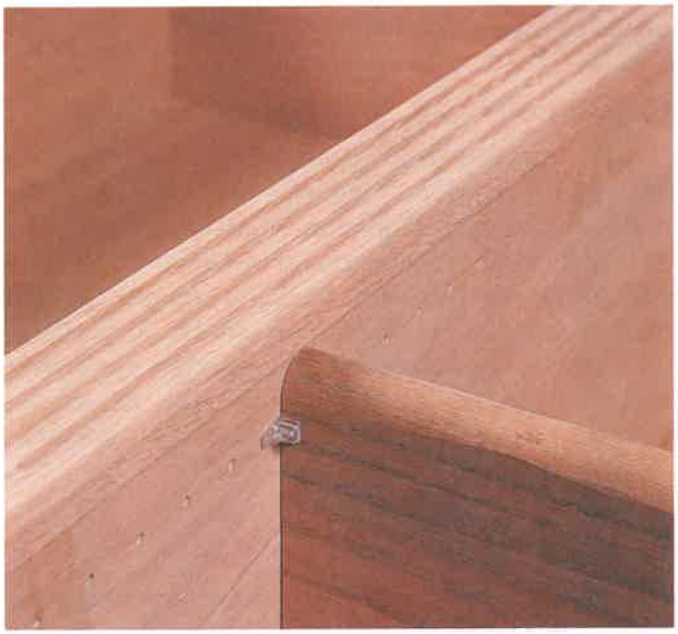


Figure 17-44. Height adjustments are limited by the number and spacing of holes. The distances between these holes are 32 mm on center. (*Chuck Davis Cabinets*)

Shelf supports may also fit a ***shelf support strip***, often called a *pilaster*. See **Figure 17-46**. Two support strips on each side allow for many height locations. Install strips either on the surface or in a routed groove with screws or adhesive. Supports must match the rectangular or round holes.

Locks

Locks are installed in doors and drawers to protect contents. Three types are common: bolt action,

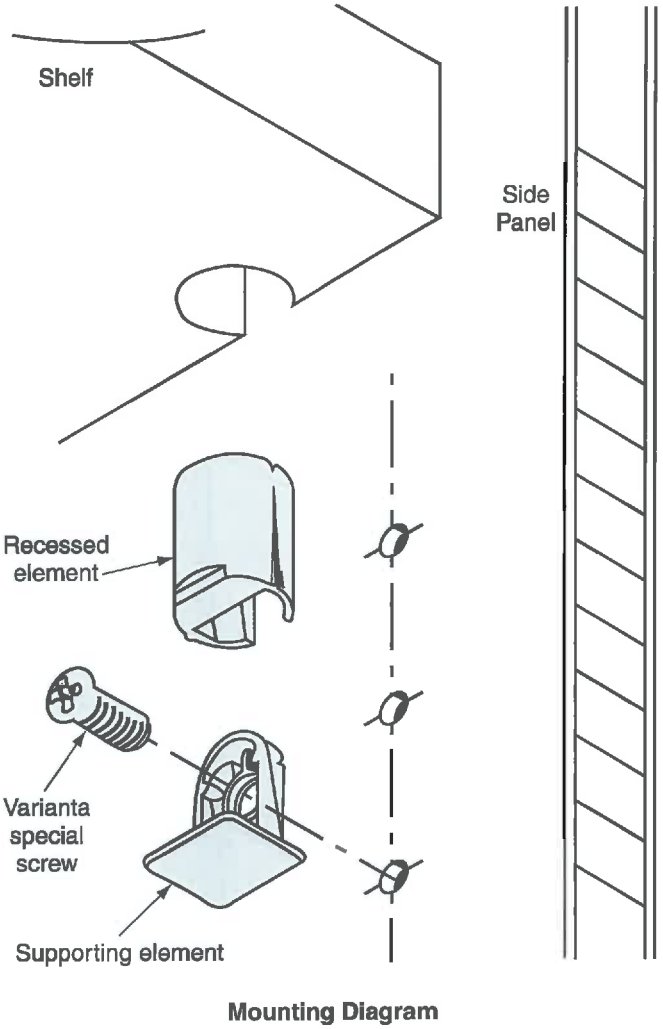


Figure 17-45. Heavy-duty shelving support. A—Careful drilling of the holes assures satisfactory installation. (*Häfele America Co.*) B—The support is almost hidden. (*Chuck Davis Cabinets*)

cam action, and ratchet action. See **Figure 17-47.** When the key is turned in a ***bolt action lock***, the bolt moves in a straight line. A ***cam action lock*** rotates a flat metal arm into a slot. The body of a cam action lock is flat on one or both sides. This keeps it from rotating in similar shaped holes punched in metal cabinet doors and drawers. Spur washers provide this function for use in wood applications. ***Ratchet action locks*** secure glass sliding doors. No drilling is needed.

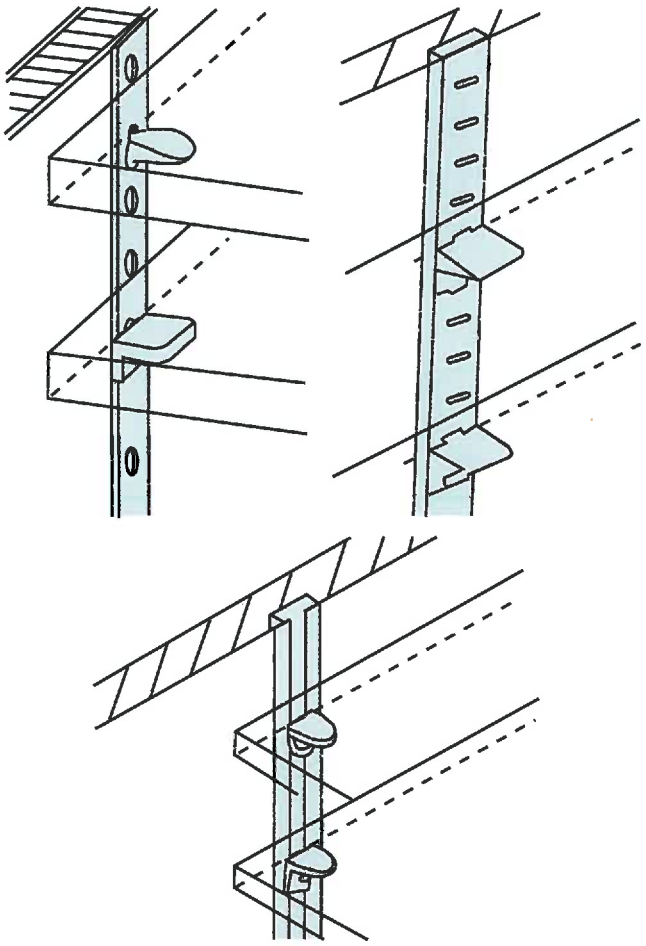


Figure 17-46. Shelf support strips may be flush mount or inset, with rectangular or round holes. (*Häfele America Co., Liberty Hardware*)

Generally lock bodies are a standard diameter (¾" or 19 mm); however, they vary in length. Different lengths are provided for different applications. The length required is determined by a combination of the door or drawer front thickness, and lipped or overlay construction.

Casters

Casters are mounted on cabinet bottoms or leg ends for mobility. They may be single or dual wheel. Some have a brake lever to prevent cabinet movement. Casters may be installed with pins and sleeve, mounting plates, or threaded bolts. Pin and sleeve casters require a sleeve-sized hole in the cabinet bottom. Some are of slim proportions for use in wooden legs. See **Figure 17-48A**. Plate mounted casters require screws to attach the mounting plate to a flat surface. See **Figure 17-48B**. Threaded bolt casters require holes to be bored through the cabinet bottom. Use bolts when the inside bottom is hidden.

Bed Hardware

Bed frames usually are assembled with two-piece ***bed rail*** hardware. See **Figure 17-49**. A set of four is required. One part of the connector contains holes. It is mortised into the footboard and headboard. The other part of the connector has hooks. It mounts on both ends of each bed rail. Bed connectors are designed for quick and easy assembly. Some connectors are surface mounted. They lock together and do not require bedpost or frame mortising. Casters are sometimes installed in the ends of the legs.

Lid and Drop Leaf Hardware

Lid and drop leaf table hardware includes hinges, lid supports, and lid stays. Hinges allow a table leaf to fold down or a lid or table leaf to fold up. See **Figure 17-50.** ***Lid supports*** prevent lids from dropping too far. An adjustable brake may control

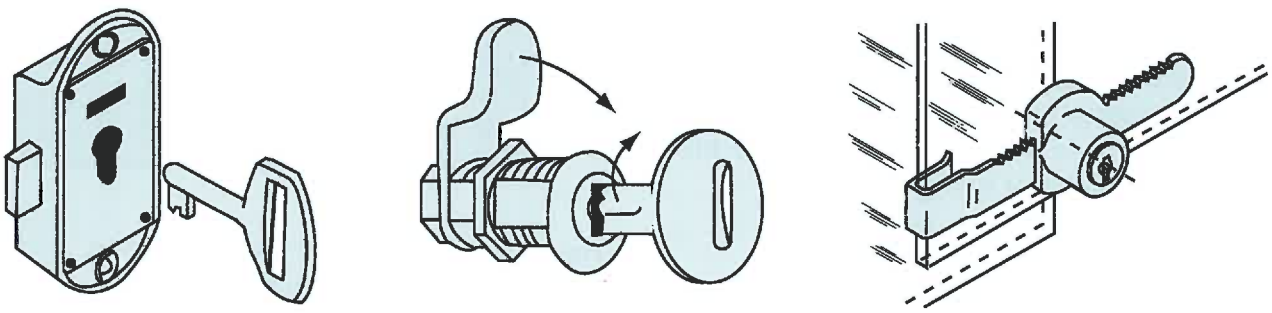


Figure 17-47. Three types of locks. Left—Bolt action. Middle—Cam action. Right—Ratchet action. (*Häfele America Co.*)

A

B

Figure 17-48. A—Casters may be pin and sleeve mounted. B—Similar casters are plate mounted. (*Chuck Davis Cabinets*)

the speed at which the lid may fall. These are common on desk lids. See **Figure 17-51.** ***Lid stays*** support lids or table leaves. See **Figure 17-52.**

Furniture Glides

Furniture glides protect the bottoms and legs of freestanding cabinetry. They raise the cabinet or legs slightly off the floor. This prevents cabinet chipping and lessens damage to the floor when the item is moved. Also, since glides are harder and smoother than the cabinet material, reduced friction between the cabinet and the floor makes it easier to move. Glides nail in or are inserted into a drilled hole. See **Figure 17-53.**

Furniture Levelers

Furniture levelers serve two purposes. See **Figure 17-54.** They allow height adjustment to make the product stable on an uneven surface. They also act as glides. Levelers may screw into an insert nut. They may also attach underneath the cabinet with wood screws.

Kitchen and bath base cabinets may be supported and leveled with leg leveling systems. See **Figure 17-55.** The system is made up of several components.

A socket that mounts to the bottom of the cabinet. Several styles are available; some attach with a hollow bolt.

A three piece leveler, has a 4″ to 6″ (102 mm to 152 mm) height adjustment. Adjustments can be made with a long screw driver inserted through the bolt, inserting a screw driver in the slots in the foot, or by gripping the adjuster foot.

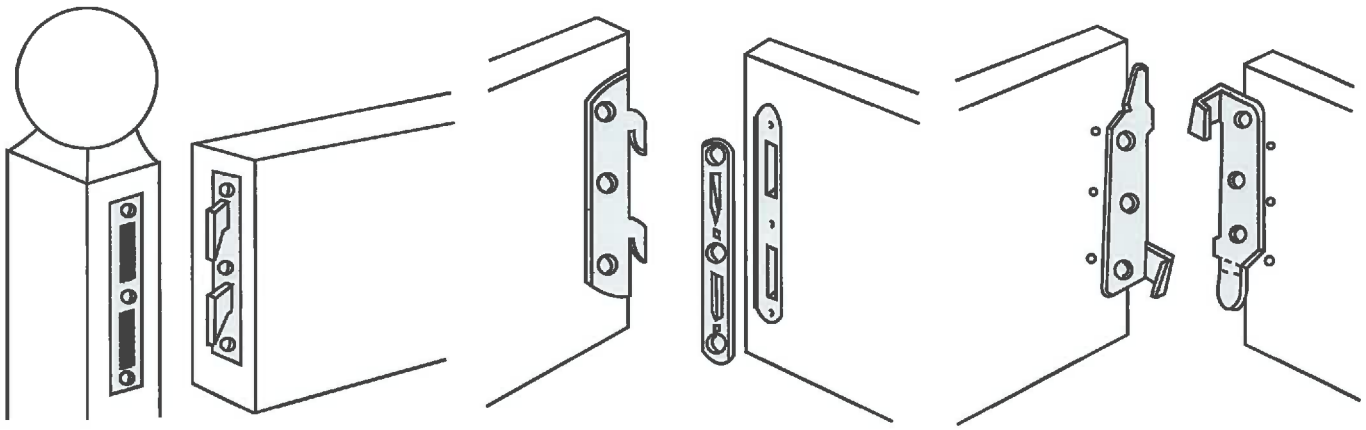


Figure 17-49. Beds are assembled with hooklike hardware. Connectors may be mortised into the rail or installed on the surface. (*Liberty Hardware, Häfele America Co.*)

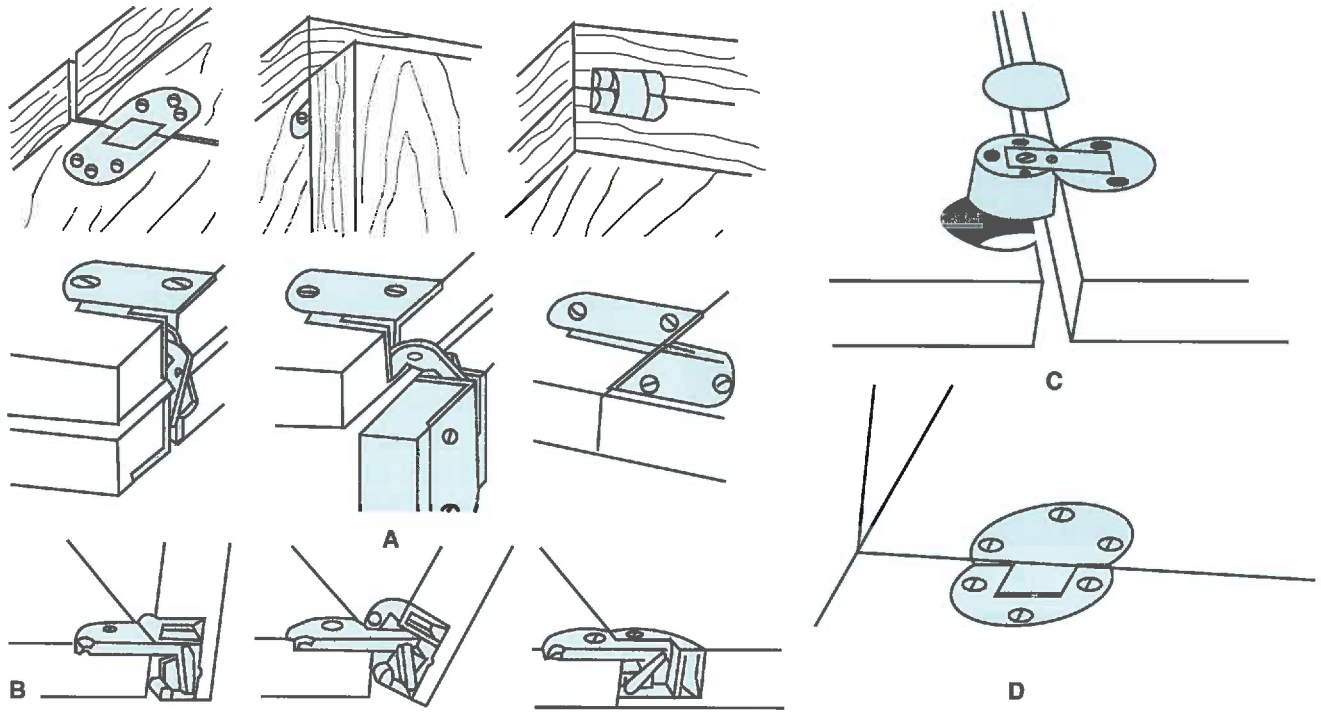


Figure 17-50. A—Hinges for desk lids and drop leaf tables. B—Hinge folds down and under the table. C—Hinge folds up and over the table. D—Flap hinges are often used for desk lids. (*Häfele America Co.*)

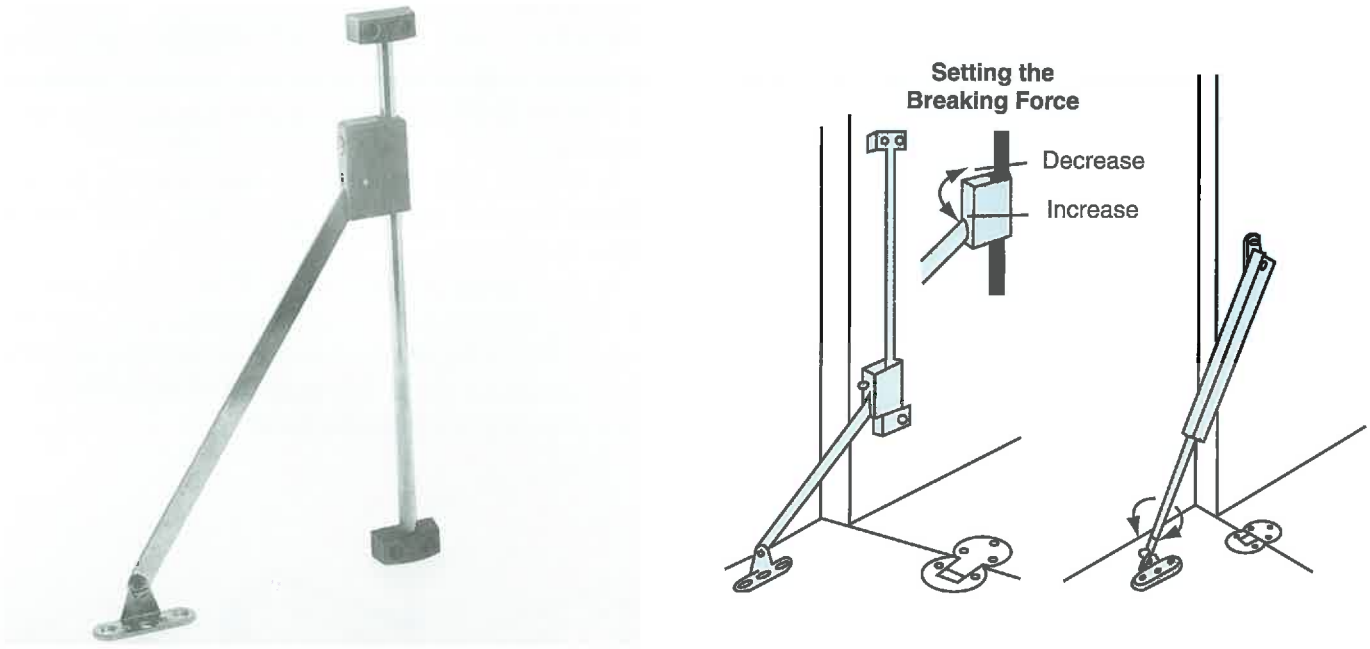
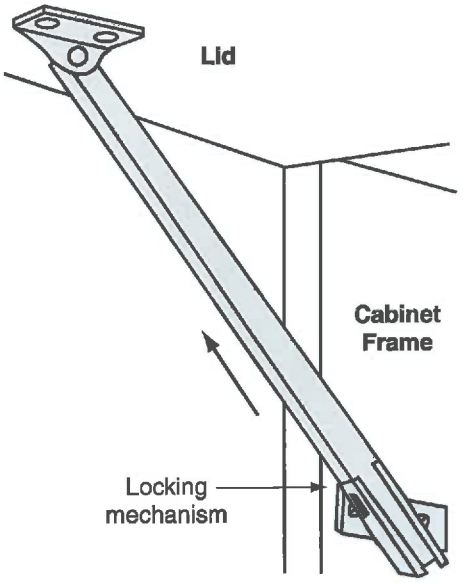


Figure 17-51. Lid supports have a brake to prevent the lid from dropping too fast. (*Häfele America Co.*)

Toe kick clips, screw, or groove mount variations.

There are many reasons to use these systems:

- The cabinets may be installed before the finish floor is installed. Adjust the legs long enough so that your countertop will be the correct distance from the top of the finished floor.
- Installation is faster because no shimming is necessary.
- Material is saved by eliminating the toe kick notch in side panels.
- The plastic sockets are used as skids between assembly and installation.
- The toe kick is attached with clips that slip on the legs. See **Figure 17-55**. Install the kick after the flooring or carpet is installed. Adjustment is up or down and left or right.



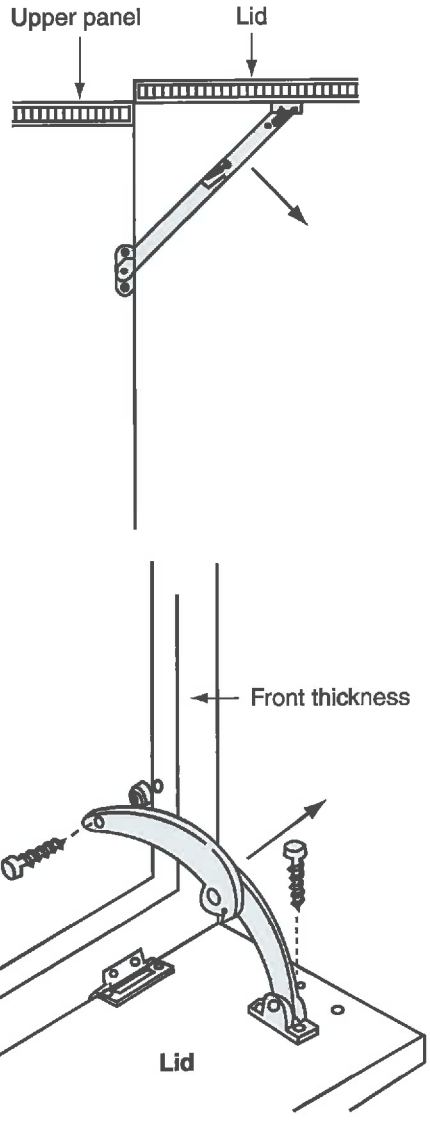


Figure 17-52. Lid stays may slide or fold to lock into place. (*Häfele America Co.*)

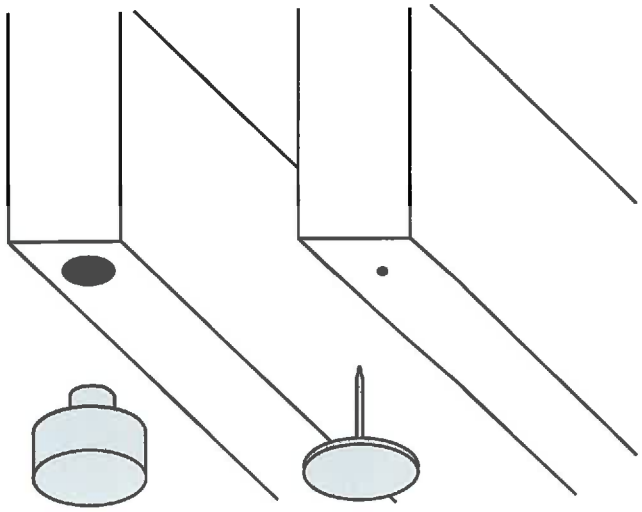


Figure 17-53. Glides prevent the bottom of the cabinet from chipping or marring the floor.

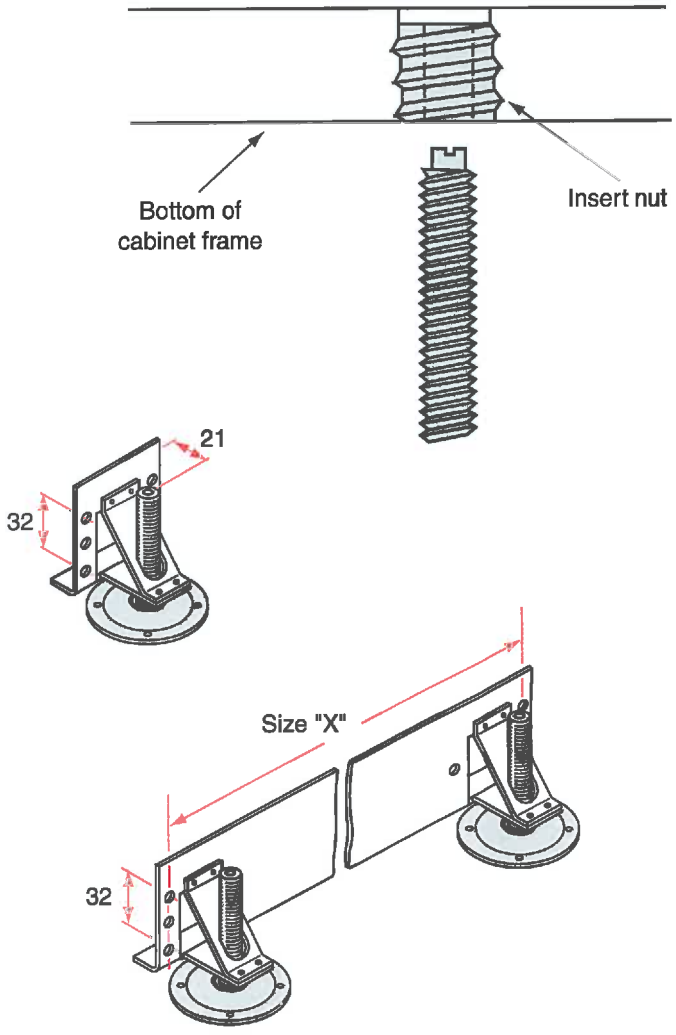


Figure 17-54. Levelers can be adjusted to keep the cabinet from wobbling. They may screw into a bracket or into an insert nut in the bottom of the cabinet. (*Häfele America Co.*)

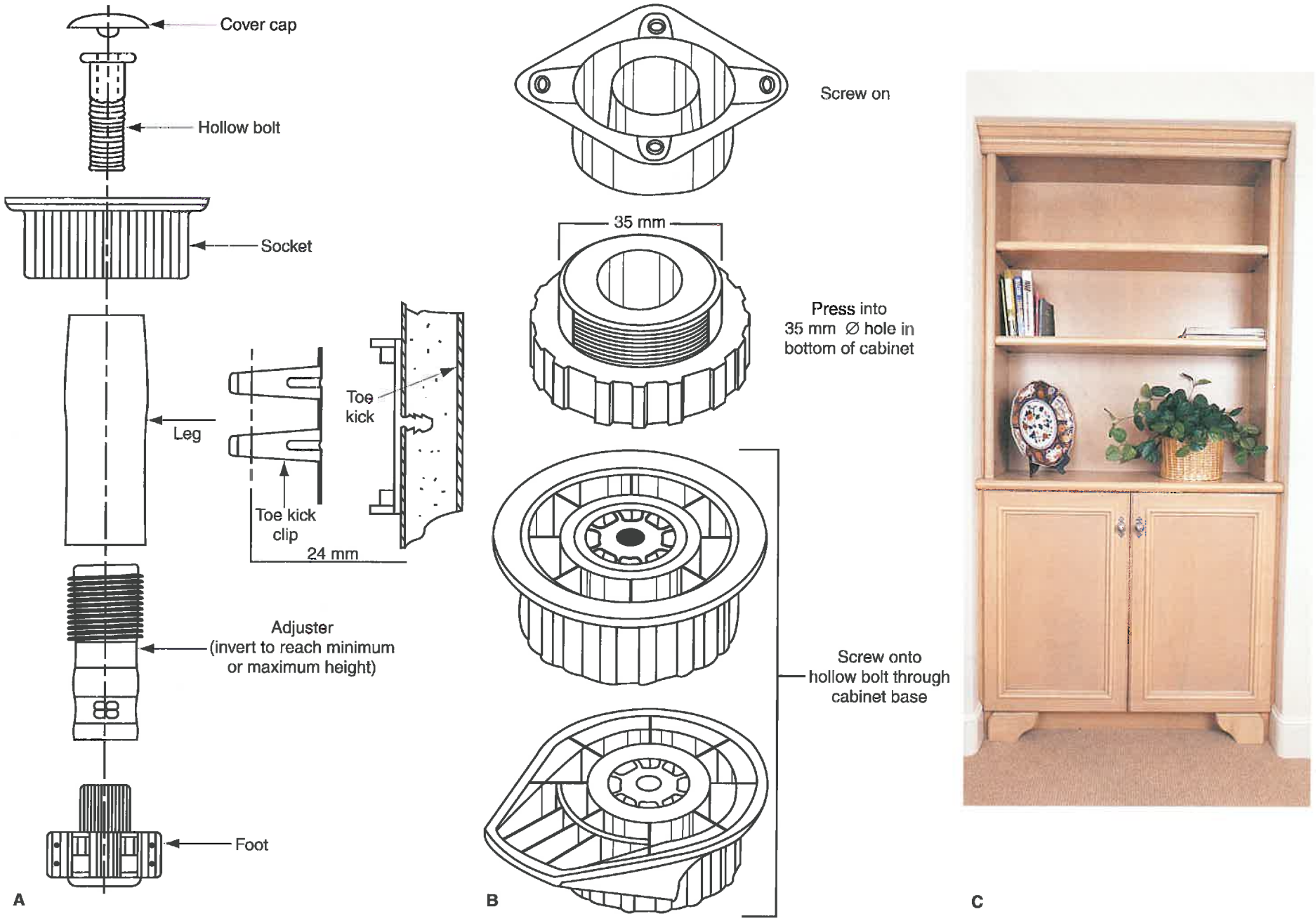


Figure 17-55. Cabinet levelers. A—Essential components of a Camar® cabinet leveler. (*Peter Meier, Inc.*) B—A variety of sockets. The wide flange socket can support two adjoining cabinets. (*Peter Meier, Inc.*) C—The toe kick and *faux* legs clip onto the levelers under this cabinet. (*Chuck Davis Cabinets*)

Summary

Hardware adds convenience and beauty to cabinetry. Pulls and knobs assist you when opening doors and drawers. Most are decorative. Door hardware includes hinges and sliding tracks. Many varieties of hinges are available. They may be visible, semiconcealed, or hidden completely. Choose them according to the cabinetry style you intend to build. Catches hold hinged doors closed either mechanically or by magnetism. Latches both hold the door closed and help to open the door. Drawer slides are selected according to extension, capacity, and type of mount. Shelf supports are small rods or brackets that hold shelves. They may be inserted into a shelf strip or directly into holes in the cabinet sides. Locks are installed to protect contents of the cabinet. Common lock types are cam action, bolt action, and ratchet action. Casters are mounted on cabinet bottoms for mobility. Drop lids and drop leaf tables require hinges as well as lid supports and stays. Furniture glides protect the bottom of the cabinet from chipping. Furniture levelers permit you to stabilize cabinets on an uneven surface.

The metal bail pulls are a decorative accent to this secretary. (*Thomasville*)

Test Your Knowledge

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

1. Sliding doors use ____ pulls.
2. Describe the similarities between bail pulls and ring pulls.
3. Why do lower sliding door tracks have a ridge on which the door slides?
4. The height of the sliding door is affected by _____ and _____.
5. Diagram five cabinet front styles. How do they determine the appropriate type of hinge?

On a separate sheet of paper, match the following hinges to their description (Use numbers 6 through 15):

a. Continuous hinge
b. Euro-style hinge
c. Formed hinge
d. Invisible hinge
e. Mortised butt hinge
f. Nonmortised butt hinge
g. Pin hinge
h. Pivot hinge
i. Semiconcealed formed hinge
j. Surface hinge

6. Flaps are bent around the door and/or the frame. Often used for flush overlay doors.
7. Flaps bent around frame and door. Visible part of hinge is finished to enhance cabinet appearance.
8. Fully adjustable hinge. Requires mortising in door.
9. Holes are drilled in the top and bottom inside surfaces of the cabinet. Hinge fits into hole using a nylon bushing.
10. Least visible hinge. Fits into two holes mortised in the edge of the door and inside surface of the cabinet.
11. May be sold in 50′ (15 m) coils.
12. Most visible hinge. May be shaped in "H" or "HL" pattern.
13. Outer flap connected to the frame. Inner flap connected to the door. Designed for flush and reveal overlay fronts with face frame.
14. Two flaps connected by a pin. Must be mortised into the door and frame. Made for conventional flush fronts.
15. Two plates riveted together. Requires mortising the top and bottom, and middle hinge needs a saw kerf to fit properly.
16. Which glass door hinges do not require drilling the glass?
17. Explain how glass door pulls are different from wood door and drawer pulls.

18. A hinged door catch has two parts: the _____ and _____.
19. Select drawer slides according to _____, _____, and _____.
20. Most drawers are mounted with _____.
21. Which type of lock requires no boring?
22. Describe the hardware you would choose to mount a drop lid for a secretary desk.
23. Nail guides are inserted in the bottom of the cabinet to prevent _____.
24. Explain the function of furniture levelers.

Health and Safety

Objectives

After studying this chapter, you will be able to:

- Identify unsafe acts.
- Explain how to reduce or eliminate hazardous conditions around machines and equipment.
- Handle and store materials properly.
- Explain procedures to follow if accidents occur.

Important Terms

Class A fire
Class B fire
Class C fire
dust collection system
electrical grounding
enclosure guard
exhaust system
fire extinguisher
flame arrestor
flash point
hazardous conditions
interlocking guard
nonskid mat
point-of-operation guard
unsafe acts

No workplace is perfectly safe. All you can do is to make it as risk-free as possible. There are many health and safety concerns for cabinetmakers. They include protecting yourself as well as looking out for others. Always have a well planned, organized, and controlled safety program. Accidents occur as the result of unsafe acts and hazardous conditions. These two problems result in accidents and injuries. Data for all kinds of industrial injuries are listed in **Figure 18-1**.

You cannot reduce risks simply by *being more careful so accidents don't happen*. This is only one part of the approach to safety. You must always be aware of your surroundings. Machines are only one of the causes for accidents and injuries. You must be alert to all types of hazards. Use common sense when handling materials and operating machines. Always read and follow:

- Labels on containers.
- Safety instructions for operating machines.
- Caution signs posted in the workplace.
- Written (and verbal) warnings about cabinetmaking processes and products.

Instructions and warnings are provided for your benefit. They are there as reminders while you work. Producers of materials and equipment want you to use their products in a risk-free and productive manner.

Unsafe Acts

Individuals often work carelessly or under physical or emotional stress. Working under these conditions may cause people to perform ***unsafe acts***.

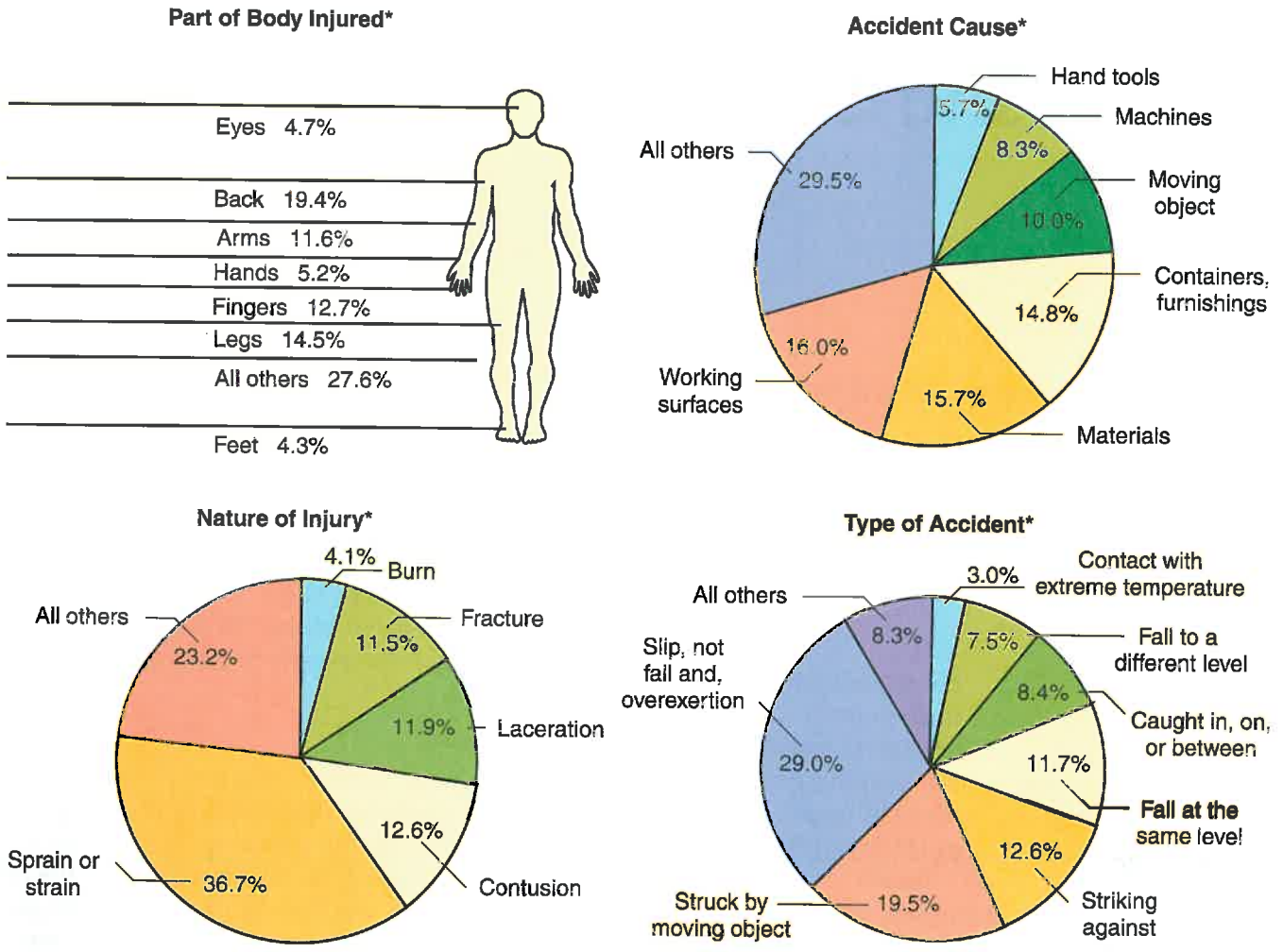
Carelessness

Carelessness invites injury. People try to perform a machine operation without proper knowledge or thorough planning. See **Figure 18-2**. These acts often result in personal injury. Cuts and bruises might heal, but the loss of an eye or finger is permanent. In either case, recovery takes longer than it does to perform the operation properly.

The best preparation for any cabinetwork is to read, watch, and understand. Read all the information about the process. Then, if possible, watch another person perform the process. Lastly, if you have any questions, ask an expert. Learn to perform tasks skillfully rather than chance injury to yourself or someone else.

Stress

People often try to work while under physical or emotional stress. Physical illnesses, such as aches and pains, are distracting. Many operations require you to hold materials and tools tightly. Without adequate grip, an accident may occur. Mishaps caused by illness may result from, or lead to, emotional stress. Emotional stress, such as feelings of anger or frustration, interferes with your concentration. If you have cut a workpiece too short three times in a row, take a break. Look for the true source of the problem. A wrong measurement or incorrect machine setup may have caused your problem.



*Based on lost time claims filed under the Ohio Workers' Compensation Law involving one or more days away from work.

Figure 18-1. There is a wide range of accident types and their causes. Accidents result in many kinds of injuries. (*Ohio Industrial Commission*)

Figure 18-2. Notice how this operator is standing to one side while operating this stationary planer. (*Delta International Machinery Corp.*)

Distractions

Avoid ***distracting*** others. Never talk to someone who is operating a machine. Wait until they are finished. Startling someone may be a painful mistake.

Tool handling

Handling and operating hand or power tools requires common sense. Carry sharp tools only by the handle. Never carry them in your pockets. Inspect all tools regularly. Handles should be tight and in good condition. Never carry a power tool by its cord. Before you start work, check power tool and extension cords for wear. If you are outside or in a wet location, make sure the cords are grounded and suitable for outdoor use. If possible, have all circuits equipped with ***ground fault circuit interrupters*** (***GFCIs***). These devices detect the slightest difference in the normal conditions of equal current in the hot and neutral wires, and disconnect the circuit.

Keep your hands away from blades, bits, and moving parts. Make setups only with the power disconnected. Be sure a tool is switched off before plugging in or unplugging. Concentrate when the machine is running. Machine guards will not guarantee total safety.

Some portable tools have a ***trigger lock***, which keeps the tool running even when you remove your hand. Use this feature only when you are able to maintain control during the operation or the tool is mounted in a stand. An unsupported tool could be wrenched from your hand. This may cause damage to your workpiece as well as injury to you and others.

After you finish using a certain tool or machine, leave it ready for the next person or operation. This means cleaning and storing hand tools. For machines, this includes unplugging them and cleaning off all debris with a cloth or brush. Reinstall the normal blade or bit if you have installed a special one. Put all guards in their protective positions.

Handling materials

Materials should be handled according to size, shape, and weight. Many back injuries occur when lifting items improperly. The items do not have to be heavy or bulky to cause injury. Lift with your knees bent, not your back. Keep your back straight and look forward, not down, when you lift.

Moving cabinetmaking materials may require two persons or a cart. Full sheet panel products, such as plywood, are awkward and often heavy. Long lengths of lumber can be difficult to move by yourself. Two people should carry large or heavy materials near machines in operation. A careless move could result in an accident and possible injury.

Hazardous Conditions

Hazardous conditions exist either because people lack the proper safety knowledge or have a poor attitude about safety. Nevertheless, they should be reduced or eliminated. Some conditions will be noticeably dangerous. Others are harder to detect.

Walking and working surfaces

Debris should be cleaned from any surface. Pick up and discard dust, shavings, or wood scraps from floors, tables, and machines. Treat liquid spills with absorbent compounds or dry wood chips. Remove the compound when the spill is absorbed. ***Nonskid mats, adhesive strips,*** or ***coating materials*** may be applied to the floor around working areas. See **Figure 18-3.** These reduce the slippery nature of concrete and wood floors.

Keep walkways clear. This is very important in case of an emergency, such as a fire. Outline aisles and walkways with yellow paint. Keep marked areas totally free of obstructions or materials.

Flammable liquids

Flammable liquids ignite easily, burn readily, and are difficult to extinguish. Vapors are apt to explode. In cabinetmaking, finishing materials and adhesives are often flammable. This makes them serious hazards for cabinetmakers.

Flammable liquids are categorized as shown in **Figure 18-4.** The class is determined by the flash point. The ***flash point*** is the minimum temperature at which the liquid vaporizes enough to ignite. Containers must be labeled according to the class. Class I liquids are the most dangerous because the flash point is within room temperature.

Figure 18-3. Nonskid mats cover slippery nature of concrete and wood floors. (*Lab Safety Supply Co., Inc.*)

Classifications of Hazardous Liquids

Class	Labeling	Flash Point	Liquids Included
Class I	Flammable	Below 100 °F (38 °C)	Acetone Benzene Ethyl alcohol Gasoline Lacquer thinner Mineral spirits Petroleum distillates Turpentine
Class II	Combustible	Between 100 °F (38 °C) and 140 °F (60 °C)	Kerosene
Class III	Combustible	Above 140 °F (60 °C)	Fuel oil

Figure 18-4. Know the potential hazards before using flammable liquids.

Preventive measures are necessary when using flammable liquids. You might use a lower class (higher flash point) or even a nonflammable liquid.

While filling flammable liquid storage cans, electrically ground them with a copper wire, **Figure 18-5.** The wire, attached to a metal object, drains off any static electricity that might spark a fire.

Store flammable liquids only in ***approved steel cabinets*** and ***safety cans***. Cabinets have a certain capacity to resist fire. The walls are thick enough to contain a fire for more than an hour if the doors remain closed. The bottom of the cabinet is also leak-proof up to the doors. See **Figure 18-6.**

Storage cans are fitted with flame arrestors. A ***flame arrestor*** is a wire screen placed in the neck of the can that stops flames from getting inside the can. See **Figure 18-7.** Further protection is provided by the spring loaded lid. When you release the handle, the lid closes and seals the safety can.

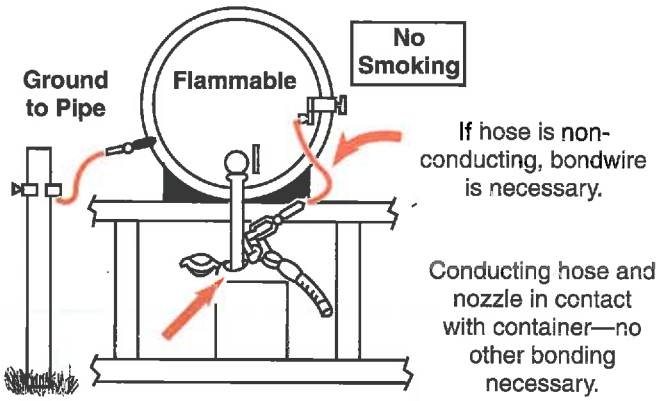


Figure 18-5. Ground your safety cans when filling from a storage tank. Static electricity could create a spark. (*National Institute for Occupational Safety and Health*)

Figure 18-6. An approved safety cabinet will resist fire for a period of time. It also is watertight to retain any leaking fluids. (*Justrite Manufacturing Co.*)

Vapors are the most dangerous aspect of flammable liquids. A ventilation system is necessary for controlling them. It collects and removes vapors from the workplace.

Hazardous substances

Be aware of hazardous substances other than flammable liquids. Most are nuisances and irritants. However, others may be fatal. Read the label of any solid, liquid, or gaseous substance you use, especially if you are unfamiliar with the product. The container's label might recommend wearing a respirator to prevent inhaling dust, fumes, mists, gases, or vapors. See **Figure 18-8.** Gloves may be recommended to prevent a skin reaction or chemical burn.

Exhaust and ventilation

Effective workplace exhaust and ventilation systems are essential. See **Figure 18-9.** Many woodworking machines produce dust that can be harmful if inhaled. ***Dust collection systems*** remove most small wood chips and dust particles from machines. Others control dust that is in the air. Some solvents and finishing materials give off toxic fumes. ***Exhaust systems*** for finishing rooms remove harmful vapors.

Finishing room hazards

Within finishing areas, people breathe toxic fumes and use flammable liquids, often Class I. Respirators should be worn by persons in the finishing room. The potential for igniting a fire is high. Only explosion proof light fixtures and fan motors should be installed in the room. Switches for lights and fans should be either spark proof or located outside the room. Overspray should be controlled with exhaust filters. Clean and replace filters regularly.

Good housekeeping is essential. Finish and thinner containers should be kept covered and labeled. Place rags, strainers, and other items in approved disposal containers. Spontaneous combustion can occur in a pile of rags that have been used for wiping oil finishes.

Material storage

Many safety problems occur when storing materials. Instead of returning materials to their proper storage place, people tend to leave them elsewhere.

Figure 18-7. Storage cans. Left—Safety can to store new materials, Middle—Safety bench can for disposal of liquid materials. Right—Oily waste can for disposal of rags or other materials saturated with flammable liquids. (*Justrite Manufacturing Co.*)

Figure 18-8. Inhaling dust, fumes, mists, gases, or vapors can be prevented by wearing a respirator. (*Justrite Manufacturing Co.*)

Always return tools, equipment, and materials to their proper places. See **Figure 18-10.**

Store lumber horizontally on sturdy shelves or vertically in racks. Lumber stored horizontally should not extend over aisles. Store wood product panels flat or on an edge. Stack partial pieces flat to reduce warpage.

Electrical

Nearly all cabinetmakers use electric power equipment. Special precautions must be taken to reduce risks.

Label voltages and intended use for switches, circuit breakers, and other electrical control devices. See **Figure 18-11.** Apply a label directly on the device. Enclose or guard all switches or other electrical equipment carrying between 50 volts (V) and 600 V.

Machines and electrical equipment should be wired in compliance with the National Electrical Code (NEC). This includes proper grounding. Stationary machines, rated over 120 V, should have cutoff switches with magnetic controls. New machines have low voltage transformers on switches to reduce hazards of electrical shock.

Electrical cords can be a source of problems. They must be inspected regularly. With age cords often become brittle. Insulation breaks, exposing bare wires. Tools may also damage cords. A belt sander could cut into the cord. A portable circular saw may sever the cord. Keep cords away from the point-of-operation.

Shock protection

Power tools with plastic housings insulate you from electrical power. Those labeled *double insulated* further protect you from electrical shock. ***Double insulated*** tools have ***two-prong plugs.*** On two-prong polarized plugs, one of the prongs is wider than the other. See **Figure 18-12.** This plug will fit in a receptacle only *one way* in a polarized receptacle. It will not fit an older style nonpolarized receptacle. Notice that receptacle slots are of different sizes. As a rule, power tools with metal housings need to be grounded. There is too much danger of electrical shock.

Electrical grounding

Electrical grounding prevents you from being shocked or electrocuted. Inspect electrical tools,

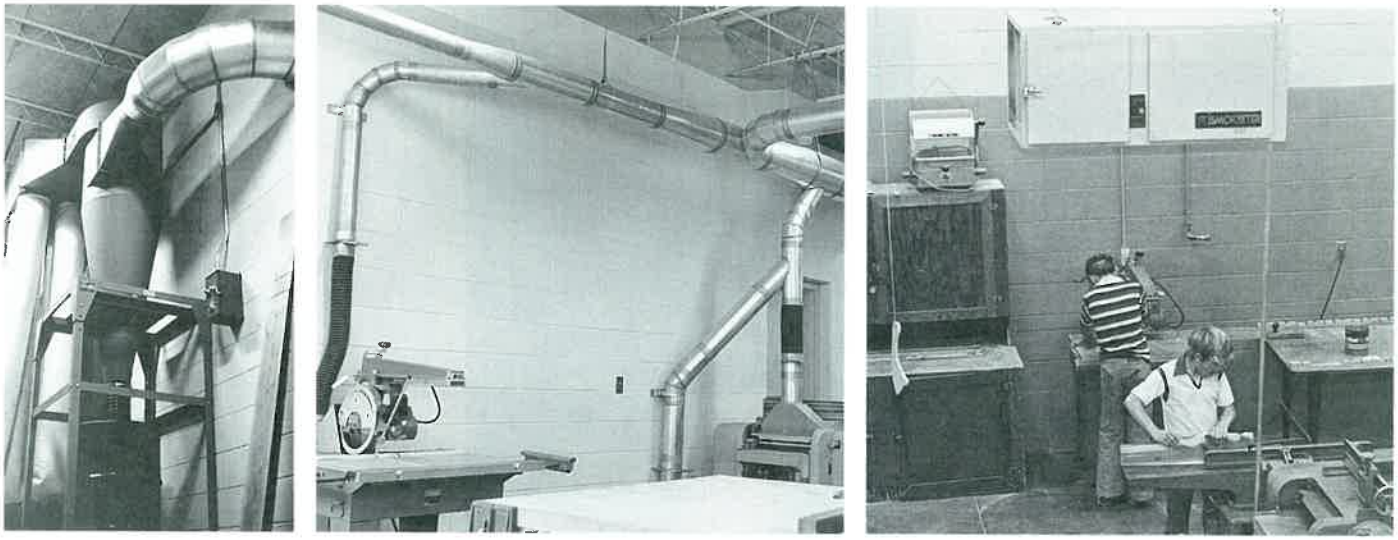


Figure 18-9. Chips and dust should be removed from the work area. Left—Dust collector removes debris from machines. (*Donaldson Company, Inc.*) Right—Air filtration system removes smaller dust particles from the air. (*United Air Specialties*)

Figure 18-10. This shop has a well organized tool cabinet. After using a tool it should be returned to its proper place.

especially those that are portable, for proper grounding. Grounding is accomplished by the addition of a ground wire. This wire is attached to the grounding prong. The receptacle's ground is wired to the building's main ground. This completes the ground circuit.

Two-slot receptacles

Inspect all two-slot receptacles for proper grounding. Receptacles are also known as outlets. Do so with a voltage tester. See **Figure 18-13**. The tester lamp will glow when the tester is inserted into both slots. It should also light between the

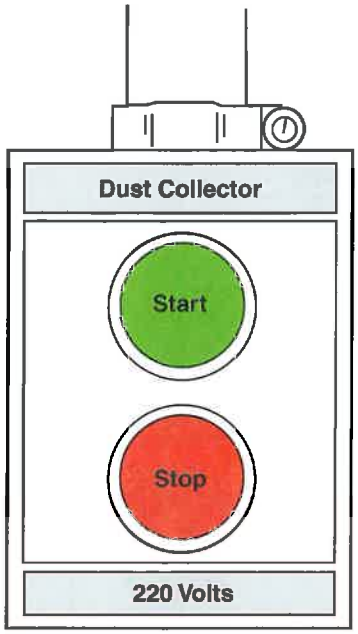


Figure 18-11. All switch panels should be clearly marked with intended use and voltage.

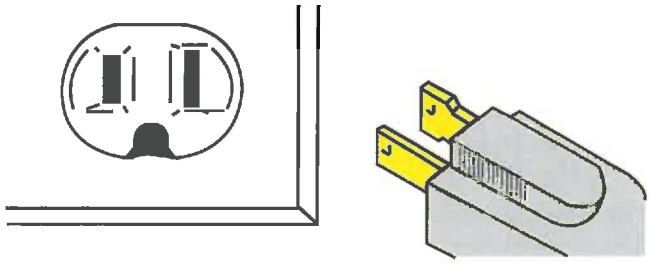


Figure 18-12. Two-prong polarized plugs can only be inserted into polarized receptacles and then in only one way.

receptacle's short slot and the cover screw. The lamp should not glow between the long slot and the screw. If it does, the receptacle is wired improperly.

Three-prong plug

Power tools without double insulation provide protection through a ground wire. The ground wire is attached to the third prong of a ***three-prong plug***. Generally, two prongs are flat and the ground prong is round.

Warning

The ground prong must never be damaged or removed.

The cord for this tool contains three wires. One wire connects the tool's metal housing or case to the ground on the plug. The other wires carry the electrical current.

Three-prong plugs cannot be connected directly to receptacles with just two slots. You must use an adapter. Do so only after you know that the receptacle is grounded. Connect the adapter wire to the cover plate screw. The use of the three-prong adapter with its pigtail connected to the center screw that holds the switch plate will provide a ground under certain, but not all circumstances. Some wiring systems use nonmetallic cable and provide no grounding system whatever. The test described above will determine if receptacles are grounded. That is, if putting one leg of the tester in the hot slot and the other onto the cover screw results in the tester lighting, you can be sure that the receptacle is grounded. See **Figure 18-14.**

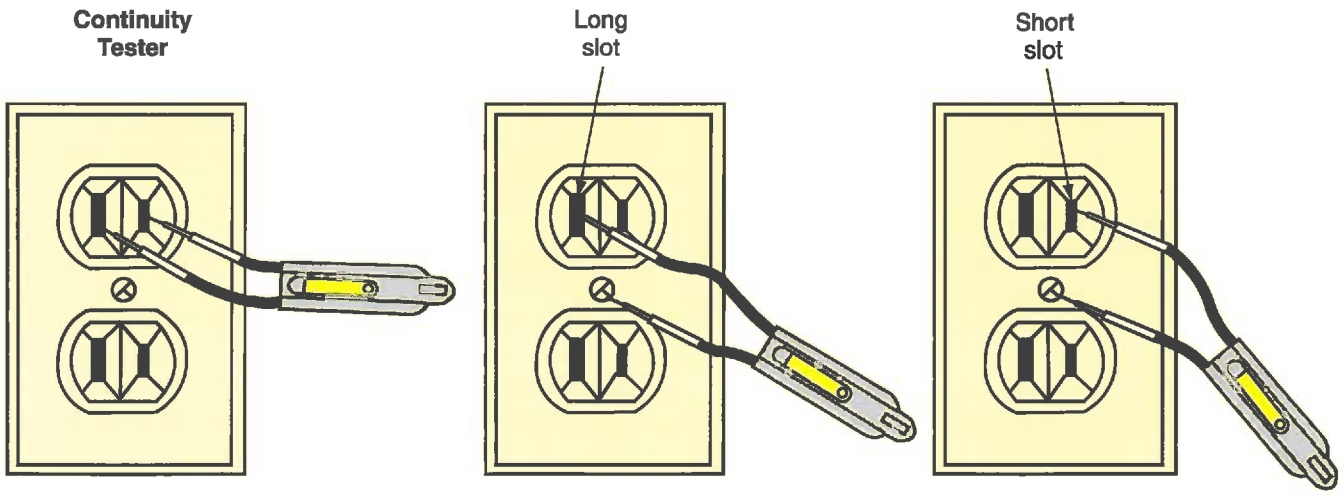


Figure 18-13. Use a voltage tester to check electrical ground. (*GE Wiring Devices Dept.*)

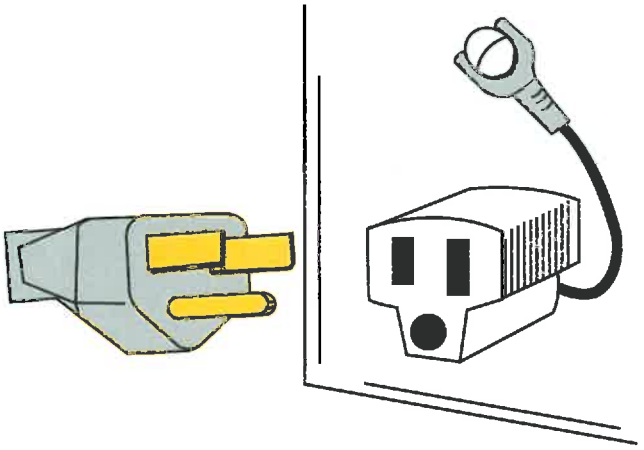


Figure 18-14. Proper connection for a three-prong adapter plug.

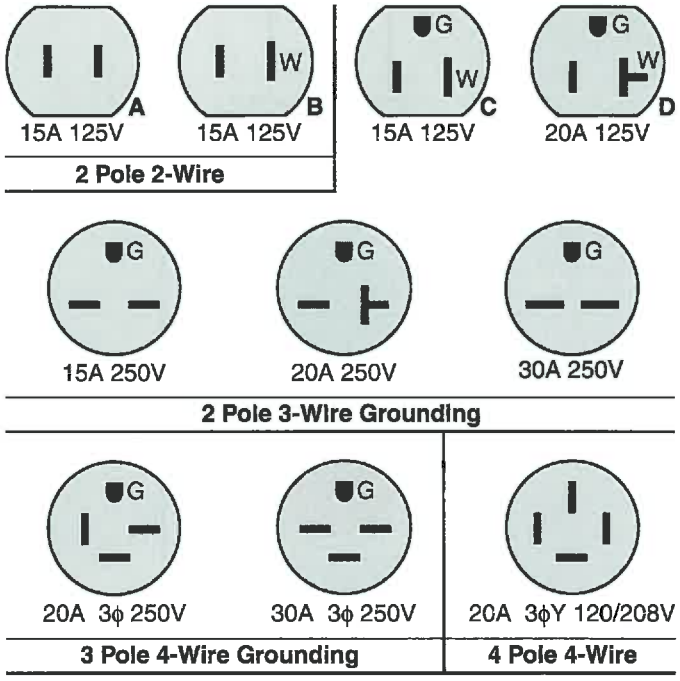


Figure 18-15. An assortment of receptacles found in many cabinet shops. Twist-lock versions may be available. (*Chuck Davis Cabinets*)

Receptacle styles

There is a wide assortment of receptacle styles. The plug normally matches the receptacle. Receptacles are rated in amperes and volts. **Figure 18-15** shows several receptacles that are commonly found in cabinet shops. Receptacle A is a nongrounded nonpolarized receptacle and is no longer available. Two-prong ***polarized*** plugs cannot be inserted. Receptacle B is a nongrounded polarized receptacle and is sold only for replacement use. Plugs that will fit A, will also fit B, C, or D. A plug that will fit B, will also fit C or D. A plug that will fit C will also fit D. One made specifically for D will not fit A, B, or C. All of the other patterns are noninterchangeable.

When using a machine rated at 12 amps (A), it is unwise to use it in a 30 A circuit. If there is an overload condition, the 30 A circuit breaker, or fuse, will not shut down the circuit. This may result in damage to the machine.

Some power tools are equipped with ***twist-lock*** plugs. The matching receptacle may be in the wall or hang from an overhead electrical track. Insert the plug in the receptacle, and twist it slightly to lock it in place. It must be twisted slightly to disconnect power.

Some stationary power tools require 240 V or 480 V three-phase power supply. These plugs are four-prong and may or may not be twist-lock.

Compressed air

Compressed air is used to power air tools and to remove dust, chips, and other debris from machinery. Air hoses for debris removal use a *pressure relief nozzle*. This nozzle has extra holes that lessen the pressure exiting the main nozzle jet. They also allow air to escape if the primary air passage is blocked. Limit air hose pressure to 30 pounds per square inch (psi) if a pressure relief nozzle is not available. See **Figure 18-16**. Wear safety glasses when using an air nozzle. Chips or dust could be blown back into your face. Point the nozzle away from yourself. Using a brush or tack cloth to remove debris is safer.

Air tool hazards are often the result of damaged hoses and worn couplings. Hoses deteriorate or become damaged due to improper use. They may be cracked or severed during use. Inspect hoses and couplings regularly. Couplings should fit tightly and be free of air leaks.

Air lines and pressure tanks should be free of moisture. Air lines should have filters. Compressor tanks have drain valves to remove accumulated condensed water.

Fire Protection

Fire protection includes fire alarms, sprinkler systems, and fire extinguishers. The use of several inexpensive smoke detectors can alert people to a potentially dangerous fire. All fire protection equipment should be checked regularly.

A fire requires fuel, heat, and oxygen. Sprinkler systems and ***fire extinguishers*** are designed to reduce the heat and/or the supply of oxygen. Sprinkler

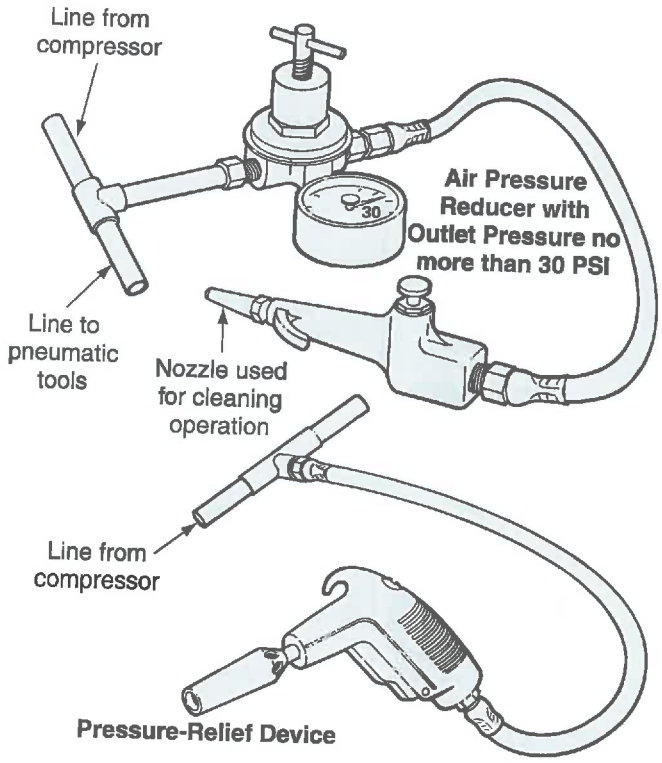


Figure 18-16. These are two acceptable types of air nozzles to blow debris from surfaces. Each meets the 30 psi requirement. (*National Institute for Occupational Safety and Health*)

systems start when heat is present. They should be checked periodically by a service technician.

Everyone should be able to use fire extinguishers. Locate these devices within 75′ (23 m) of any work area. An extinguisher weighing 40 lbs (18 kg) or more should be mounted within 5′ (1524 mm) of the floor. Lighter weight extinguishers should be located within easy reach.

Check the pressure rating on the extinguisher regularly. Most approved types have a pressure dial on them. The needle should be in the green area labeled *Properly Charged*. Also look for inspection tags indicating when the extinguisher was last tested by a technician.

Selecting and using extinguishers

There are three classifications of fires:

- ***Class A fires.*** Burning solid waste.
- ***Class B fires.*** Flammable and combustible liquids.
- ***Class C fires.*** Electrical fire.

Not all fire extinguishers are effective for every kind of fire. The best extinguisher is the ABC multipurpose dry chemical extinguisher. The chemical removes oxygen and smothers the fire.

The soda acid liquid extinguisher is effective only for Class A fires. A burning liquid (Class B fire) would float on the water. A liquid stream on an electrical fire is a conductor. The person holding the extinguisher could be electrocuted.

The carbon dioxide extinguisher is effective on Class B and C fires. The chemical, if used on specific solid waste fires, could produce toxic fumes. The fumes can make the user ill or unconscious.

Figure 18-17 shows various extinguishers and their proper uses. Remember that a majority of extinguishers will last for no more than 30 seconds. Some stop working in about 15 seconds. Never try to extinguish a very large fire. Report the fire by dialing the 911 emergency telephone number or the number of your local fire department.

To use an extinguisher, pull out the safety pin. Aim the extinguisher according to the type of fire and the operating procedure described in **Figure 18-17.** Squeeze the handle to release the contents. Soda acid extinguishers must be held upside down to operate properly. Check the instructions before an emergency arises.

Personal Protective Equipment

People must be protected from harmful substances. Hazards include inhalation, absorption, or physical contact with irritants and toxic substances.

Respirators

Respirators filter out harmful dust and certain gases. See **Figure 18-18.** Several styles are available. Select a respirator that fits properly and is designed for the type of work you are doing. Thin paper and cloth respirators seldom filter out more than small dust particles.

Gloves

Gloves provide protection from splinters when handling rough lumber. Rubber or vinyl gloves may be required when handling harmful liquids. Wear gloves that cover your hands and forearms up to other clothing. This is particularly important for people who are allergic to certain materials.

Warning

Remove gloves while operating power machinery.

Gloves can be caught in a machine and draw your hand into the cutting tool or other moving parts. Serious injury could result from failure to remove gloves.

Fires	Type	Use	Operation
Class A fires Ordinary combustible materials such as wood, paper, textiles and so forth. Requires... cooling–quenching.	**Soda–acid** Bicarbonate of soda solution and sulfuric acid.	OK for A Not for B C	Soda–acid: Direct stream at base of flame.
	Pressurized Water Water under pressure.	OK for A Not for B C	Pressurized water: Direct stream at base of flame.
Class B fires Flammable liquids, greases, gasoline, oils, paints, and so forth. Requires... blanketing or smothering.	**Carbon Dioxide** Carbon dioxide gas under pressure.	Not for A OK for B C	Carbon dioxide: Direct discharge as close to fire as possible. First at edge of flames and gradually forward and upward.
	Foam Solution of aluminum sulfate and bicarbonate of soda.	OK for A B Not for C	Foam: Direct stream into the burning material or liquid. Allow foam to fall lightly on fire.
Class C fires Electrical equipment, motors, switches, and so forth. Requires... a nonconducting agent.	**Dry Chemical**	Multi-purpose type: OK for A B C Ordinary BC type: Not for A; OK for B C	Dry chemical: Direct stream at base of flames, use rapid left-to-right motion toward flames.

Figure 18-17. Not all fire extinguishers will put out every kind of fire. Check the label on the extinguisher. Using the wrong extinguisher may electrocute you or produce toxic fumes.

Figure 18-18. While sanding, it is advisable to wear a face shield and some form of respirator. *(Lab Safety Supply Co., Inc.)*

Shoes

Protective footwear prevents injury from sharp or falling objects and solvents. Steel toed shoes reduce injury from falling objects. Some have solvent-resistant soles. Canvas or vinyl shoe tops with soft rubber soles are not adequate protection.

Eye protection

Eye protection is essential in the shop. Goggles and industrial safety glasses with side shields are best. See **Figure 18-19**. You can obtain safety glasses with prescription lenses. Safety lenses are thicker than those people normally wear. Safety glasses are etched with the manufacturer's logo. You can wear approved goggles over prescription glasses. Have an inspection and replacement system to detect and replace pitted or scratched lenses.

Figure 18-19. Eye protection. Right—Industrial safety glasses. Left—Safety goggles.

Goggles sometimes tend to collect moisture from perspiration. This may cloud your vision. If this happens, a face shield should be worn instead. It protects you from flying chips and splashing solvents. You are protected best with approved goggles or glasses beneath the shield.

When wearing contact lenses, additional care must be taken to avoid direct contact with dust. Even when wearing goggles, dust can get under goggles and cause eye irritation and distraction.

Ear protection

Loud noises may cause temporary or permanent hearing impairment. Saws, planers, and jointers create noise when in use. Noise levels increase as cutting tools become dull. Two symptoms of noise overexposure are nervousness and a ringing in your ears.

Ear muffs or fitted ***ear plugs*** provide approved hearing protection. See **Figure 18-20.** You should not be exposed to noise over 90 decibels (dBA). See **Figure 18-21.**

Figure 18-20. Ear muffs and ear plugs provide comfortable and effective ear protection.

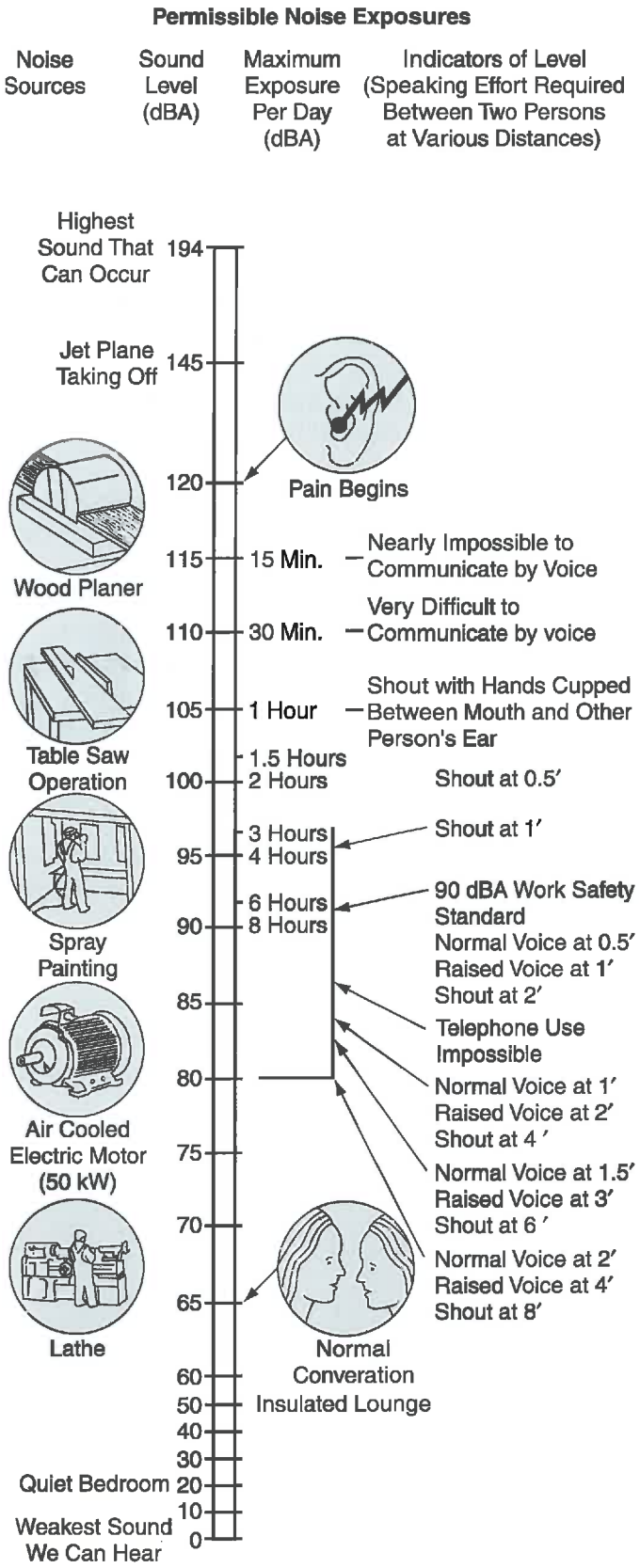


Figure 18-21. Recommended maximum exposure per day to various noise levels. You can quickly determine the noise level according to how loud you have to speak.

Clothes

Wear snug-fitting clothes. Roll up or tightly button long sleeved shirts. Wear a shop apron, otherwise make sure your clothes are tucked in. Remove jewelry such as rings, watches, and especially necklaces.

Mechanical Guarding

Every moving part of a machine is a potential hazard. You sense that by observing a machine in motion. All belts, pulleys, gears, and cutter edges are dangerous. The operator must be protected. Much of the protection is built in by manufacturers. However, risks are created by operators who do not install or position guards properly.

Proper machine guarding covers all moving parts. See **Figure 18-22**. There are three kinds of motion that can produce a crushing or shearing action:

- ***Rotary motion.*** Includes circular saw blades, pulleys, belts, cutterheads, and spindles.
- ***Reciprocating motion.*** Back and forth straight line movement. Examples are machines such as jig and saber saws, shears, and presses.
- ***Straight-line motion.*** Occurs with band saw blades and belt sanders.

Guards can be grouped into several classifications. These are point-of-operation, enclosure, interlocking, automatic, and remote control.

Point-of-operation guards

Point-of-operation (PO) guards protect your hands or body from the cutting tool. They also protect the operator from flying chips. See **Figure 18-23**. PO guards are made of metal or high impact plastic. Clear plastic allows you to observe your work safely. Often PO guarding is moved for tool setup or adjustments and must be reinstalled. A majority of accidents occur when PO guards have not been positioned correctly. New machinery is required to have PO guards. Retrofit older equipment with PO guards.

Enclosure guards

Enclosure guards completely cover moving parts other than the point-of-operation. They generally are removed only for maintenance. They protect you from motors, shafts, pulleys, and belts. See **Figure 18-24**. Examples are the upper and lower wheel covers on a band saw.

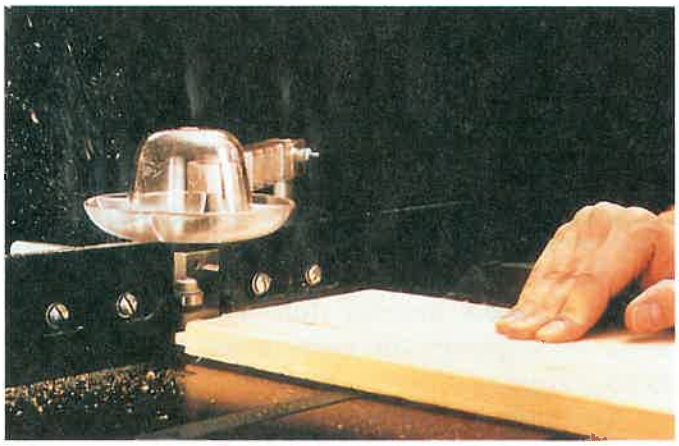


Figure 18-23. Clear plastic point-of-operation guards allow you to see your work. (*Porter-Cable Corp.*)

A

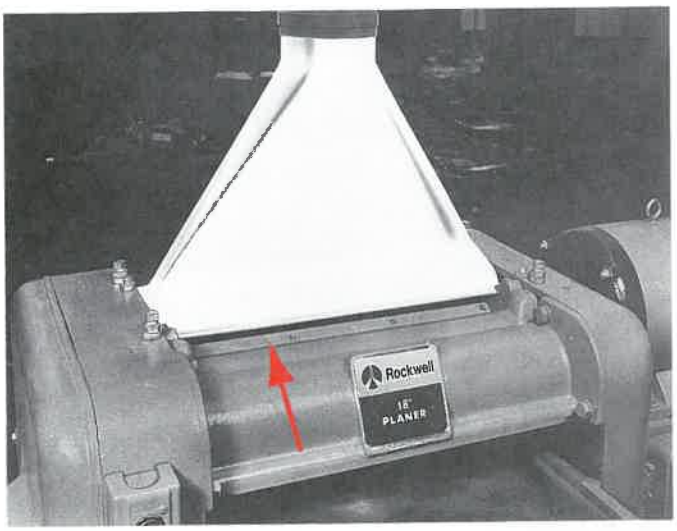
B

C

Figure 18-22. Beware of motions that can cause injury. A—Rotary. (*Makita U.S.A., Inc.*) B—Reciprocating. (*Makita U.S.A., Inc.*) C—Straight-line. (*Delta International Machinery Corp.*)

Interlocking guards

Interlocking guards prevent machines from operation while dangerous parts are exposed. An electrical or mechanical device disconnects power while the PO or enclosure guard is off. For example, a microswitch prevents a band saw from being turned on while the wheel enclosure guard is off or not secured.



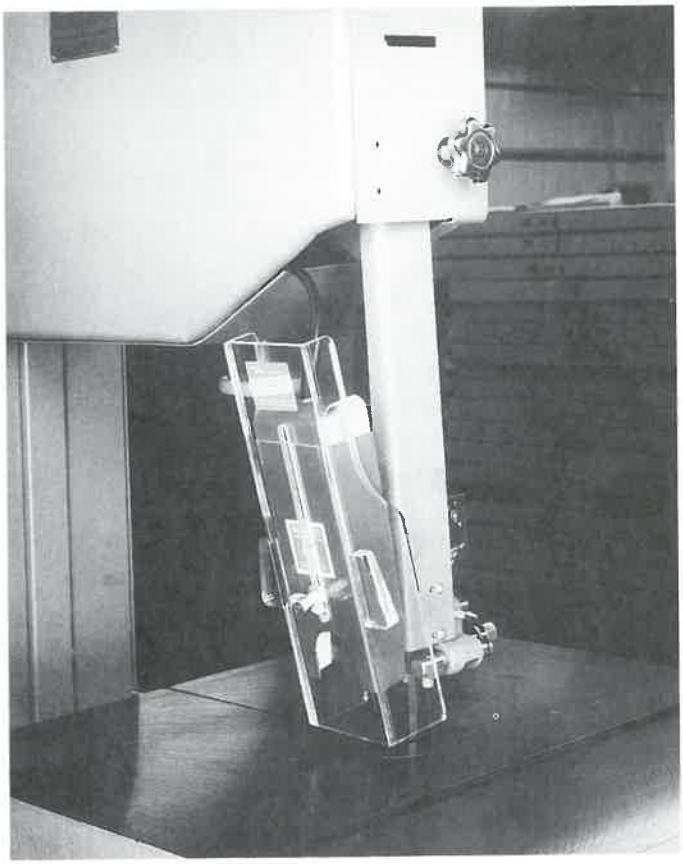


Figure 18-24. Enclosure guards cover mechanical parts. Top—Fixed enclosure guard. (*Rockwell International*) Bottom—Adjustable enclosure guard also used as PO guard. (*Brodhead-Garrett*)

Automatic guards

Automatic guards act independently of the machine operator. As you push the wood through the point of operation, the guard is raised or pushed aside. See **Figure 18-25**. It moves only enough to allow the stock to pass. After the material passes the point of operation, the guard returns to its normal position.

Table saws and radial arm saws have automatic guarding. Sharp toothed antikickback devices lift while stock passes under them. The device prevents the material from being thrown back toward the operator. If the stock attempts to move backwards, the teeth or fingers dig into the wood to stop it.

Jointers also have automatic guards. The guard covers the cutter. As stock is fed through the jointer, the guard moves aside.

Figure 18-25. Automatic guards move aside as the stock is cut. (*Delta International Machinery Corp., Makita U.S.A., Inc.*)

Remote control guards

Remote control guards are special purpose guards. They are used primarily in automated cabinetmaking systems. Stock is fed by a chute, hopper, or conveyor. There are no operator access openings on the machine. Automatic feed keeps the operator at a safe distance.

Guards are placed to protect all parts of the body. On foot controlled machines, cover all pedals, treadles, or switches to prevent accidental starting. On hand controlled machines, move both hands away from the point of operation before starting the machine.

First Aid

Even the most experienced individuals have accidents. Be able to get the needed assistance in an emergency. Post local emergency numbers or a 911 reminder on the telephone.

People who work with tools, materials, and supplies for cabinetmaking should have first aid training. Learn the proper first aid procedures in case of an injury. Read the labeling on hazardous substance containers before using them. Be ready to respond if the need arises.

Summary

An accident and injury-free workplace is always a worthy goal. Work carefully, yet also look for hazards that result because of an unsafe environment.

Accidents occur to both the novice and experienced cabinetmaker. Many accidents occur to novice cabinetmakers because they fear the machines. Confidence is very important. It comes from planning your work carefully and gaining experience. Unfortunately, some people become overconfident, which leads to carelessness. Be aware of the risks you might take.

People always think about an accident after they are injured. Experienced cabinetmakers say they knew better, but were in a hurry or didn't own the proper tool. They took shortcuts and didn't follow all the precautions. The novice cabinetmaker may not know better. This is why novices should try to watch an experienced cabinetmaker in action.

Your shop is only as safe as you make it. Machine guards, eye protection, and other safety items are effective only when used properly. Warnings about unsafe acts and hazardous conditions serve only those who read and heed them.

Having skill and knowledge about machines and processes is not enough to prevent accidents. These are important, but must be accompanied by a positive attitude toward safety. Too often you take risks and your attitude improves only after an injury or a near miss.

Safety tips are given throughout the remaining chapters. They relate to safe practices in each area of cabinetmaking. If you are a novice, read and remember each safety tip. If you are an experienced cabinetmaker, review them as a personal reminder.

Test Your Knowledge

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

1. Accidents occur as a result of _____ and _____.
2. Explain factors that might lead to an unsafe act.
3. Hazardous conditions exist either because _____ or _____.
4. Describe how you can ensure a fast and easy exit in case of emergency.
5. Identify storage requirements of flammable liquids.
6. Flame arrestors are placed _____.
   a. inside safety cans
   b. in sprinkler systems
   c. in the neck of fire extinguishers
   d. in the wall of safety cabinets
7. Use explosion proof switches in _____.
   a. areas of woodworking machines
   b. finishing rooms
   c. storage rooms
   d. warehouses
8. How do you detect if a two-prong electrical receptacle is properly grounded?
9. List the three classes of fires and the material that burns in each.
10. A fire will not burn without _____, _____, and _____.
11. The best fire extinguisher to have is the _____ type.
12. The class of flammable liquid is determined by the _____.
13. List three types of eye protection.
14. The three types of motions that should be guarded are _____, _____, and _____.
15. List the five types of guards and identify two examples of each.

Ordering Materials and Supplies

Objectives

After studying this chapter, you will be able to:

- Prepare a material order list based on the working drawings and bill of materials.
- Identify and order supplies required to build a product.
- Explain order amounts and packaging by sizes and volumes.

Important Terms

bill of materials
comparison shopping
extra charges
merchandise returns
packaging
plan of procedure
price breaks

The two most important factors when ordering are to be thorough and economical. Being thorough requires you to know and specify the exact quality and quantity of every material, supply, and tool it will take to complete your product. Being economical means getting the right price for the right quantity at the right time at the quality level you need.

Be Thorough

To be thorough means you must study the working drawings. See **Figure 19-1.** This includes the product views, ***bill of materials (BOM)***, and plan of procedure. Then you must write complete, detailed, and accurate orders for the required materials.

From the bill of materials, make a list of the lumber, manufactured products, mechanical fasteners, and hardware needed. If this information is not in the bill of materials, study the detail drawings and notes carefully to find it. Read the steps in the ***plan of procedure***. Itemize supplies, such as adhesives, abrasives, stain, tack cloth, etc. You will need to order these, if you do not have them on hand. The plan of procedure may also recommend tools, machines, and equipment. Be sure you have similar equipment to perform the work.

Be Economical

Economy seems to be the bottom line for making many decisions. Economy of time means: How long must you look for items and, if production is being held up, how long before you receive them? Economy of money means: What quality and quantity do you get for your money? In time, you will find reliable dealers. In the beginning, make decisions by comparison shopping.

If cabinetmaking is to be a career, immediately establish accounts with one or more of the following types of vendors:

- Wholesale hardware houses.
- Hardwood lumber dealers.
- Cabinet door manufacturers, if you choose to buy.

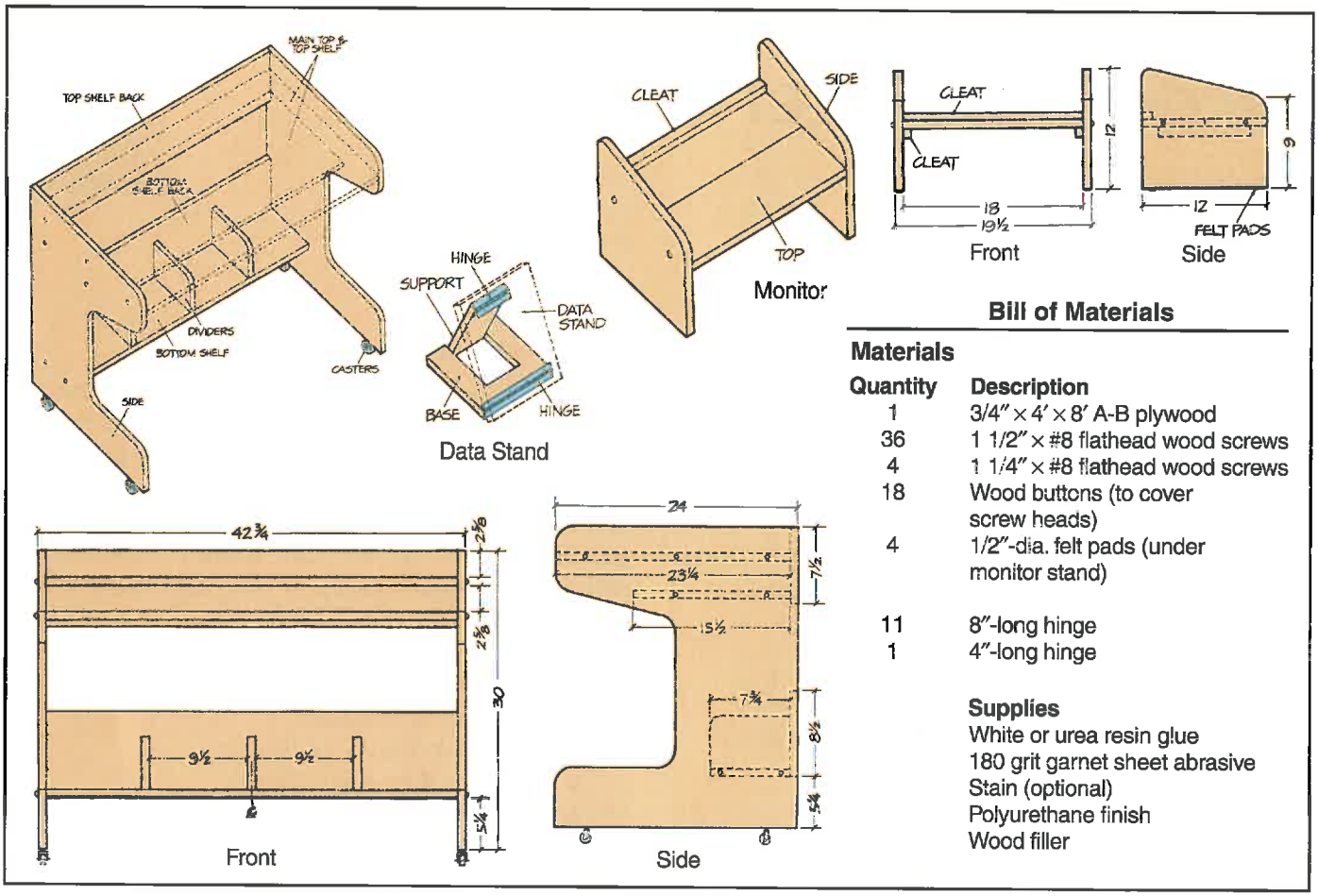
Besides providing a catalog, salespeople for these vendors provide a large amount of information. Many catalog items will be accompanied with *how to* instructions. However, the manufacturer can also be contacted for answers to most questions.

Wholesale hardware vendors may not be located in your community, but added parcel delivery charges seldom cause the price of an order to exceed the local retail store price. Also, many times orders over $300 or $400 are shipped free of charge.

Comparison shopping

Often, the time involved in ordering has much to do with ***comparison shopping***. Decide which building supply company, lumber yard, hardware store, or paint dealer has what you need for a reasonable price. This may not mean the lowest cost because quality varies. Remember, the least expensive items may not be the most economical. Low priced boards may contain too many knots, checks, etc. Poor quality tools may dull, bend, or break too easily.

Is it more economical to order in a store, by telephone, or through the mail? Shopping at a store takes time. However, it allows you to inspect items before paying for them. Telephone, facsimile, and mail orders require less of your time. However, the material is inspected and decided upon by the seller, not you.



Bill of Materials

Materials

Quantity	Description
1	3/4" × 4' × 8' A-B plywood
36	1 1/2" × #8 flathead wood screws
4	1 1/4" × #8 flathead wood screws
18	Wood buttons (to cover screw heads)
4	1/2"-dia. felt pads (under monitor stand)
11	8"-long hinge
1	4"-long hinge

Supplies

White or urea resin glue
180 grit garnet sheet abrasive
Stain (optional)
Polyurethane finish
Wood filler

Figure 19-1. You can determine the materials and supplies you need by looking at the product views and bill of materials. (*APA-The Engineered Wood Assoc.*)

Price breaks

Be aware of ***price breaks*** when ordering. Some products may be cheaper if purchased by the dozen, more so in boxes of 1000. For example, the money you spend for eight individual items might have bought twelve in a package. The same holds true for liquid materials. A quart of filler probably costs less per ounce than a pint. See **Figure 19-2**.

A supplier occasionally will have a special promotion offer. You can have great savings if you need the items or can reasonably expect to need them in the near future. If your lumber dealer has a special sale on stock that you regularly buy, buy this material for future production needs.

Merchandise returns

Ask dealers about ***merchandise return*** policies. What if you buy too much? Under what conditions will they take it back? If they accept unopened items, is there a restocking charge?

Figure 19-2. Larger containers are generally cheaper per ounce.

Extra charges

Extra charges are often added when dealers cut lumber and panel products to size for you. For example, suppose you need a half sheet of an exotic veneer plywood that is $100.00 per sheet. The dealer quotes you a price of $65.00 per half sheet. You realize you are paying a $15.00 cutting charge. The dealer restocks the other half and waits for someone to buy the remainder for $50.00 or more. In addition, you may not be allowed to return the precut materials.

Reliable dealers

In time, you will come to rely on one or several wholesale vendors for your materials. Most of them want to satisfy you to make you a return customer. However, do not overlook sale items that could reduce the cost of your products.

Describing Materials and Supplies

In previous chapters on materials, sections on size and quality description were discussed. They covered topics such as grades, sizes, thicknesses, appearance, features, qualities, etc. Review these sections before ordering so you can specify exactly what you need. Read the vendor's catalog description. Order by catalog number to avoid confusion. Taking extra time to be thorough when ordering assures that you receive the necessary items.

Ordering Materials

Materials are items that become part of the finished product. Included are lumber, wood products, fasteners, glass, laminates, finish, etc.

Ordering lumber and manufactured wood products

Basic materials for any wood cabinet are lumber and manufactured wood products. Softwood lumber is most available in nominal (dimensioned) sizes. It can be ordered by species and specific size. Hardwood is usually sold in random widths and lengths. It must be ordered in volume—by thickness and by board footage or cubic meters. Dealer catalogs usually list the minimum and maximum widths and lengths. Thickness is given by quarters, such as 4/4 (1"), 5/4 (1¼"), 6/4 (1½"), etc. Besides size, you must specify whether you want kiln dried or air dried lumber. Most dealers stock only kiln dried hardwood lumber. You might also want it surfaced on one or more sides. Be sure to specify the grade of lumber you need. See **Figure 19-3.**

Manufactured wood products include molding, veneer, plywood, particleboard, MDF, and fiberboard. Order moldings by shape or pattern number and linear feet. Plywood and other panel items normally are 4′ × 8′ (1220 mm × 2440 mm). Particleboard and MDF are usually 1" (25 mm) larger in each direction. The face species, cut, and quality of plywood panels should be specified. Refer to *Chapter 13.* Veneer may be sold in random sizes by square footage or in sheets. See **Figure 19-4.**

Estimating lumber

Plan your lumber order carefully. If you will be using nominal stock, sketch the parts for your product. See how they might be cut from different

Quantity	Manufacturer's No.	Stock No.	Size and Descripton	Unit Price	Total
6 PCS.			KD FIR 1" × 10" – 8; NO. 1 COMMON		
120 BD.FT.			4/4 CHERRY, FAS, RWL, 525, 6′ TO 8′ LENGTHS		
60 SQ. PT.			1/2" CHESTNUT, FAS, RWL, ROUGH, 8′ TO 10′ LENGTHS		
2 PC.			3/4"–12′ OAK COVE MOLDING		
1 PC.			48" × 96"–3/4" OAK PLYWOOD, G2S		

Figure 19-3. This is a sample order for lumber and wood products. Note the number of specifications required so you receive the item you need.

stock sizes. Allow an extra ¼" to ½" (6 mm to 13 mm) around each workpiece. From the sketch, you know the size and minimum amount of lumber you must order.

For random widths and lengths of hardwood lumber, determine the board feet needed in your project. Add 15% to 20% to that amount. The excess allows for defects and waste when cutting workpieces. After you receive the lumber order, lay out the parts that will come from each board. Avoid defects. You might want to surface the lumber first to see the quality of the wood.

Estimating manufactured panel products

Manufactured products are being used more often than lumber for case construction. Plywood panels, wood veneered panels, and other prefinished panels are usually 4' by 8' (1220 mm by 2440 mm). Other manufactured panel products are 1" oversize to allow for trimming. Sketch a cutout diagram showing how components would be laid out on a panel. See **Figure 19-5**. Leave space between pieces to allow for a saw kerf. Final cuts can be made later.

When laying out components, be sure that paired doors and drawers are placed next to each other. This matches the grain pattern. See **Figure 19-6**. Many manufactured panel products have no grain.

Figure 19-4. Sheet veneer is cut into dimensioned sizes and packaged for easy handling.

Ordering glass, plastics, ceramics, and laminates

Glass is sized by thickness, dimensions, and special treatment—tint, etching, etc. Be sure to specify whether edges are to be ground and/or polished. This is necessary for frameless sliding glass doors.

Solid sheet plastics are generally sold by size. Liquid resins and catalysts for casting are sold by volume.

Ceramic tiles are sold by individual pieces or mesh-backed square foot assemblies. Tiles are packaged anywhere from 1 to 24 in a box. Always specify the tile model number. Make sure you receive the

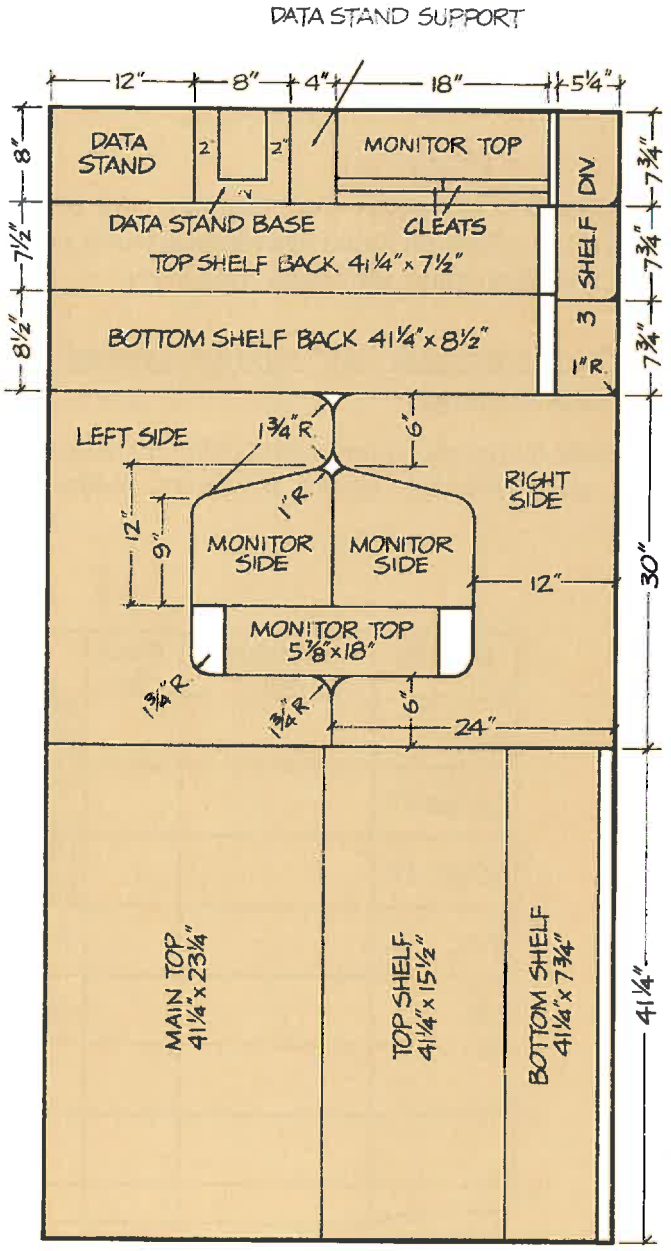


Figure 19-5. Laying out components on a sheet of plywood. Remember to leave room for saw kerfs when laying out dimensions. (*APA-The Engineered Wood Assoc.*)

proper design. Request that all tiles are from the same production run to ensure exact color match. Inspect the shipment to be sure the packages are so labeled. Inspect for shipping damage. Also order mastic and grout for laying tile. See **Figure 19-7**.

Plastic laminates are sold in sheets or rolls. You must specify one of the grades discussed in *Chapter 14*. Check the sizes offered by the dealer before ordering.

Ordering mechanical fasteners

As described in previous chapters, there are many kinds of fasteners. Order them by quantity, model number, manufacturer, finish, and size. See **Figure 19-8**. Part of the cost for fasteners is packaging. Therefore, ordering larger amounts may reduce the price per item. For example, you can buy fasteners in a plastic bubble from a display, cardboard box, or loose. See **Figure 19-9**. For the same price, you may get twice as many if you count them from a bin. The cost may be even less if you buy a carton of 5000. However, can you use the excess fasteners later and is storage space available? Some fasteners, such as nails, are sold by the pound. A chart is usually provided at the store to show you approximately how many nails are in a pound.

Figure 19-6. Lay out doors and drawer fronts next to each other so the grain pattern matches.

Fastener orders may specify the type of finish. Fasteners with a *bright* finish have no coatings. Otherwise, they may be galvanized (zinc coated) or plated with nickel, brass, and other metals. Nails often have cement coatings to increase their holding power.

Ordering hardware

Hardware items, such as pulls and hinges, may be packaged, boxed, or in bulk forms. Packages of individual pulls, hinges, and catches usually have screws with them. However, box or bulk purchases may not include fasteners. For most orders, you need only specify the stock number or manufacturer's number. See **Figure 19-8**. If none is listed, you must specify the type, size, material, surface finish, and other features.

Ordering finishing products

Finishing products include fillers, sealers, stains, and topcoatings. Common quantities are half-pints, pints, quarts, and gallons. The container label should indicate the number of square feet per gallon the finish will cover. The listed figure usually is determined under controlled testing conditions. You will likely cover 10% to 20% less surface area with the same amount.

Order solvents for finishing materials in larger sizes, such as one and five gallon containers. You will likely need it for thinning as well as cleanup after the finish is applied. Be sure to order the proper solvent and amount. Most finishes require a compatible type of solvent.

Figure 19-7. This example shows the range of materials, supplies, and tools you must have to lay tile. (*Red Devil*)

Quantity	Manufacturer's No.	Stock No.	Size and Description	Unit Price	Total
100			#6 × 1 1/4" F.H. BRIGHT STEEL WOOD SCREWS		
3 LB.			4d CEMENT COATED BOX NAILS		
1 LB.			#16 × 1" BRADS		
10		345	PLASTIC CABINET PULLS, 4", BLACK		
6		A–40	MAGNETIC CABINET CATCHES, TAN PLASTIC		
6 PR.		123	CABINET HINGES FOR LIPDOORS, BRUSH BRONZE		

Figure 19-8. Sample order for mechanical fasteners and hardware.

Figure 19-9. Small quantities of mechanical fasteners are sold in plastic and cardboard packages, or loose.

Check the shelf life (storage time) of the product. This is often labeled on the container. Order only the amount you will use within that time. If you will use a gallon, order that amount instead of two quarts now and two later. A gallon is much cheaper per ounce of finish.

Ordering Supplies

Supplies for cabinetmaking include consumable items that do not become a major part of the cabinet. Examples are abrasives, adhesives, rags, steel wool, and wax.

Ordering abrasives

You will need an assortment of abrasives (sandpaper). Order by grit, type, and form. Grit size refers to coarseness. Types may be natural (flint, garnet) or synthetic (silicon carbide, aluminum oxide). Forms of abrasives include sheets, belts, disks, sleeves, pads, or powders. The form you choose depends on the tool or sanding machine.

Sheets come in various sizes, but are commonly 9" by 11". Be sure the size can be cut to fit your hand sander and finishing sander. Sheets are sold as single sheets or in packages. See **Figure 19-10**. Packages of 100 sheets are called ***sleeves***.

After purchasing the abrasive, store it in a dry place. Moisture can soften the adhesive holding the grit to the backing. As a result, the abrasive comes off the product. This does not occur with wet-or-dry abrasives designed for use with oil and water.

Ordering adhesives

Adhesives include cements, glues, and mastics. Refer to *Chapter 32*. You can buy these in various size containers from gallon containers to small squeeze-type plastic bottles and tubes. See **Figure 19-11**. Construction adhesives are often in tubes for use with a caulking gun.

Check the adhesive's shelf life before buying large quantities. The label may say to store it in a cool place for no longer than six months. In some cases, the expiration date will be listed. Apply the glue before that specific date; otherwise it may not bond properly.

Have the correct solvents on hand to remove excess adhesives. These may be water, mineral spirits, or acetone.

Ordering Tools

Buying stationary machinery is most easily done by shopping at the store. You can ask the sales person for alternatives and then select the exact model you need. When ordering by mail, facsimile or phone, specify the item by manufacturer and model number. Some additional information, such as preferred shipping method, may be needed to complete the order. See **Figure 19-12.**

Quantity	Manufacturer's No.	Stock No.	Size and Description	Unit Price	Total
20		P2500	9" × 11" SHEET GARNET 280 GRIT	.31	6.20
5		P2530	SILICON CARBIDE PAPER 400 GRIT	.60	3.00
10		P2522	ALUMINUM OXIDE PAPER 120 GRIT	.48	4.80
2		P2574	3" × 21" SOX WOOD SANDING BELT	20.95	41.90

Figure 19-10. A—Sample order for abrasives. B—Boxed quantities of abrasives can be cheaper than buying individual sheets.

Figure 19-11. Adhesives are sold in various quantities, from 1 oz. to 55 gallons.

Summary

Be thorough when ordering materials, supplies, and tools. Know your exact needs when shopping over the counter, by telephone, facsimile, or through the mail.

Be economical in what you buy. The least expensive item may be the most costly, if it does not do the job as well. Shopping at a store allows you to inspect items before you pay for them. This is time consuming and may not be economical. Purchases by telephone, facsimile, and mail require less of your time. However, you must be very accurate when preparing your order. Grades, qualities, quantities, model numbers, and other information are essential. Rarely can you include too many specifications. Too little information may prevent filling the order.

You should know your exact needs from the bill of materials. When ordering, look for the highest quality products for the lowest cost. You may wish to buy in quantity to reduce the price. However, if you buy too much, you have to store it. You also risk the chance of it becoming outdated.

Quantity	Manufacturer's No.	Stock No.	Size and Description	Unit Price	Total
1	R-331		2 H.P. RYOBI D-HANDLE ROUTER		
1		#C-8	26" 8-TOOTH CROSSCUT HAND SAW		
1		#CT-2	DOVETAIL ROUTER BIT 1/4" × 7/16" CUTTER 1/4" SHANK		
1			12"-13" GA. CARBIDE TIPPED CIRCULAR SAW BLADE COMBINATION – 20TEETH 130 KERF		

Figure 19-12. The router at top is ordered by manufacturer's model number. Other tools might be specified by the vendor's stock number for that item. (*Porter Cable*)

Test Your Knowledge

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

1. The two most important factors when ordering are being _____ and _____.
2. Where do working drawings provide information about materials, supplies, and tools?
3. The lowest cost item may not be the one to buy because _____ may vary.
4. You can be sure to receive the item you need when shopping _____.
   a. in a store
   b. through the mail
   c. by facsimile
   d. over the telephone
5. Describe a *cutting charge.*
6. Usually, the least expensive way to buy fasteners is in _____ quantities.
7. Describe how you would specify the size of the following items:
   a. hardwood lumber
   b. softwood lumber
   c. plywood
   d. moldings
8. How would you determine the square footage a container of finish will cover?
9. Order abrasives by _____, _____, and _____.
10. The best way to specify tools is by _____ and _____.

Measuring and Laying Out Materials

20

Objectives

After studying this chapter, you will be able to:

- Select marking, measuring, and layout tools.
- Lay out lines and geometric shapes.
- Maintain measurement and layout tools.

Important Terms

squareness
marking tools
measuring tools
caliper rule
square
brace measure table
octagon scale
layout tools
marking gauge
caliper
compass
dividers
trammel points
template former
template

Accurate measurement and layout is essential for high quality cabinetmaking. Your design means very little unless you can transfer the shapes onto your materials. With skillful measuring, you can mark, cut, and assemble parts with precision.

Much of cabinetmaking relies on square edges and joints. ***Squareness*** simply means that all corners join at a 90° angle. See **Figure 20-1.** When a piece is not cut square, or two pieces are not assembled square, the entire cabinet is affected.

This chapter describes how to mark accurate geometric shapes on your materials. A number of tools are used by cabinetmakers to complete layouts. These include marking, measuring, and layout tools.

Figure 20-1. The manufacture of high quality products requires accurately measured, laid out, and cut materials. (*Wellborn Cabinets, Inc.*)

Marking Tools

Most cabinetmakers mark with a pencil. A sharp pencil will make a narrow line. Later, when removing pencil marks, use an eraser before sanding. A knife or *scratch awl* (scriber) will also mark the wood. See **Figure 20-2.** A light cut makes a visible reference line for sawing or other work. A knife is often used when the mark will be used as a locator for a chisel point. A scratch awl can indent the wood to center a drill. See **Figure 20-3.** Avoid ink; it bleeds into wood cells.

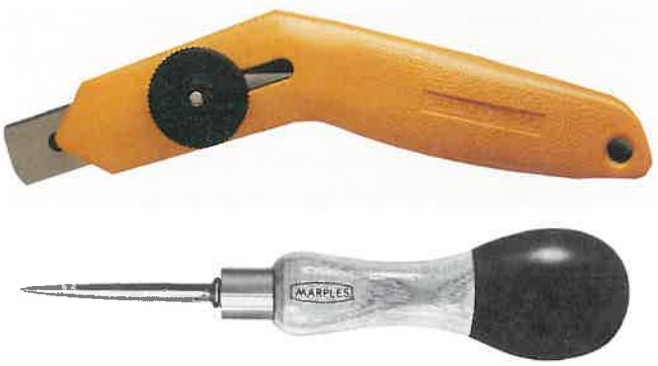


Figure 20-2. Knives and scratch awls make precise marks. A variety of styles are used. (*Stanley Tools, Record Ridgway Tools, Brookstone*)

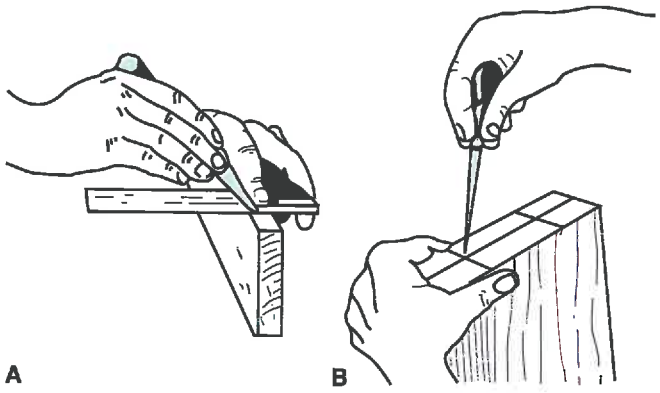


Figure 20-3. Marking. A—Marking a line with a knife. B—Marking a drill center point with an awl. (*Stanley Tools*)

Measuring Tools

Measuring tools follow two systems, which are the U.S. customary and metric. U.S. Customary rulers and scales measure feet and inches. Smaller units are measured in fractions of an inch. See **Figure 20-4A**. Find the fractional distance you need by counting spaces across the board. This becomes the numerator (top number). Count the spaces in one inch on the rule. This is the denominator (bottom number). Metric rulers and scales measure in millimeters. They are typically numbered every 10 mm. See **Figure 20-4B**. The metric rule may be further divided into 0.5 (half) mm. Both systems may appear on the same measuring tool, as shown in **Figure 20-4C.**

The measuring system you choose depends on the working drawings. The title block will tell what system is used. It will also provide the scale of the drawing. If the scale reads *1" = 1'-0"*, then each inch on the drawing will be 1' on the layout.

Rule

The ***rule*** you select depends mostly on the accuracy you need and which style you prefer. Rules may be flat, flexible, or folding types. They are made of wood, fiberglass, plastic, metal, or cloth. Often, both customary and metric measurements are found on the rule.

Flat rules are typically metal, wood, or plastic. They may be 1' to 4' long. High quality wood rules have a brass edge. The brass edge is not dented as easily as a wood edge. Rules may also be steel and aluminum. Special purpose rules include a ***centering rule***, with the measuring units extending both directions from the center *zero* point. This eliminates mathematics from many centering tasks.

Rigid ***folding rules*** are usually 6' long. Metric rules are 2 m long. Some have an extension rule at one end for measuring inside distances. See **Figure 20-5**.

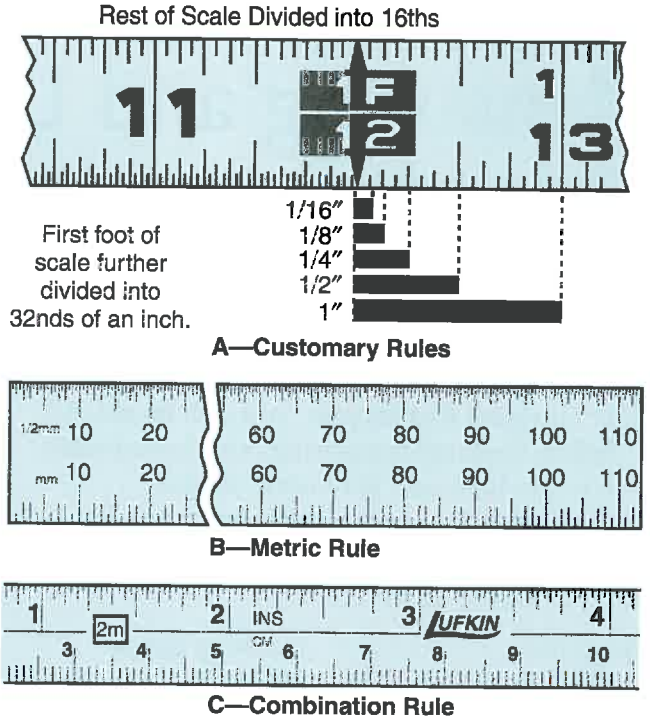


Figure 20-4. Rule measuring units may be customary, metric, or a combination of both. Use the system designated on the working drawings. (*Lufkin Division—The Cooper Group, The L.S. Starrett Co.*)

A ***flexible rule***, or ***tape measure***, is very convenient and will measure both straight lengths and curves. See **Figure 20-6**. Also use it to measure inside distances, such as a doorway. To account for the size of the tape case, add the distance indicated on the side of the case to the reading obtained. Most tape cases require that you add 2", 2½", or 3". When working with metric tape measures you are required to add compatible distances. Other tapes have a window on the top to read the inside distance.

Tape lengths commonly used by cabinetmakers range from 12' to 30' (4 m to 9 m). Other tape lengths may be up to 200' (61 m). Both customary and metric measurements may be printed on the tape.

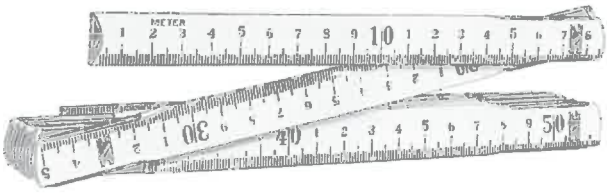
Depth gauge

The ***depth gauge*** measures depth of holes or other offsets. See **Figure 20-7**. The rule slides through the body of the gauge. Tighten the adjusting nut before lifting the gauge to read the measurement. The extension part of a folding rule may also be used to measure offsets and depths.

Caliper rule

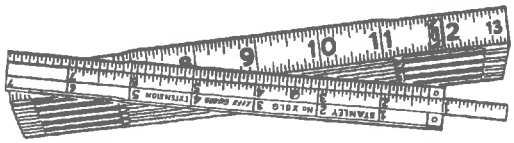
The ***caliper rule*** is used to measure outside and inside distances. Outside dimensions are read at the

6′ Zig-Zag Rule

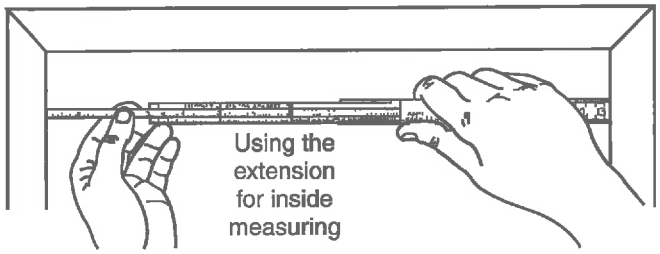


2m Zig-Zag Rule

A



6′ Extension Rule



B

Figure 20-5. A—Rigid folding rules extend to measure distances. (*Lufkin Division—The Cooper Group*). B—They also measure inside distances with an extension. (*Stanley Tools*)

out index line. Inside dimensions are read at the *in* index line. See **Figure 20-8**. Other caliper rules have offset heads to provide a common index line. This reduces reading errors. Some have depth gauges built into the body of the rule.

Squares

There are a number of different kinds of *squares*. They are used for several purposes, which include the following:

- Checking that corners form a 90° angle (squareness).
- Serving as a straightedge.
- Measuring distances and angles.

Figure 20-6. Two types of flexible rules. (*Stanley Tools*)

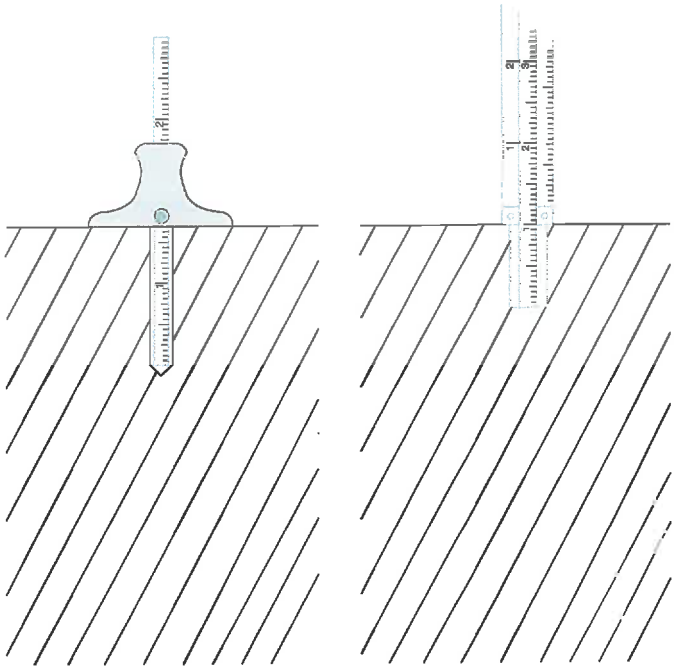


Figure 20-7. The depth gauge blade or rule extension measures hole depth. Read the dimension at the surface of the hole. (*The L. S. Starrett Co.*)

Framing and bench squares

Framing and bench squares are flat steel or aluminum. A ***framing square*** has a 24″ (610 mm) body and 16″ (406 mm) tongue that form a 90° angle (right angle). A ***bench square*** is smaller. See **Figure 20-9**. The face of the square is seen when the body is held in the

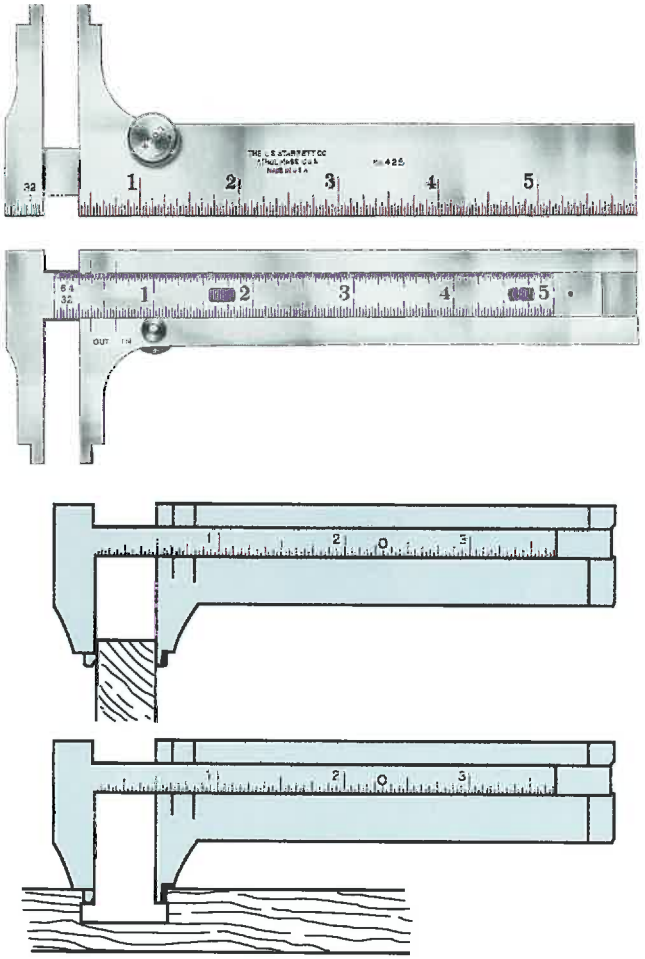


Figure 20-8. Caliper rules have a head formed to measure outside and inside dimensions. (*The L.S. Starrett Co.*)

left hand and the tongue in the right hand. The back is the other side of the square. The face and back of the square have scales and tables.

Scales

The *scales* refer to customary and metric measurements. This makes the square useful as a rule. Once a measurement is marked, the square can be used to draw a perpendicular line. See **Figure 20-10**. It can also be used to check the squareness of a constructed joint.

Tables

Tables provide helpful information for commonly used measurements. Two such tables are the brace measure table and the octagon scale, or eight square scale.

The ***brace measure table*** gives diagonal measurements that show the length needed for a diagonal piece, such as a brace to support a shelf. It is on the tongue of most framing squares. See **Figure 20-11.**

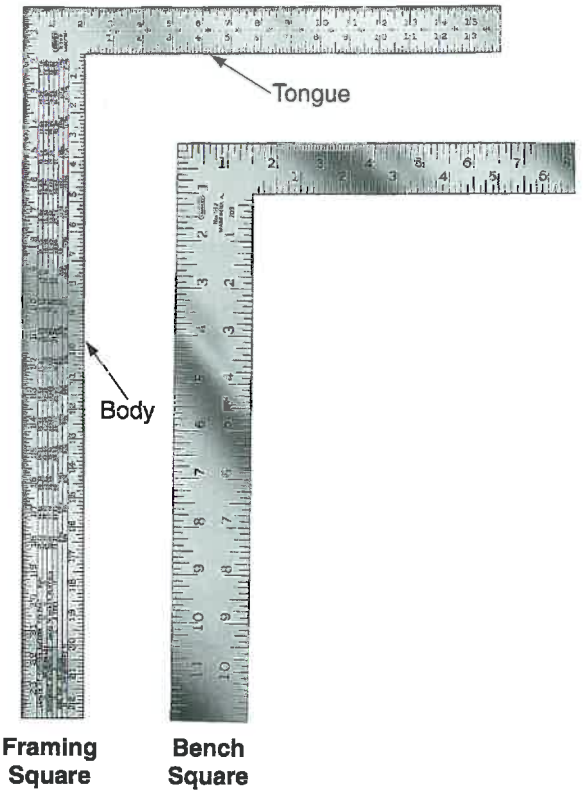


Figure 20-9. Framing squares are larger than bench squares. The framing square may also have a list of scales and tables printed on it. (*Stanley Tools*)

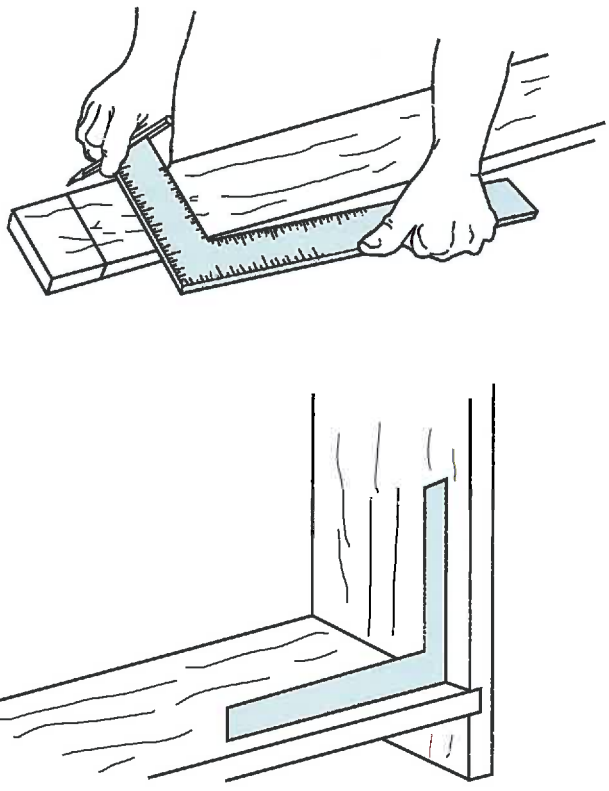


Figure 20-10. Framing and bench squares are used for measuring and marking, as well as checking squareness.

For example, suppose you have a 22″ wide shelf and you wish to brace it at a point 18″ from the wall and from 24″ below the shelf. Find the measurement on the table marked 18/24. You will find the number 30 next to it. This is the proper length of the brace.

The *octagon scale* helps you identify critical measurements for laying out octagons. Suppose you wanted an octagon tabletop 28″ across. See **Figure 20-12.** To produce this tabletop proceed as follows:

1. Cut a piece 28″ square.
2. Draw centerlines AB and CD.
3. Set a compass or divider for 28 dots along the octagon scale.
4. Mark the distance on each side of the centerlines along the four edges of the board.
5. Connect the newly marked locations to form the eight sides.

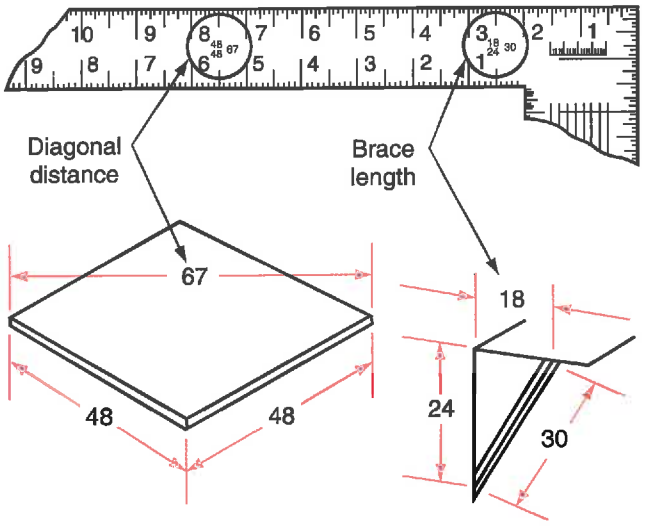


Figure 20-11. The brace measure table shows brace lengths.

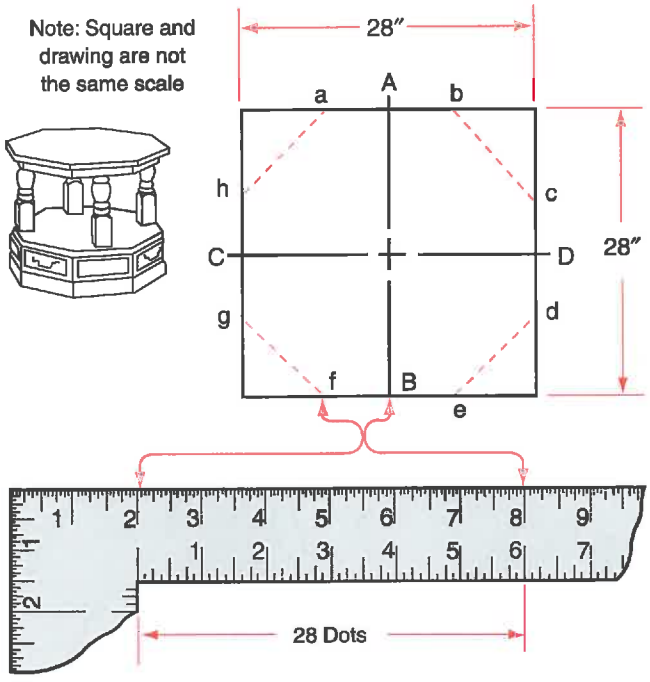


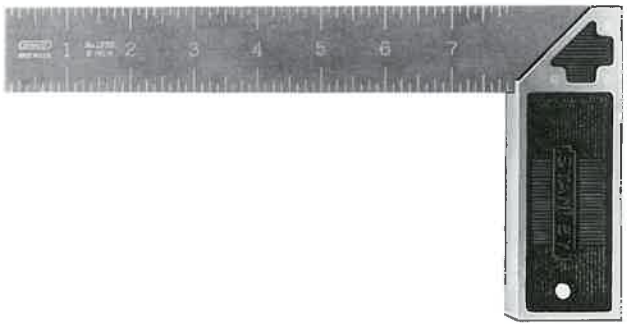
Figure 20-12. The octagon scale, found on some framing squares, is a row of numbered dots for laying out octagons. (*Stanley Tools*)

Try square

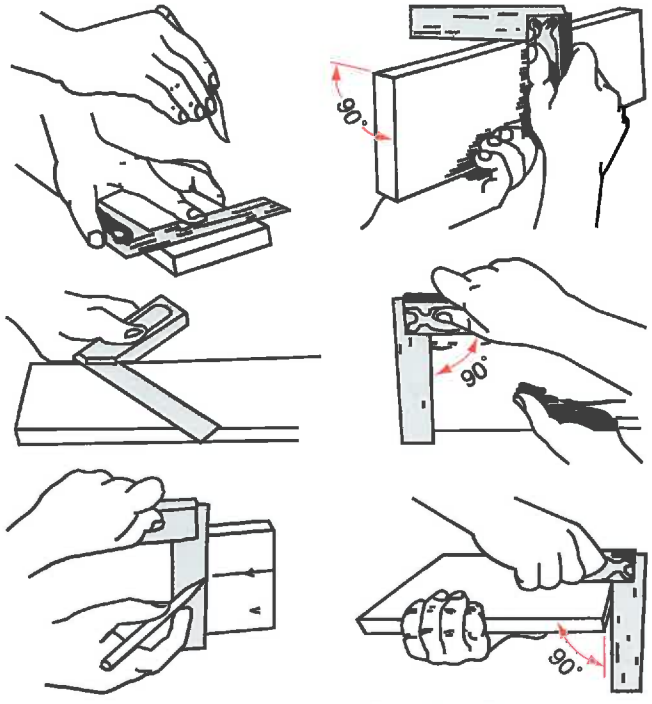
Try squares have a steel blade and a steel or wood handle. Some have a 45° angle cut into the handle. Use them for making layouts or checking squareness. See **Figure 20-13.**

Combination square

The ***combination square*** is generally more versatile than the try square. It consists of a grooved blade that slides through the handle. It may also



Try Square



Marking **Checking Squareness**

Figure 20-13. Try squares are for both marking and checking squareness. (*Stanley Tools*)

have protractor and center heads. See **Figure 20-14.** You can use a combination square for a number of purposes:

- Measure distances and depths.
- Layout 90° angles, 45° diagonal, and parallel lines.
- Locate centers.

Parallel lines can be laid out easily. Adjust the blade to the intended distance. Place a marking device such as a pencil, scratch awl (from the handle on some squares), or knife point against the end of the blade. While holding the marking device against the blade, slide the square down the material. See **Figure 20-15A.**

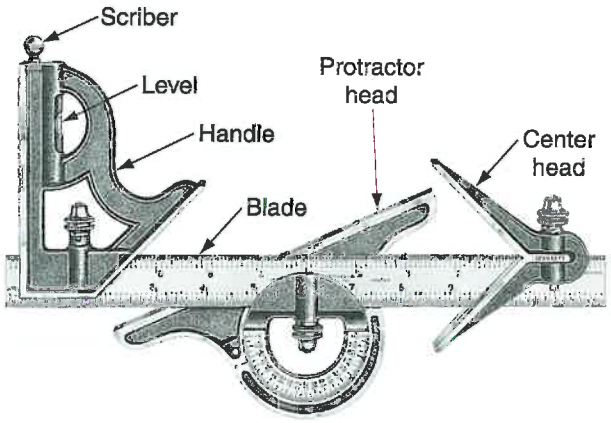


Figure 20-14. Parts of a combination square. (*The L.S. Starrett Co.*)

Many combination squares have a center head. Hold the center head against any circular or curved surface. The blade's edge will point directly through the center of a circle. See **Figure 20-15B.**

The protractor head adjusts for any angle. You may wish to remove the handle and center head when using the protractor head. See **Figure 20-15C.**

Marking gauge

The ***marking gauge*** is designed to make parallel lines. It has an adjustable head and a steel pin. See **Figure 20-16A.** It will mark parallel lines on wood, plastic, and metal. To use the gauge:

1. Adjust the head to the appropriate width from the edge of the board to the line using the scale printed on the beam. See **Figure 20-16B.**
2. Place the gauge flat on the material. The steel point should point sideways, without touching the wood.
3. Roll the gauge toward you until the awl pin touches the material.
4. Push the gauge away from you. Keep the head against the edge of the work. The point should make a visible score line. See **Figure 20-16C.**

Also use a marking gauge to transfer dimensions. Set the marking gauge to the size of part you wish to copy. Then mark the new workpiece. This is helpful when duplicating parts.

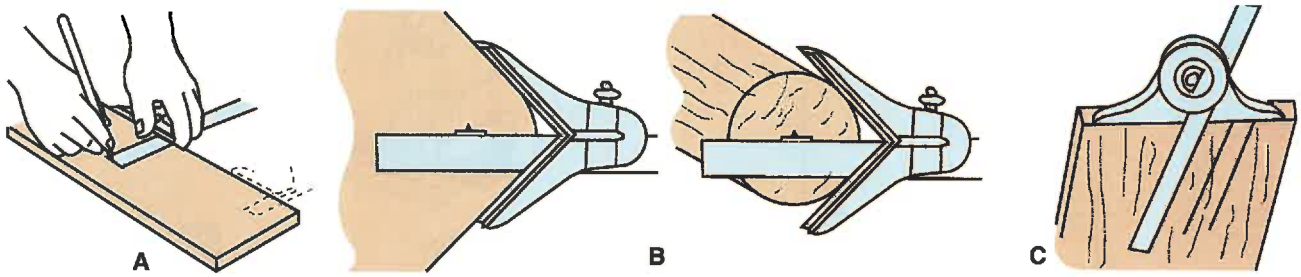


Figure 20-15. Use the combination square to: A—Mark parallel lines. B—Find centers. C—Mark angles.

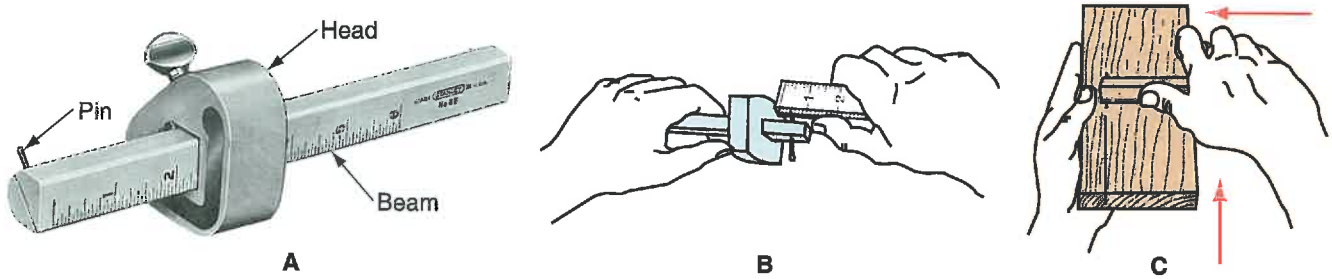


Figure 20-16. A—Components of a marking gauge. (Stanley Tools) B—Setting the marking gauge. C—Marking a parallel line.

Layout Tools

Layout tools transfer distances, angles, and contours. Most lack scales for measuring distances and angles. They are set with a measuring tool. The following descriptions cover common layout tools.

Sliding T-bevel

The ***sliding T-bevel*** will lay out and transfer angles. See **Figure 20-17.** Set the angle of the T-bevel blade with a protractor. Loosen the locking device on the handle to move the blade. After you set the proper angle, tighten the locking device.

Besides layout, T-bevels can set the angles for table saw blades, jointer fences, and drill press tables. If you are setting 90° angles, use a try square. T-bevels are not as accurate as a square.

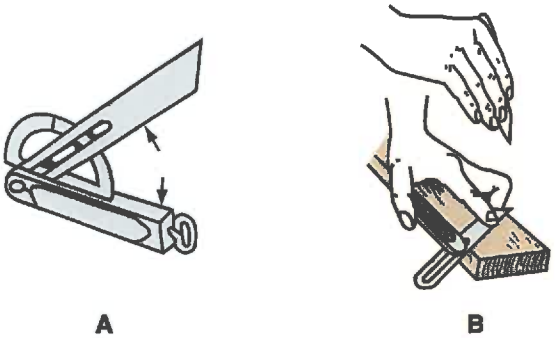
Angle divider

An ***angle divider*** looks like a T-bevel with two blades. See **Figure 20-18A.** The blades move apart from 0° to 90°. If the blades are adjusted to an angle or a corner, the body bisects the angle. This angle helps when cutting miter joints. See **Figure 20-18B.**

Angle dividers have numbers on the body and an index mark on the adjusting nut. The numbers on the side of the nut are 30°, 45°, and 60°. Aligning the index mark along these numbers accurately sets the blades to that angle. The numbers on the other side of the nut are 4, 5, 6, 8, 10, and 0. These indicate settings for polygons. Aligning the index nut at 6 will set the angle of the blades for a hexagon (a six sided polygon). The angle between the blades will be 120°. The body will bisect the angle at 60°. When the index mark is set at 0, the blades form a straight line with the body.

For example, to lay out an octagon picture frame, proceed as follows:

1. Set the index mark even with the 8.
2. Hold the body of the angle divider against the edge of the frame material.
3. Mark the mitering angle and saw the workpiece on that line. See **Figure 20-18C.**



A B

Figure 20-17. The T-bevel has a body, blade, and locking device. A—Set it with a protractor. B—Marking the wood with a T-bevel.

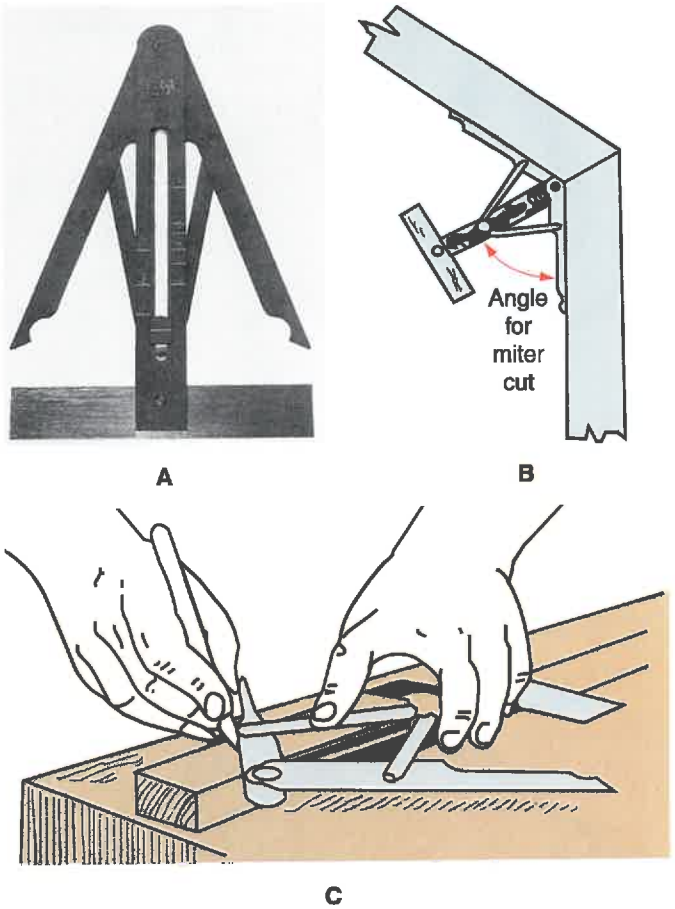
Calipers

Calipers are used to transfer dimensions. The three types of calipers are outside, inside, and hermaphrodite. See **Figure 20-19.** Some are assembled with a firm (friction) joint. Others have a bow spring with an adjusting screw and nut. Firm joint calipers are quicker to adjust, yet bow spring calipers maintain greater accuracy during use.

Calipers are used most often when wood turning. When the *lathe* is stopped, you can check or transfer thicknesses and distances.

Outside caliper

An ***outside caliper*** checks outside diameters on turnings. See **Figure 20-20.** First, set the caliper with a rule. Then turn the material until the caliper slips over it. When making duplicate parts, set the caliper by the workpiece being copied.



A B

C

Figure 20-18. Angle dividers are helpful when setting angles for cutting miter joints. (*General Hardware*)

Inside caliper

An ***inside caliper*** checks inside diameters. Preset the caliper with a scale. Then turn the work until the diameter is reached. See **Figure 20-21.**

Hermaphrodite caliper

The ***hermaphrodite caliper*** is a firm joint tool that has one leg like a caliper and the other has a needle-like point. The hermaphrodite caliper is used for the following:

- Locate outside and inside centers by scribing three or four arcs. See **Figure 20-22A.**
- Mark a parallel line on flat or round stock. See **Figure 20-22B.**
- Copy a contour, which is often called coping. See **Figure 20-22C.**

The tools described thus far measure and mark distances, lines, and angles. You will also lay out circles, arcs, and curves. Tools for these purposes are compasses, dividers, irregular curves, and template formers.

Compass and divider

Compasses and ***dividers*** are similar layout tools. Both have two legs. However, a compass has a pencil point on one leg instead of a steel point. See **Figure 20-23.** Use compasses and dividers to:

- Step off distances.
- Bisect lines, angles, and arcs.
- Construct lines and arcs tangent to each other.
- Scribe circles, ellipses, and arcs.
- Lay out polygons.
- Cope a contour, such as for fitting molding.

Using tools associated with bisecting lines, angles, and arcs; constructing lines and arcs tangent to each other; and laying out polygons were covered

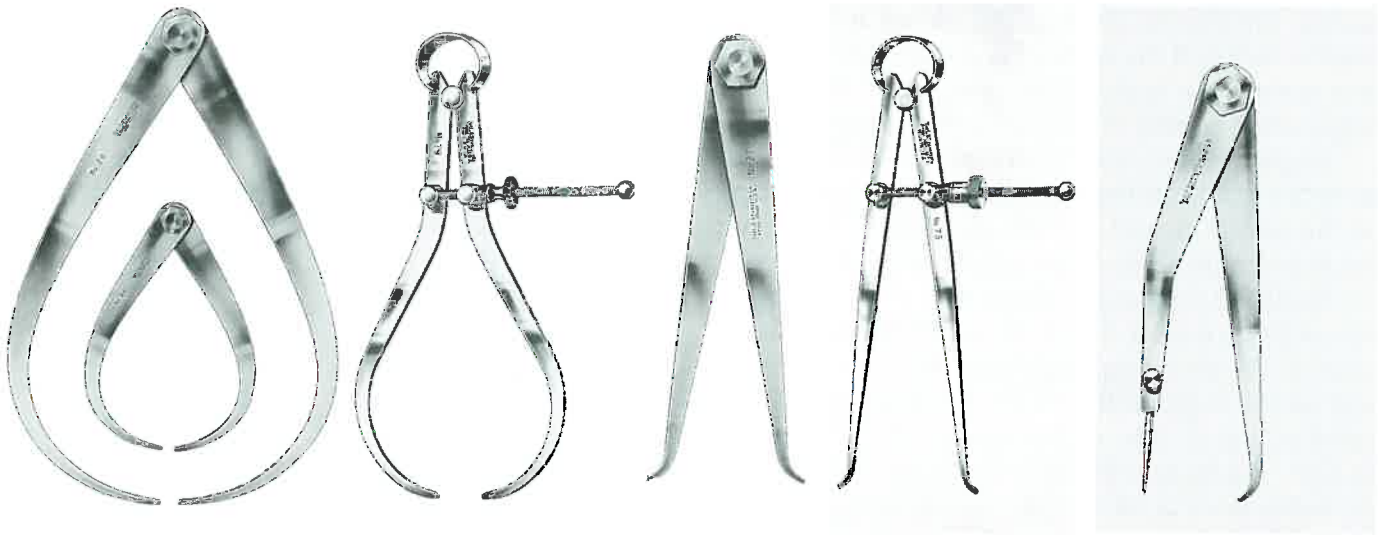


Figure 20-19. Calipers for transferring outside and inside measurements and parallel lines. A—Firm joint outside calipers. B—Bowspring outside calipers. C—Firm joint inside calipers. D—Bow spring inside calipers. E—Hermaphrodite calipers. (The L.S. Starrett Co.)

Figure 20-20. Set and use the outside caliper to check diameter measurements. (*The L. S. Starrett Co.*)

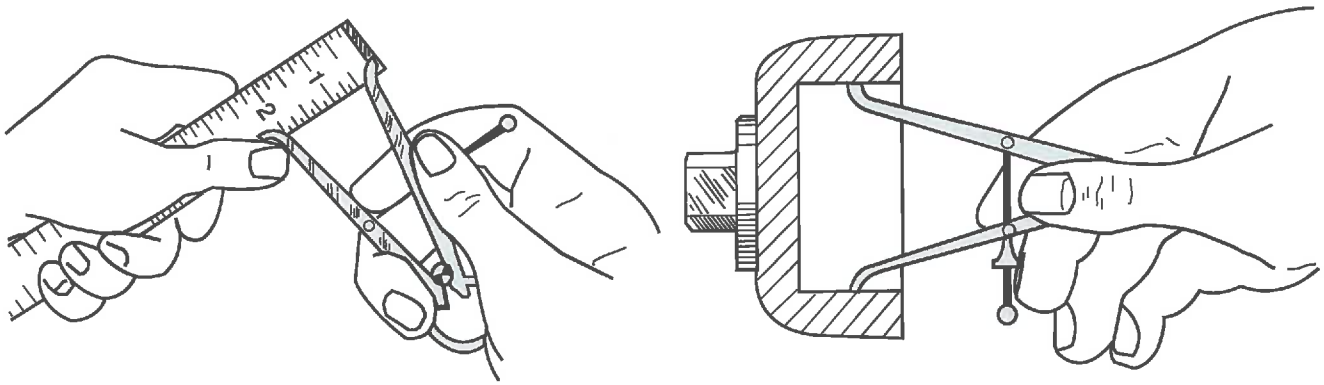


Figure 20-21. The inside caliper is set and used to check dimensions on the inside of round material. (*The L.S. Starrett Co.*)

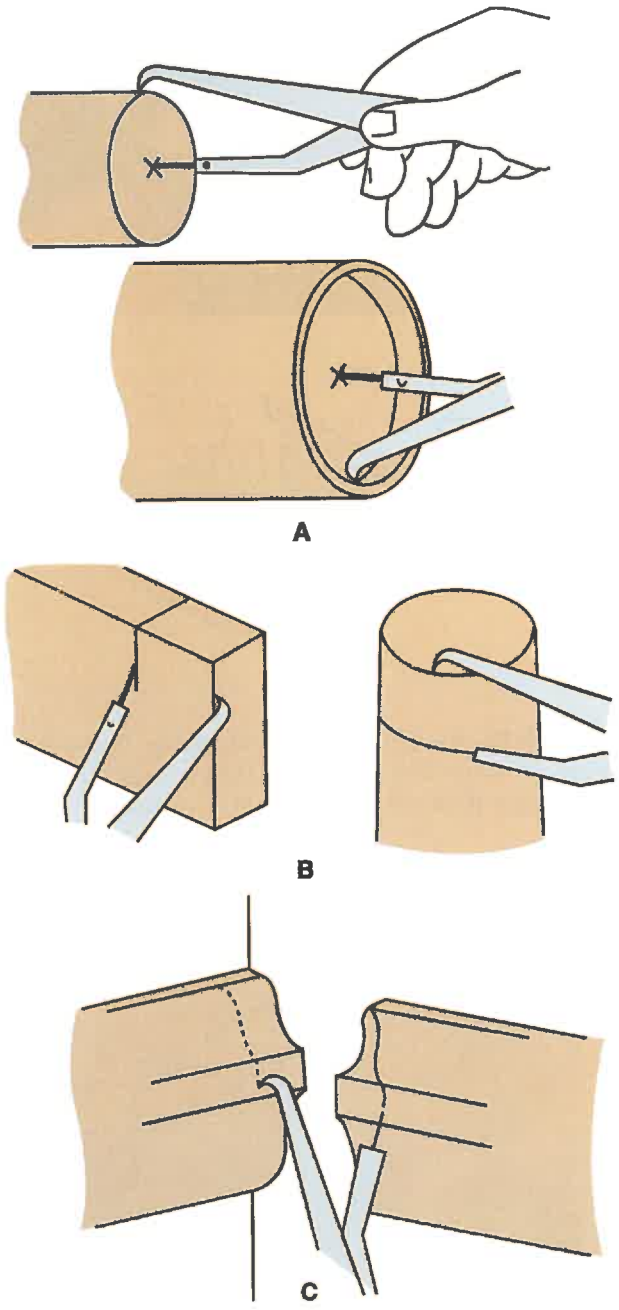


Figure 20-22. Locate centers and mark parallel lines with the hermaphrodite caliper.

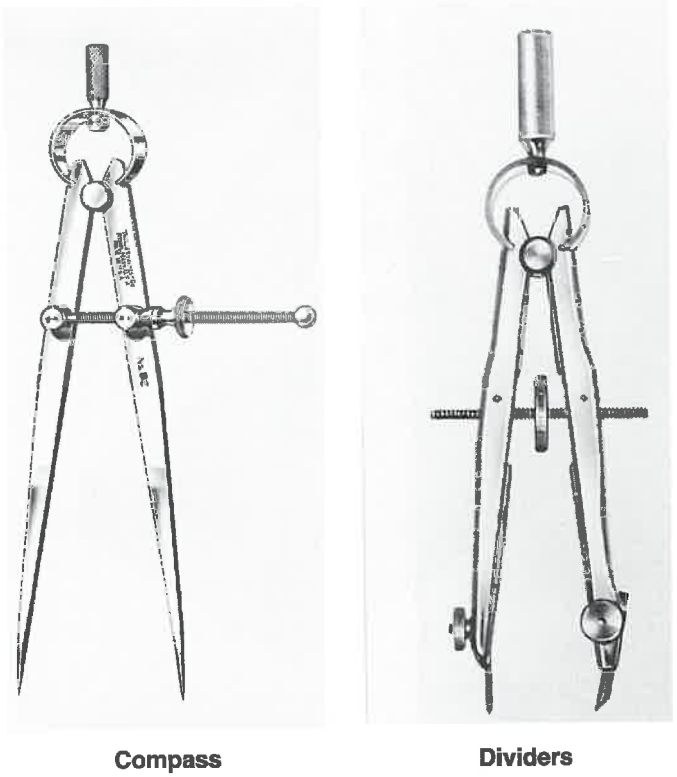


Figure 20-23. Compasses have a pencil and steel point. Dividers have two steel points. (The L.S. Starrett Co.)

in *Chapter 9*. Compasses and dividers discussed there were layout tools for working drawings. Tools for material layout are much more sturdy.

Marking with a compass requires some hand coordination. Place one hand on or near the top (joint) of the compass or divider. See **Figure 20-24A**. The other hand sets the pivot location of the steel point.

Use compasses and dividers as you would when drafting. Adjust the compass or divider to the proper measurement when transferring distances. See **Figure 20-24B**. Then, mark the material. You can also duplicate parts by setting the dividers the size of the original part. Then mark the new material.

Trammel points

Trammel points are used for making large circles and arcs. Two steel points are clamped on a rectangular piece of lumber. See **Figure 20-25A**. Some have one point that holds a pencil. This allows either a pencil mark or a scratch for marking the wood.

The size of the circle is limited only by the length of lumber you choose.

To lay out a circle with trammel points, proceed as follows:

1. Adjust the trammel points to the desired radius with a rule.
2. Hold one steel point of the trammel at the center of the circle.
3. Swing the other trammel point in an arc to mark the circle on the material. See **Figure 20-24B**.

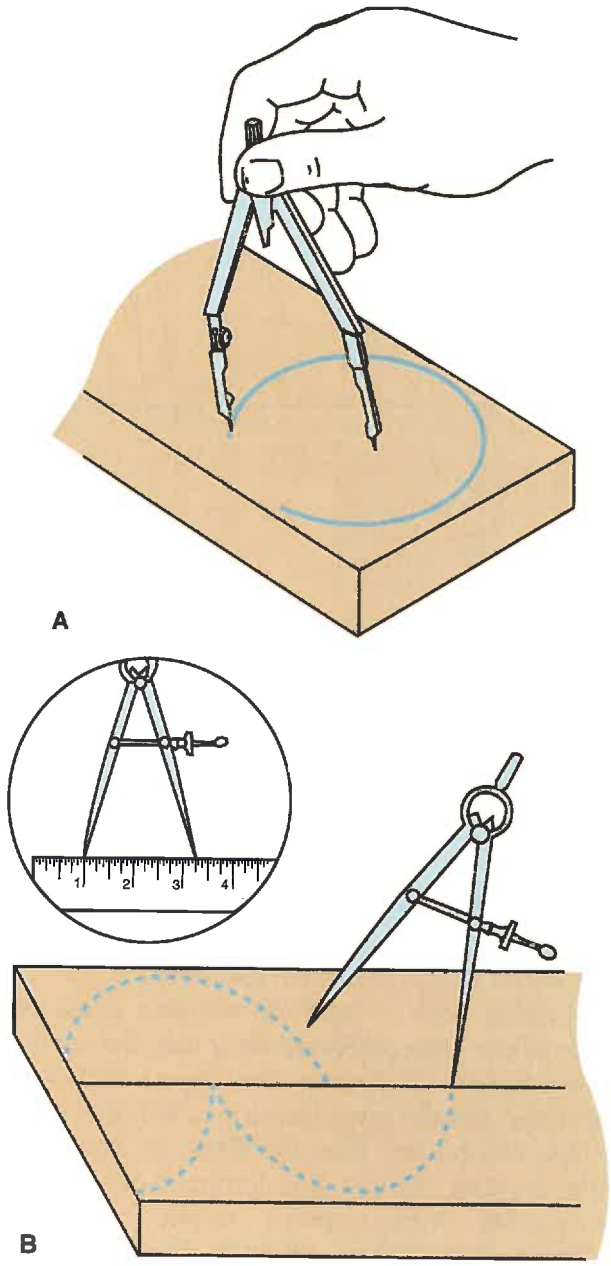


Figure 20-24. A—Place and swing the compass on the center point of the circle or arc. B—The divider can be used for stepping off measurements.

Template former

The ***template former*** is used to copy irregular shapes. See **Figure 20-26**. Press it against a curved surface. This causes the individual pieces of wire to

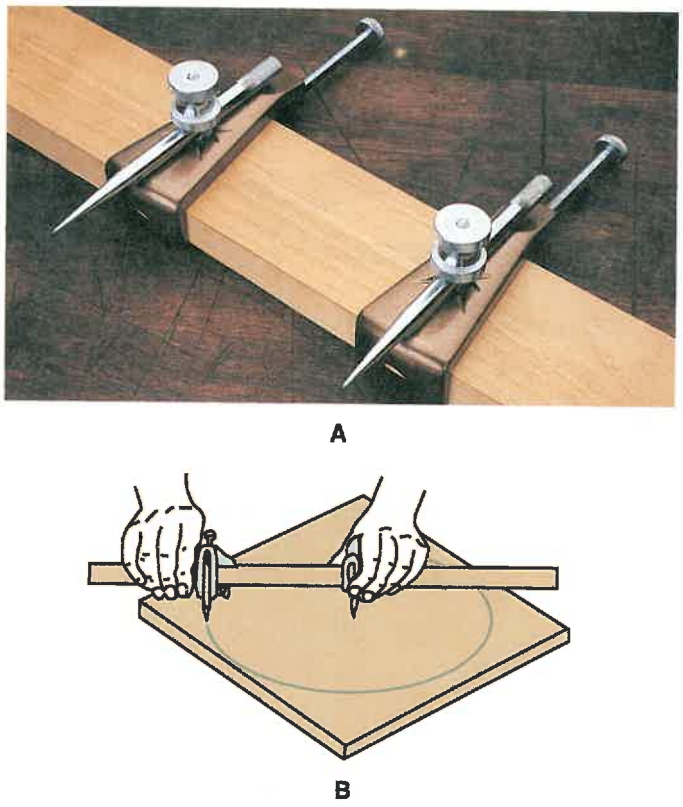


Figure 20-25. A—Clamp trammel points to a piece of lumber. (*The Fine Tool Shops*) B—They are used to lay out circles larger than are possible with a compass.

Figure 20-26. The template former conforms to the shape of the piece to be copied. (*The Fine Tool Shops*)

slide. Once shaped, the former's contour can be transferred to a pattern paper or the material to be cut.

Layout Practices

Layout must be done with accuracy. Although layout tools can be used many ways, select the tool that is best suited to your work.

Marking points

When marking a distance, the best pencil mark to make is an arrow or "V". See **Figure 20-27.** The point of the arrow shows the proper location. A pencil dot may be lost among the scratches or blemishes in the wood. A short line does not tell which end of the line is the proper measurement. When making the mark, do not press hard. Remember, any pencil marks, dents, or scratches you make during layout must be removed later. Erase all pencil marks.

Be sure that the rule you use is undamaged. The end should not have dents. If the corner is damaged, begin measuring from the 10" mark. For example, to lay out a distance of 3", measure from the rule's 10" mark to the 13" mark. Remember to account for starting away from the end of the rule. When using a tape, make it a habit to frequently inspect the hook to make sure it is undamaged. If the hook has been bent, you will read incorrect measurements.

Lines

Most lines are made using a rule or square. For lines that must be parallel to the edge, use a marking gauge, combination square, or hermaphrodite caliper.

Circles and arcs

Compasses, dividers, and trammel points make accurate circles and arcs. To set them, place one leg on the 1" or 10 mm mark of a rule. Adjust the other leg according to the desired measurement. Again, be sure to account for starting away from the end of the rule.

Arcs are partial circles. The arc has a center point and radius. Set the layout tool for the radius of the arc. Then locate the point of the tool at the arc's center and swing the desired arc.

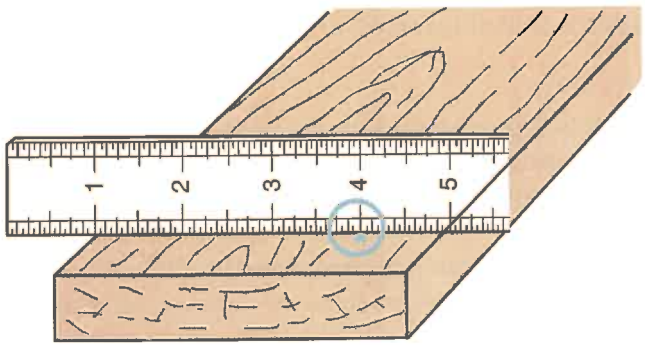


Figure 20-27. Points are most accurately marked with a *V*.

Polygons

Common ***polygons*** are triangles, squares, rectangles, hexagons, and octagons. Polygon shapes are used for tabletops, mirror and picture frames, clock faces, legs, etc.

Two common tools for laying out polygons are the framing square and protractor. Set angles on the framing square using two pieces of wood and the measurements on the tongue and body. See **Figure 20-28.**

Certain polygons are often laid out with a compass. Two examples are hexagons (six sides) and octagons (eight sides). To draw a hexagon, proceed as follows:

1. Draw a circle with the radius equal to one side of the hexagon. See **Figure 20-29.**
2. Keep the same setting of the compass after drawing the circle.
3. Start at any point on the circle and draw an arc that intersects the circle.
4. Move the compass to where the arc intersected the circle and construct another arc. Keep doing so until you divide the circle into six parts.
5. Connect the six intersections to complete the hexagon.

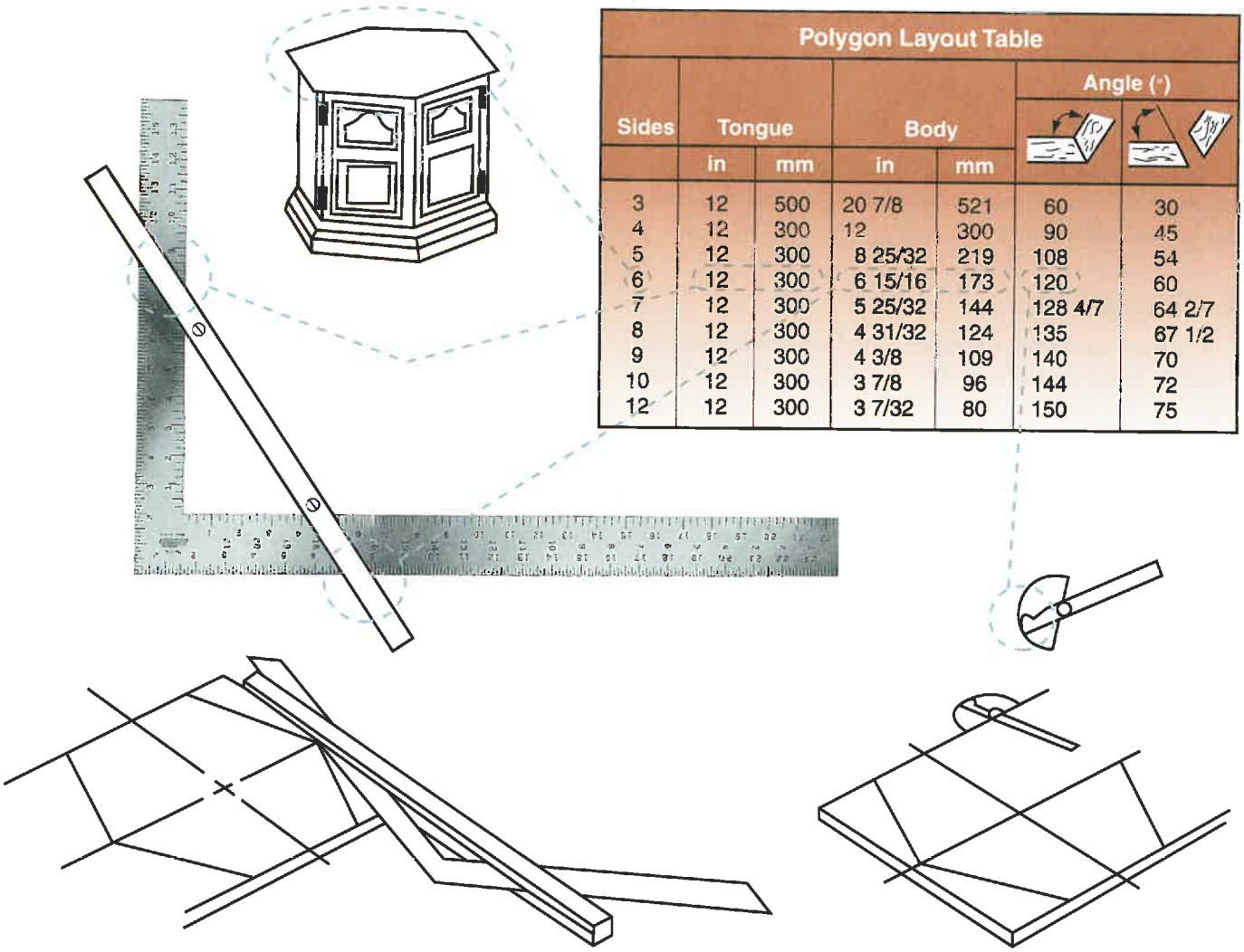
To draw an octagon, proceed as follows:

1. Draw a square the size of the octagon. See **Figure 20-30.**
2. Draw diagonals across the corners of the square.
3. Set the compass to the distance from a corner of the square to the intersection of the diagonals.
4. Place the compass point on each corner of the square and construct arcs.
5. Connect the points where the arcs intersect the edges of the square.

Ellipses

An ellipse (oval) can be laid out easily with a string. See **Figure 20-31.** Select a string that will not stretch, and proceed as follows:

1. Cut out a rectangle the desired size of the ellipse.
2. Make centerlines EF and GH.
3. Make an arc using point B as the pivot and line BC as the radius.
4. Measure the length of line AD.



Polygon Layout Table						
Sides	Tongue		Body		Angle (°)	
	in	mm	in	mm		
3	12	500	20 7/8	521	60	30
4	12	300	12	300	90	45
5	12	300	8 25/32	219	108	54
6	12	300	6 15/16	173	120	60
7	12	300	5 25/32	144	128 4/7	64 2/7
8	12	300	4 31/32	124	135	67 1/2
9	12	300	4 3/8	109	140	70
10	12	300	3 7/8	96	144	72
12	12	300	3 7/32	80	150	75

Figure 20-28. A protractor or framing square and straightedge may be used for polygon layouts.

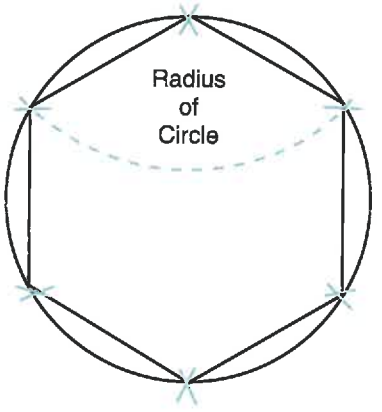


Figure 20-29. Hexagon layout made by striking arcs with a pair of dividers.

5. Divide that distance by two. (AD/2)
6. Measure this distance on each side of O to locate points I and J.
7. Put thumbtacks or small nails at points E, I, and J.
8. Tie a string tightly around the thumbtacks.
9. Remove the thumbtack at point E.
10. Place a pencil inside the string loop and pull the loop tight. Move the pencil to create the ellipse. For accuracy, keep the string at the same point on the pencil while moving about the ellipse.

Irregular shapes

Some cabinet styles have irregularly shaped parts. For example, Early American furniture has many curves. Working drawings usually include patterns that show how to lay out the shape.

Patterns

Drawings may provide full, half, or detail patterns. See **Figure 20-32.** A ***half pattern*** shows detail on one side of a centerline. You mark around the pattern, then turn it over and mark again. A ***detail pattern*** may be necessary for more complex shaped parts.

A ***square grid pattern*** is a way to transfer complex designs from working drawings to material. Make two square grid patterns. One pattern is traced

over the working drawing and the other is a full size pattern. The size of grids should correspond to the scale of the working drawing. If the scale is ¼" equals 1", use a ¼" grid sheet. The full size transfer pattern will be 1" squares.

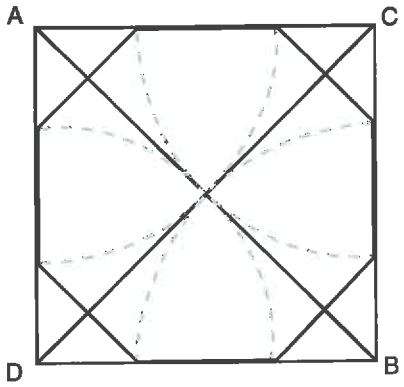


Figure 20-30. Laying out an octagon with a divider or compass.

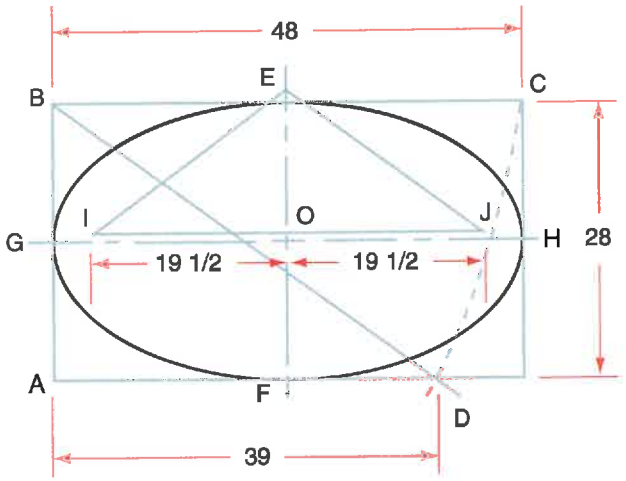


Figure 20-31. An ellipse for an oval tabletop can easily be laid out within a rectangle.

Make the grid on tracing paper put over your working drawings. Then, trace the shape from the working drawing. See **Figure 20-33A.**

Cut a sheet of heavy wrapping paper for the full size pattern. Lay out the proper size squares on the paper. Place a dot on the pattern grid where the design crosses it. See **Figure 20-33B.** Connect the dots to complete the full size pattern. Cut out the pattern with scissors. Then lay the pattern on the wood and trace around it.

Templates

A ***template*** is a permanent full size pattern. It may be made of cardboard, hardboard, or thin sheet metal. Make a pattern when you intend to use the shape several times.

A template is also valuable for guiding a tool. For example, you may lay a template over material to guide a router bit.

Template former

When duplicating irregular curves, use a ***template former***. See **Figure 20-26.** It is much simpler than measuring the original part and making a pattern.

Layout rod

A ***layout rod*** is a record of often used distances. Plan to make one for standard cabinets you produce. It eliminates repeated measuring with a rule. The rod also helps with machine setups.

The rod is marked with important dimensions of the cabinet. See **Figure 20-34.** These may be the location of shelves, doors, and joints. Measurements are marked full size. Therefore, make the rod

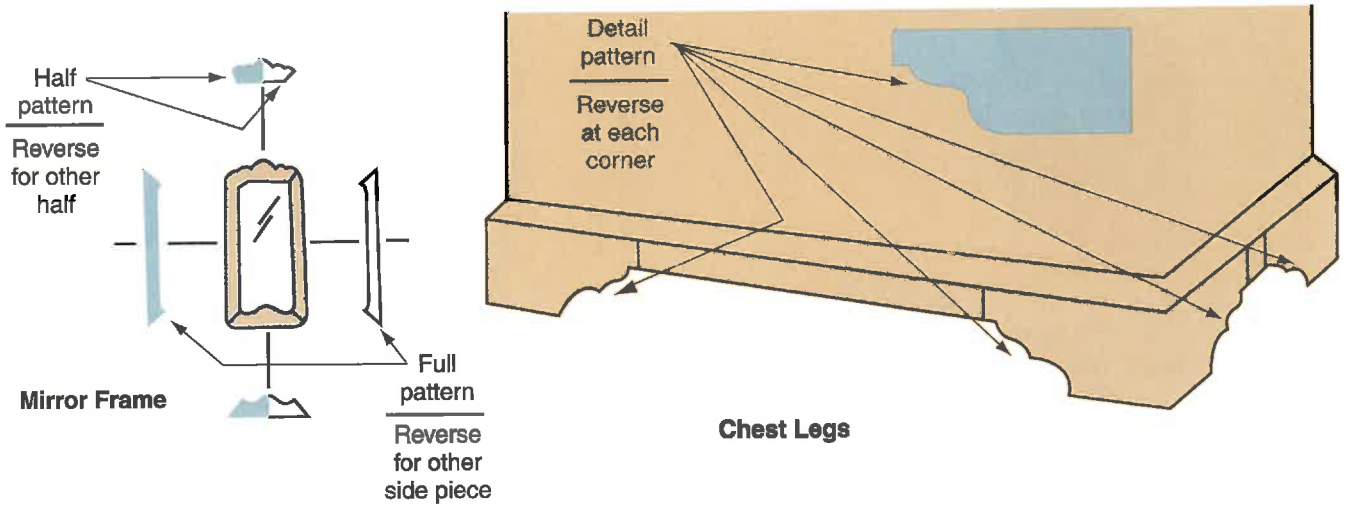


Figure 20-32. Full, half, and detail patterns are valuable layout devices.

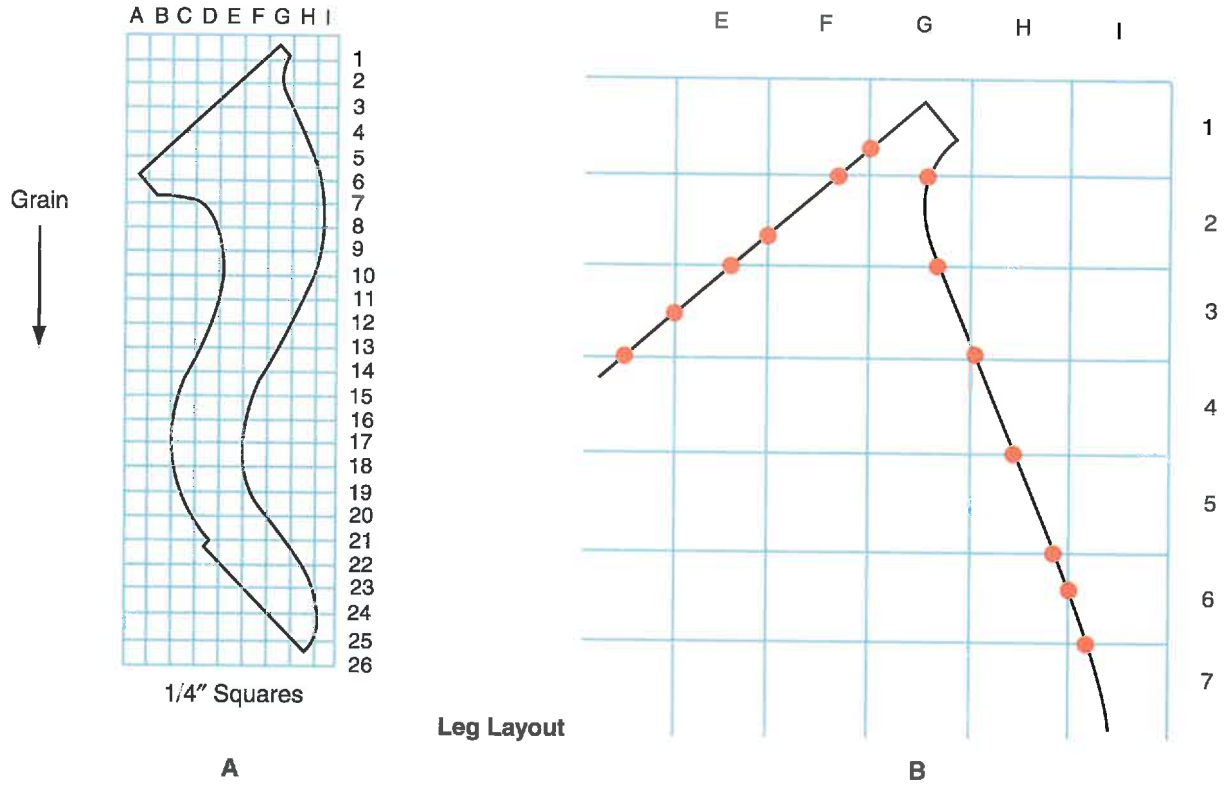


Figure 20-33. Transfer lines in individual squares from the square grid pattern to the layout.

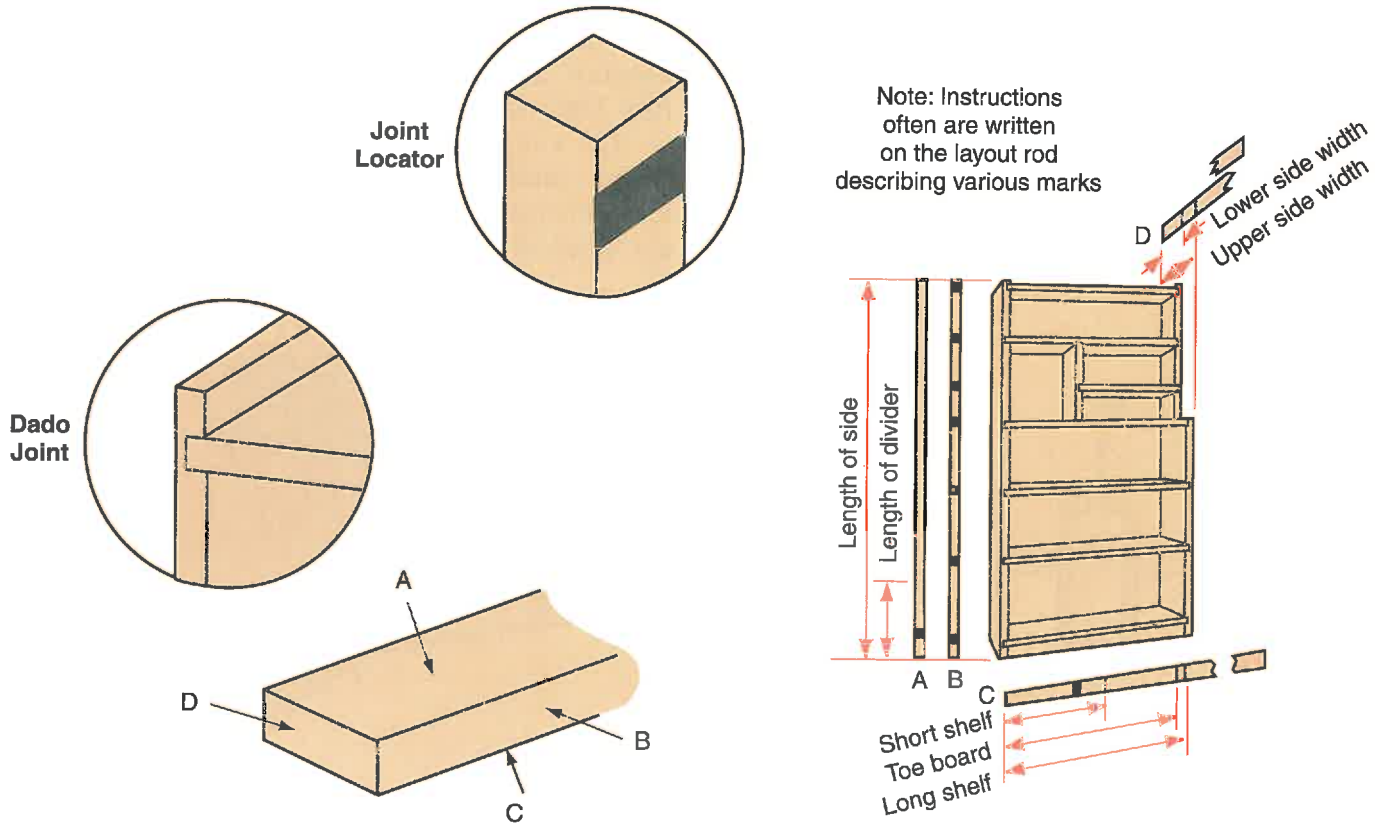


Figure 20-34. Layout rods become permanent references for a particular cabinet.

slightly longer than the greatest dimension of the cabinet. The rod is used for height, width, and depth measurements.

A rod is made of 1 × 1 or 1 × 2 lumber. It is surfaced on all four sides. One side may contain width measurements. A second side may contain height measurements. Other sides are used for depth and other needed distances.

Story pole

Similar to a layout rod, the ***story pole*** is used to mark locations of all items to be found in a room. It is usually made of 1 × 3 lumber and is as long as possible (up to the room width). A second pole is made equal to the height of the room, or the top of the highest cabinet. Besides marking cabinets on the layout rod, mark all other items in the room. Examples are: electrical outlets, switches, doors, windows, HVAC vents and radiators, plumbing, and light fixtures.

Measuring and Layout Tool Maintenance

Measuring and layout tools need very little maintenance. There are few moving parts. However, care is needed during handling and storage of the tool.

Some measuring tools, such as framing and try squares have scales stamped on them. They may become difficult to read. If so, wipe across them with a cloth pad containing white paint. Then remove the excess from the surface of the tool with steel wool. The measurements should be readable again.

Many tools are plated or painted to prevent rust. If rust does occur, possibly on the blade of a try square, remove it with steel wool. Then rub the blade with paste wax. Oil should not be applied to woodworking tools. It will stain your wood.

Moving joints should be rubbed with paste wax for lubrication. However, be careful when lubricating firm joint tools, such as calipers. This might cause the joint to move too freely.

Knives and awls need sharpening. Follow instructions for maintaining hand tools in *Chapter* 22. The points on dividers, compasses, trammel points, and marking gauges may need sharpening occasionally.

Think Safety—Act Safely

When measuring and laying out workpieces:

- Hold sharp points of tools away from you when carrying them.
- Cover sharp tool points if you must have them in your pocket.

Summary

The size of cabinet components are only as accurate as your layout. Three types of tools are used when laying out material: marking tools, measuring tools, and layout tools.

Marking tools include pencils, awls, and knives. They indicate measurements and location points on your material. Measuring tools include rules, gauges, and squares. Many of these are also used as layout tools. Layout tools transfer distances, angles, and contours. Those without measurements on them must be preset with a measuring tool. Layout tools include T-bevels, angle dividers, calipers, compasses, dividers, trammel points, and template formers.

When laying out material, you construct lines, polygons, circles, and curves. Patterns may be made to trace your design onto the material. Square grid patterns transfer complex shapes from working drawings to stock. For often-built cabinets, a layout rod may be used. It is marked with all the critical measurements of the cabinet.

Test Your Knowledge

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

1. Proper measuring and layout result in cabinets that are _____.
   a. flawless
   b. horizontal
   c. plumb
   d. square
2. Usually cabinetmakers mark measurement with a(n) _____.
3. Three types of marking tools are _____, _____, and _____.
4. What rule would you select when laying out a tall curio cabinet?
5. Two measuring systems are _____ and _____.
6. Depth of a hole may be measured with a(n) _____ or _____.
7. A caliper rule measures _____.
   a. circumference
   b. inside and outside distances
   c. irregular curves
   d. measurements over 1'
8. Describe two differences between a framing square and a bench square.

9. Brace lengths can be found on the framing square _____.
10. The type of square you should use to check small pieces is the _____ square.
    a. bench
    b. combination
    c. framing
    d. try
11. Name three components attached to a combination square blade.
12. You set the angle of a sliding T-bevel with a(n) _____.
13. Describe three types of calipers and their use.
14. Circles can be laid out with what tools?
15. The most accurate mark is the _____.
    a. arrow
    b. dot
    c. line
    d. None of the above.
16. When copying an irregular shape, use a(n) _____.

Sawing with Stationary Power Machines

Objectives

After studying this chapter, you will be able to:

- Select stationary power saws for cutting straight or curved kerfs or cuts.
- Discuss the proper operation of stationary power saws.
- Choose the most appropriate saw blade for a given operation.
- Maintain stationary power equipment.

Important Terms

antikickback pawls
band saw
beveling
carbide-tipped blade
crosscutting
handedness
miter cut
radial arm saw
rear tension scroll saw
resawing
ripping
scroll saw
sleeve design scroll saw
table saw
tilting arbor table saw

Sawing with ***stationary power machines*** is the most fundamental processing operation in cabinetmaking. Cabinetmakers use table saws, radial arm saws, band saws, panel saws, and scroll saws to cut lumber and composite materials. Although sawing is also an integral part of other cabinetmaking operations, such as joint making, this chapter focuses on the problems of sawing to size and shape.

Stationary sawing equipment is designed for either straight-line or curved-line cuts. However, saws for cutting curves will do both with a straight-edge or fence. Selecting the proper saw involves several decisions:

- Select the safest saw for the cut you want to make.
- Choose an appropriate saw for the cut.
- Make sure the saw is available.
- Have prior instruction and experience with the machine.
- If more than one saw is appropriate, choose the one you prefer.

Once you have chosen the machine, consider the following suggestions for safe and efficient operation of the saw:

- Turn the switch off, and disconnect the power. Then, perform major set-up steps, such as changing blades and setting the fence.
- Be sure the saw blade is clean and sharp.
- Measure accurately. "Measure twice, cut once." Remember to check the hook on the end of your tape measure often, especially after it has been dropped.
- Have adjusted point-of-operation guards in place.
- Support material before and after the cut.
- Feed material into the saw properly.

Handedness

Problems with machine operations can be caused by ***handedness***. This refers to whether the user is left- or right-handed. In this book, right-handed setups and operations are illustrated. The left-handed person may follow them as shown, or reverse the setups. However, some sawing operations should be set up one way. One example is beveling with the table saw, which is described later in the chapter.

Sawing Straight Lines

Sawing straight lines is a standard operation for reducing stock to workpiece dimensions. Sawing stock square—all corners are 90°—is essential to producing high quality products. Blade selection is also important. You may be sawing lumber or composite materials, such as plywood or MDF panels. The proper blade often depends upon whether the material has grain or not.

The most accurate straight-line sawing is done on equipment having a circular saw blade. The diameter of the blade helps keep the cut straight. Stationary power saws which use a circular blade include: the tilting arbor table saw, tilting table saw, and radial arm saw. Other stationary machines,

such as panel saws, use circular blades, but are not discussed here. The maximum recommended blade diameter that can be installed determines machine size. Blades vary from 8" to 16" (203 mm to 406 mm), with 10" (254 mm) being most common.

Material is guided past the blade on tilting arbor saws or tilting table saws. You must support the material before and after the cut. The saw table may be large enough to do so. However, for long lumber or full sheets of manufactured panels, obtain additional supports, such as table extensions, rollers, sliding tables, or another person. The radial arm saw has an advantage over table saws for supporting lumber. The lumber is laid stationary on the table and the saw blade is pulled through the material. This makes cutting long lumber into shorter lengths very easy.

Material may be too long or heavy to control on some stationary saws. You could cut it to rough size first with a portable circular saw. Full-size sheets of plywood, particleboard, or other composite materials are best cut on either a horizontal or vertical panel saw. Table saws with accessories that extend the capacity of the table may also be used. Some of these accessories are discussed in *Chapter 28.*

Tilting Arbor Table Saw

A ***tilting arbor table saw,*** may have either a left tilting arbor or a right tilting arbor, depending on manufacturer and model. Some manufacturers make both. See **Figure 21-1.** The tilting arbor table saw is also known as a table saw, circular saw, and variety saw. It has the following major components:

- Horizontal table on a machine frame.
- Circular blade that extends up through a table insert.
- Tilting arbor that adjusts the blade angle from 0° to 45°.
- Motor.

There are several features on a table saw. The ***blade-raising device*** changes the blade height. It usually is a handwheel. A ***tilting device*** changes the blade angle. It usually is a handwheel also. A ***tilt scale*** displays approximate blade angle. Most blade control handwheels have a locking device to prevent them from moving, once set.

A switch is within easy reach under the table. On newer machines, the ON switch is recessed into the switch plate. This prevents the machine from being turned on if you bump the switch plate. The OFF switch sets above the switch plate and may be larger for ease of operation. Key-type switches can keep inexperienced operators from running the machine, if the key is removed and access to the key is controlled.

The saw manufacturer may offer many accessories with the basic machine. Other manufacturers, called ***after-market providers***, offer additional accessories that may provide for greater capacity, improved accuracy, and easier handling. Additional benefits of these accessories are improved safety and increased quality of the workpiece.

Guiding material

When using a table saw, the material should be guided past the blade. A rip fence, miter gauge, sliding table, and jig are accessories used to guide the material.

Rip fence

A ***rip fence*** guides material parallel to the blade. It is typically in place when ripping stock to width. The fence, on a guide bar or tubes, is locked in place by a fence clamp. A scale may be printed on or etched into the guide bar to help you set the fence. See **Figure 21-2.** Make minor adjustments for the blade-to-fence distance before clamping the fence.

Miter gauge

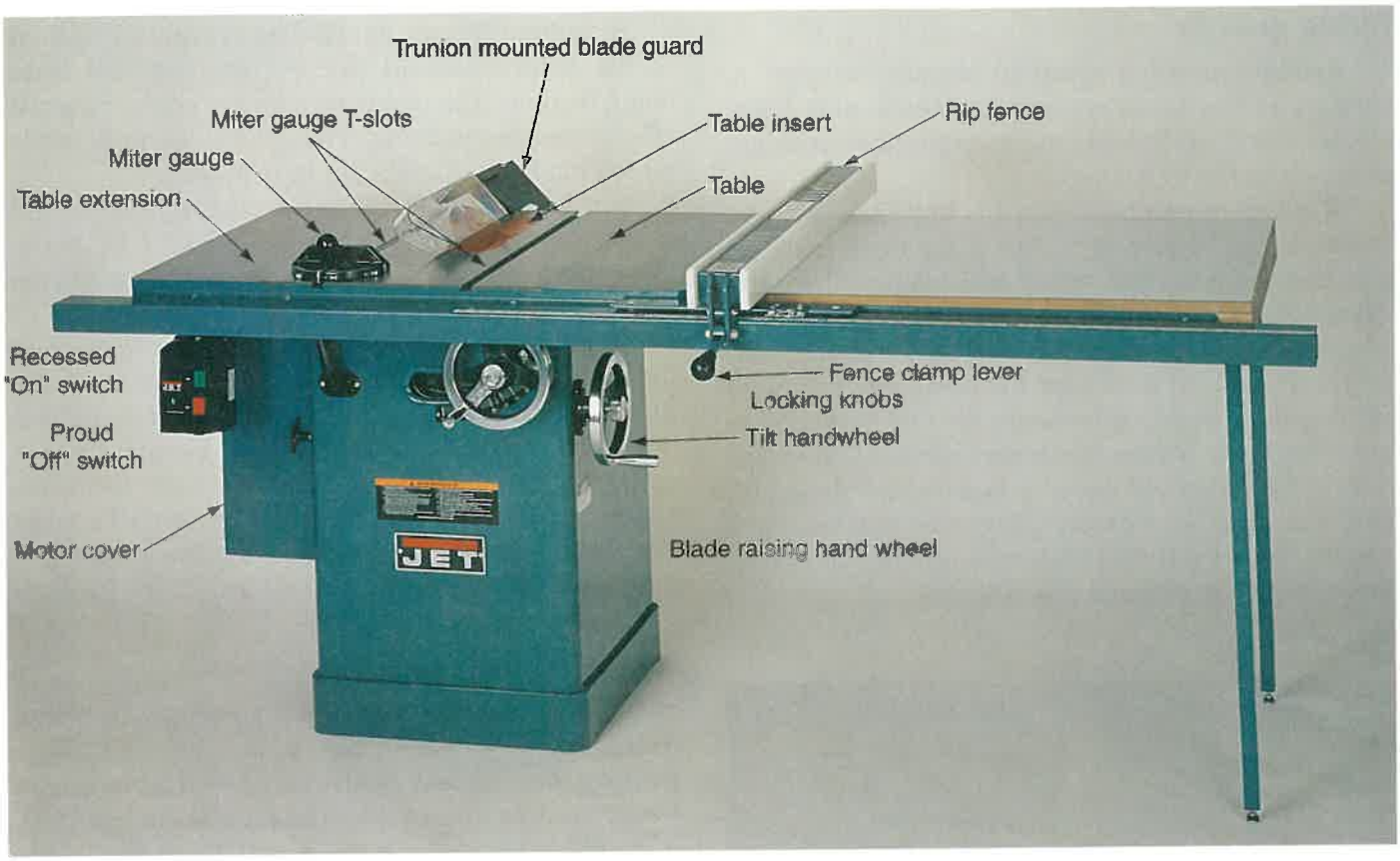
A ***miter gauge*** controls cutting narrow workpieces at angles other than parallel to the blade. It is usually adjustable through a 120° swing. A 0° or 90° setting, depending on manufacturer, positions the gauge perpendicular to the blade for squaring material to length. The miter gauge slides in table slots that may be found on each side of the blade. On some machines, these are T-slots. The miter gauge slide has a matching *T* shape. It can be inserted only at the edge of the table. The T-slot design is better than a rectangular one. The miter gauge cannot tip or be raised out of the slot.

Sliding table

To improve accuracy when cutting wider workpieces, select a saw with a ***sliding table*** or a sliding table accessory. A sliding table provides easier handling of large panels.

Jig

If either the fence or miter gauge will not perform the operation safely and accurately you may buy or build a ***jig***. User-made jigs must be sturdy and hold the workpiece firmly. Make the jig of lumber, plywood, or fiberboard. It might clamp to the rip fence or miter gauge. You could also attach wood strips to the jig bottom so it slides in both table slots. Commercially available accessories include tenoning jigs and sliding table attachments. Refer to *Chapter 28.*



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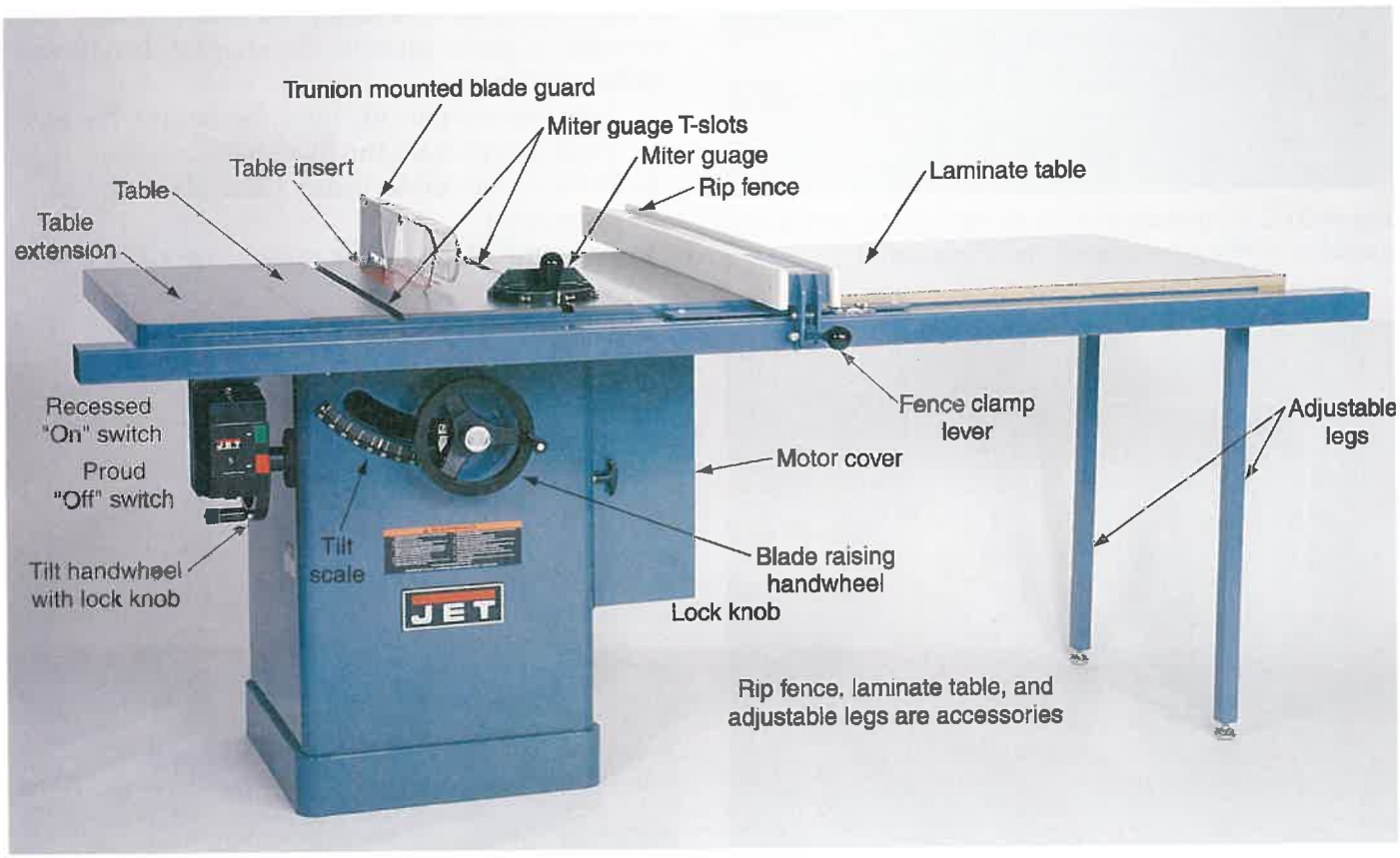


B

Figure 21-1. The table saw has a number of features and adjustments. A—Left tilting arbor. B—Right tilting arbor. (*Jet Equipment and Tools, Inc.*)

Blade guards

A ***blade guard*** is essential because it helps to keep your hands away from the blade and helps control sawdust. It may mount on the saw trunnion or attach to the table edge.

A ***trunnion-mounted guard*** is bolted to the ***saw trunnion***. See **Figure 21-3.** This is the main machine part that supports the motor and blade. When you change the blade angle, the guard will also tilt. The assembly consists of the blade guard, splitter, and pawls. The guard rests over the blade and is hinged to the splitter. The ***splitter*** keeps the saw kerf open as the cut is made. Without a splitter, lumber that warps during the cut could squeeze against the blade and bind the saw. The lumber might be thrown back toward you. With a splitter-type guard, you must saw completely through the material.

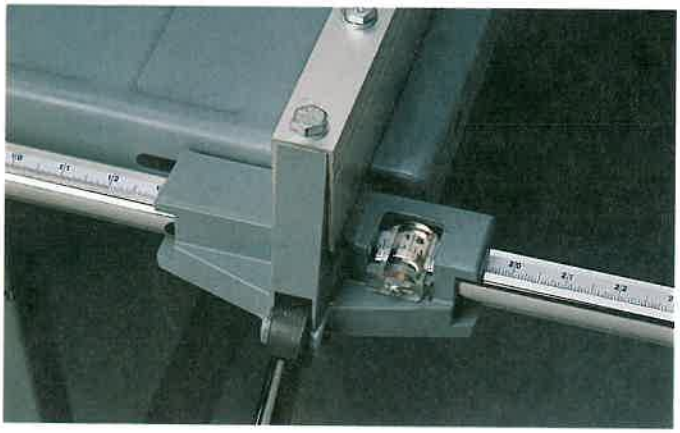


Figure 21-2. A rip scale may be printed on the table saw's guidebar. (*Delta International Machinery Corp.*)

Figure 21-3. This blade guard is mounted to the saw trunnion under the table. (*Delta International Machinery Corp.*)

If material binds, ***antikickback pawls***, attached to the splitter should prevent the material from being thrown. The pawls ride on top of the material after it passes the blade. Then, if the material binds on the blade, the pawls dig in to stop it.

If it becomes difficult to feed the material, press it against the table with a push stick or by hand. With the other hand, reach down and turn off the power. Remove the material after the saw stops.

A ***table-mounted guard*** attaches to the edge of the saw table. See **Figure 21-4.** Each side of the guard may move separately. This type of guard has no splitter. Some table-mounted guards have a spring-loaded, antikickback pawl with teeth-like sharp points. A knob on the top of the guard adjusts the pawl downward to prevent kickback. Adjust a table-mounted guard independently of the blade.

Installing saw blades

Circular saw blades are categorized by tooth design, kerf width, arbor hole size, and other features. The blade may also be labeled according to the grain direction or material it cuts. For example, a rip blade saws along the grain. A crosscut blade saws across the grain. Combination blades do both. A more detailed discussion of blade design and selection is given later in the chapter. Install saw blades as follows:

1. Turn the switch off, then disconnect the electrical power from the machine.
2. Remove the table insert (and blade guard, if necessary).
3. Raise the blade so the nut on the arbor can be reached easily.

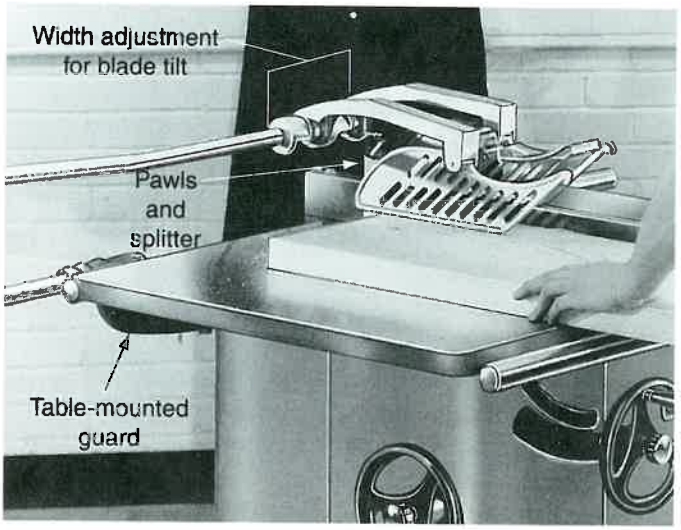


Figure 21-4. Blade guards may be mounted to the table edge. (*Delta International Machinery Corp.*)

4. Place a wrench on the nut and wedge a piece of softwood lumber against the teeth. Some saws are provided with arbor locking mechanisms, while others have flats or hex shapes on the arbor shaft that will receive an open end wrench.
5. Pull the wrench toward the front of the saw to loosen the nut. See **Figure 21-5.**
6. Remove the nut, collar, and blade.
7. Remove pitch, gum, or rust from the arbor, flange, collar, and nut with mineral spirits and fine steel wool.
8. Install the replacement blade with teeth pointing toward the front of the table (in the direction of blade rotation).
9. Install the collar and thread the nut on finger-tight.
10. Tighten the nut. While standing behind the machine, push the wrench toward the back of the saw table. Use the arbor lock, an open end wrench, or wedge a piece of softwood lumber in the teeth to keep the blade stationary. Inadequate torque when tightening the nut may result in excessive noise from the blade when the saw is running.
11. Replace the table insert and guard.

Setting up a table saw

Saw setup includes deciding whether to use a rip fence or miter gauge, setting blade height, and squaring the blade.

The following guidelines should help you make decisions when to use a rip fence or miter gauge.

As shown in **Figure 21-6,** use the rip fence when:

- The saw cut will be longer than the distance from the blade to the fence.
- The workpiece will pass between the fence and the blade. Hold and feed stock with push sticks when the blade-to-fence distance is less than 4" (100 mm).

As shown in **Figure 21-7,** use the miter gauge when:

- The saw cut is shorter than the length of the material.
- The saw cut will be shorter than the distance from the blade to the front edge of the table.

Use the rip fence and miter gauge only when:

- The blade height is less than the material thickness. The material is not cut off. This might occur when making certain joints. See **Figure 21-8.** Refer to *Chapter 29.*)
- The rip fence supports a stop block for sawing duplicate parts of equal length. The stop block provides clearance between the workpiece and the fence.

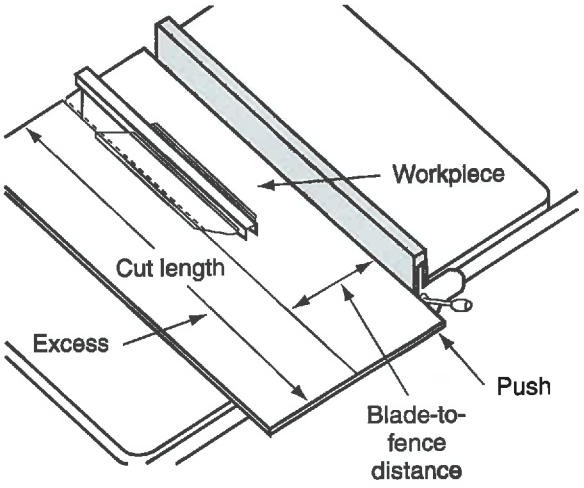


Figure 21-6. A rip fence is used when the blade-to-fence distance is less than the cut length.

Figure 21-5. To remove the arbor nut, pull the wrench from in front of the machine. (*Chuck Davis Cabinets*)

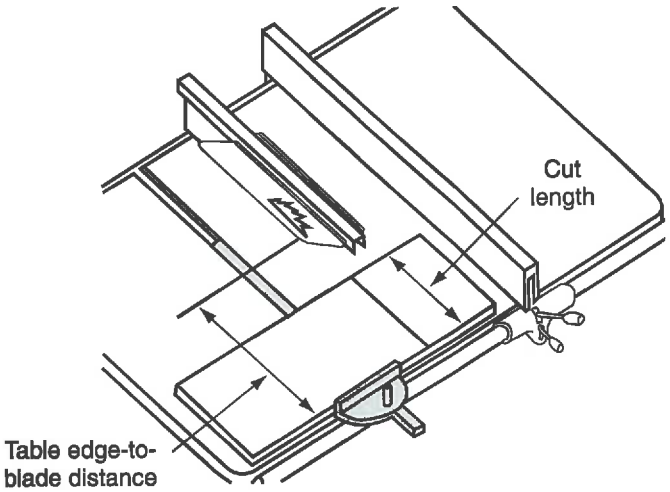


Figure 21-7. Use a miter gauge when the material width is less than the distance from the blade to the table edge.

Setting blade height

To set blade height, proceed as follows:

1. Turn the switch off, then disconnect power to the saw.
2. Loosen the blade-raising handwheel's lock knob.
3. Rotate the blade by hand so a tooth is pointing vertically.
4. Hold a ruler near the blade and adjust the height. You could also use a blade height gauge. See **Figure 21-9.**
5. Tighten the lock knob.

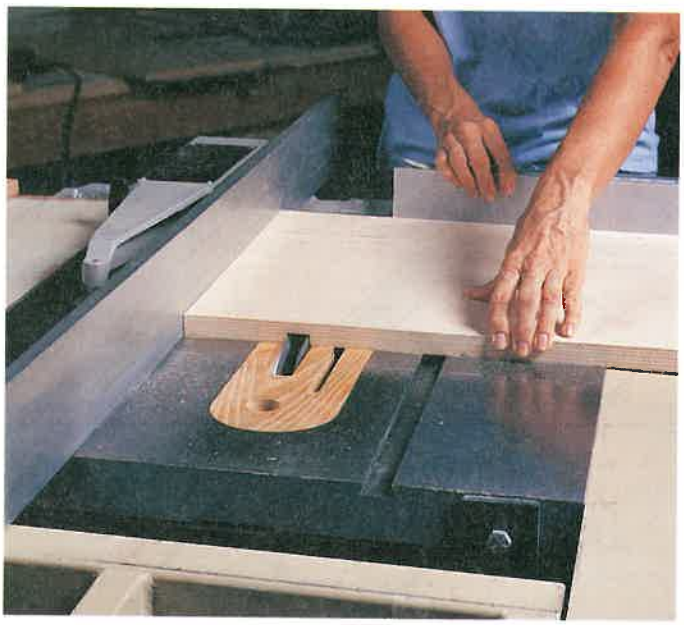


Figure 21-8. Both the rip fence and sliding table (miter gauge) are used for cuts not completely through the material. A dado cut is shown. The guard must be removed to allow this operation. (*Chuck Davis Cabinets*)

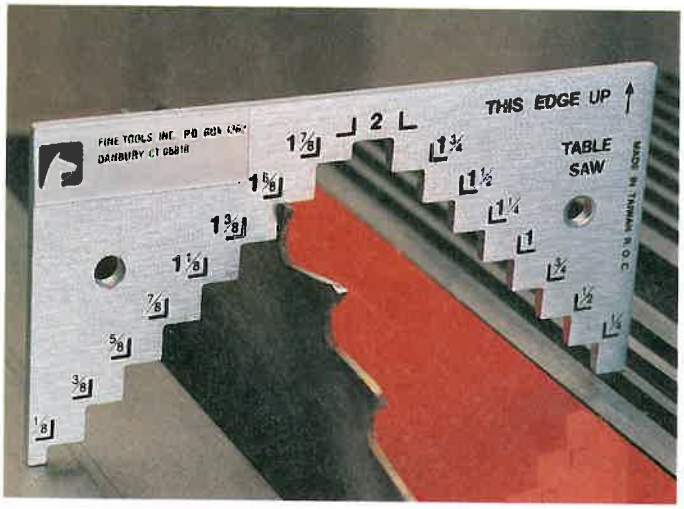


Figure 21-9. Blade height is set easily with this gauge. (*The Fine Tool Shops*)

Squaring the blade

For cuts other than bevels, the blade must be at 90° to the table. Check the blade angle between saw setups and after blade changes. Place a square on the table and against the blade. See **Figure 21-10.** The square should rest between two blade teeth. Loosen the arbor tilt lock and adjust the angle until the square rests flush against the blade body. Tighten the arbor tilt lock.

Operating the table saw

The table saw performs many different operations. Those discussed here are ripping, crosscutting, beveling, mitering, and resawing. Other operations include compound mitering, shaping, tapering, and joint making. These applications are found in other chapters.

Ripping lumber

Ripping is cutting lumber along the grain. See **Figure 21-11.** Install a carbide-tipped or standard rip blade. Set the blade height at least ¼" (6 mm) above the material thickness. At least two teeth should always be in contact with the wood. Unlock and move the rip fence to the desired width. Measure from the fence to a tooth set toward the fence. It is better to measure twice and saw once than to measure once wrong and need to saw twice. Finally, make sure the blade guard's antikickback pawls contact the workpiece.

Stock to be ripped must have one face and one edge surfaced. The face rests on the table and the edge rides along the rip fence. Turn on the saw and feed the

Figure 21-10. Checking to ensure the blade is at 90° to the table. Avoid placing the square on a tooth or its brazing. (*Chuck Davis Cabinets*)

wood past the blade. Hold it firmly on the table and against the fence. Have another person support long lengths of material. Stand to one side of the cutting line. Keep your hands at least 4" (100 mm) from the blade by using a push stick.

Remember that lumber may tend to warp while being ripped. This is because you are relieving internal stresses. The splitter should prevent sawn lumber from pinching the blade. However, maintain a firm hold and be prepared for kickback should feeding the material become difficult. Stand to either the left or right side of the material's possible path if it suddenly becomes a projectile.

Ripping plywood

Plywood, a stable manufactured product, is ripped along the face grain like lumber, **Figure 21-12.** Install and use a carbide-tipped or standard rip blade or a panel blade. Set the blade height ¼" (6 mm) above the panel thickness. Adjust the rip fence and saw plywood as if you were ripping lumber.

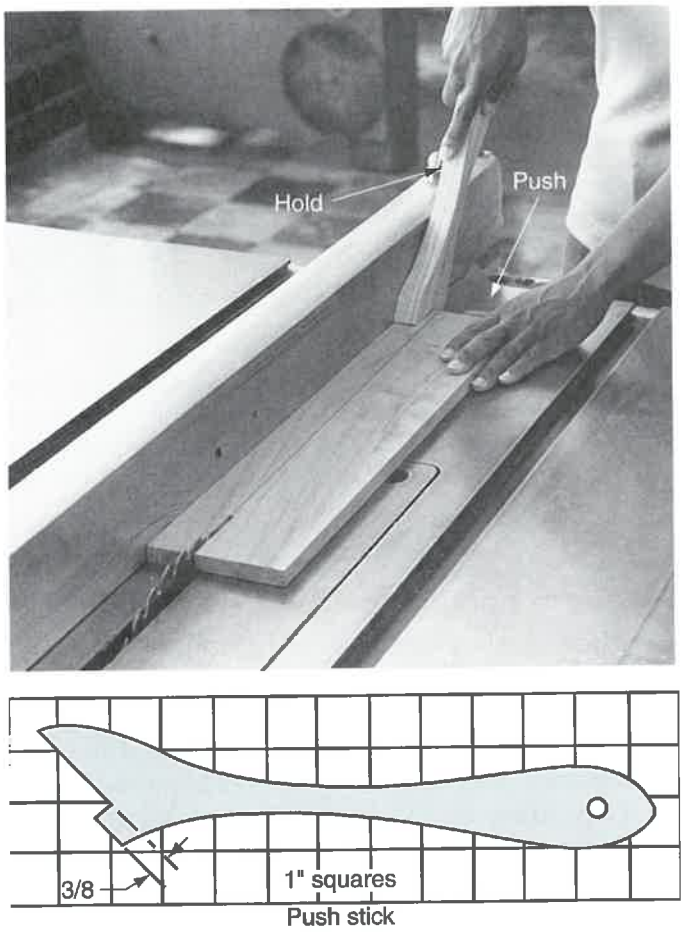


Figure 21-11. Top—For ripping narrow widths, use push sticks to hold and feed the material. The guard was removed to show the operation. Bottom—Dimensions for a typical push stick.

Crosscutting lumber and plywood

Crosscutting is sawing through lumber and plywood across the face grain. See **Figure 21-13.** Install a carbide-tipped or standard crosscut blade. Set blade height so the entire carbide tip is ¼" (6 mm) above the workpiece.

Typically, you guide the material with a miter gauge positioned in the left table slot. This is the normal cutting position of a right-handed person. Mark the cut to be made. Hold the workpiece firmly

Figure 21-12. Ripping plywood. Guards are removed to show the operation. (*Delta International Machinery Corp.*)

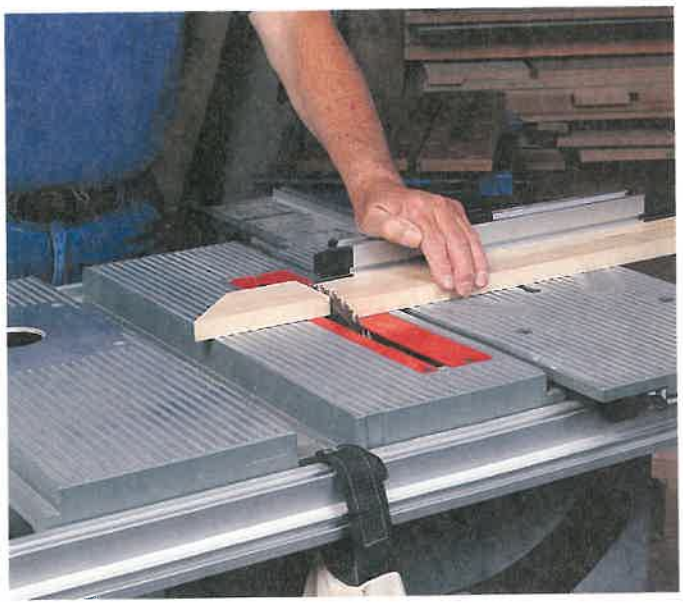


Figure 21-13. Crosscutting with the miter gauge. The guard was removed to show the operation.

against the gauge with the left hand while feeding with the right hand. With the saw off, align your cutting line with the blade. Make sure the width of the blade is on the waste side of the cutting line. Pull the workpiece back so it does not touch the blade. Start the saw and feed the stock to make the cut.

The face of most miter gauges is about 6" (150 mm) wide and 2" or 3" (50 mm to 75 mm) from the blade. Many times, this is not close enough to the blade to support short parts. Fasten an auxiliary wood face to the miter gauge that extends to the blade. Bond abrasive paper to the wood face to help grip your work. Short workpieces can then be easily crosscut.

It is sometimes difficult to use a miter gauge for crosscutting to length. Suppose the workpiece width is larger than the distance from the blade to the table edge. If so, use a radial arm saw, portable circular saw, or panel saw.

Crosscutting duplicate parts to length

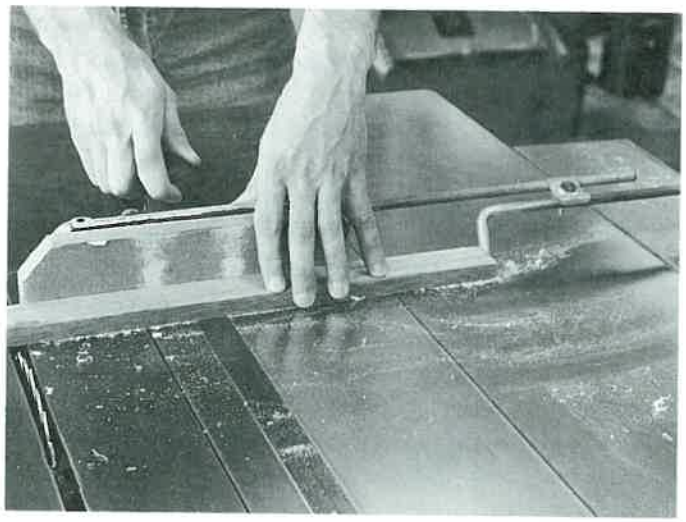
There are two methods to cut a number of workpieces to equal lengths. These methods are stop rod or stop block.

Stop rod

A ***stop rod*** is attached to the miter gauge, **Figure 21-14A.** To adjust the stop rod, mark the desired length on your first part to be cut. Align the mark with the saw blade, then butt the workpiece to the rod. Make a test cut and adjust the rod position if necessary. Sliding table accessories may be equipped with an easily read scale for positioning a stop. See **Figure 21-14B.** This eliminates measurement errors and provides easy repeatability in later operations. See **Figure 21-15.**

Stop block

A ***stop block*** may be clamped to or placed against the fence. See **Figure 21-16A.** A miter gauge and fence should not be used together for cutting parts to length. The cut off portion of the workpiece would bind between the blade and fence and could possibly be thrown. A stop block provides clearance. A stop block of 1" (25 mm) provides both adequate clearance and ease of setting the cutting length using the rip scale. The cutting length is the distance read on the rip scale less the thickness of the stop block. Alternatively, the cutting length is the distance from the block to a tooth on the blade set toward the fence. Measure and set the cutting length with the stop placed tightly against the fence beside the blade. See **Figure 21-16B**. Then, re-clamp the stop several inches in front of the blade. Guide your work with a miter gauge.



A

B

Figure 21-14. Cutting duplicate parts to length. A—Use a stop rod for cutting small parts to length. B—An accessory sliding table has a 72" (1.83 m) scale and stop for cutting parts to length. Guards are removed to show procedure. (*Chuck Davis Cabinets*)

Sawing nongrain manufactured products

More applications are being found for MDF, particleboard, fiberboard, and similar materials. The cores of these composites lack grain pattern. The adhesives that bond the panels will dull standard blades. Use carbide tipped blades in this case.

Depending on the smoothness of cut required, extra care may be necessary. MDF that is to be painted with a high-gloss opaque polyurethane requires a smooth finish. Select a blade with teeth having an alternate top bevel grind. Refer to *Figure 21-54C.*

Panels with wood veneer will require the same rip and crosscut considerations as lumber. Set the blade height so that the entire carbide tip is at least

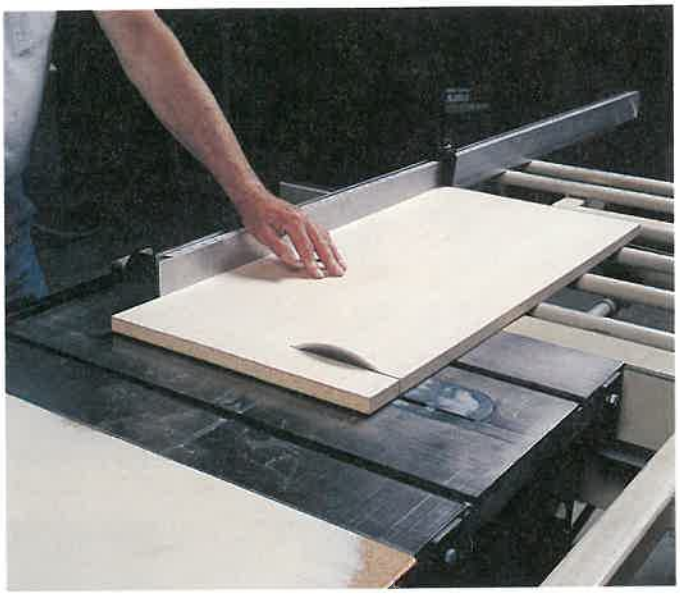


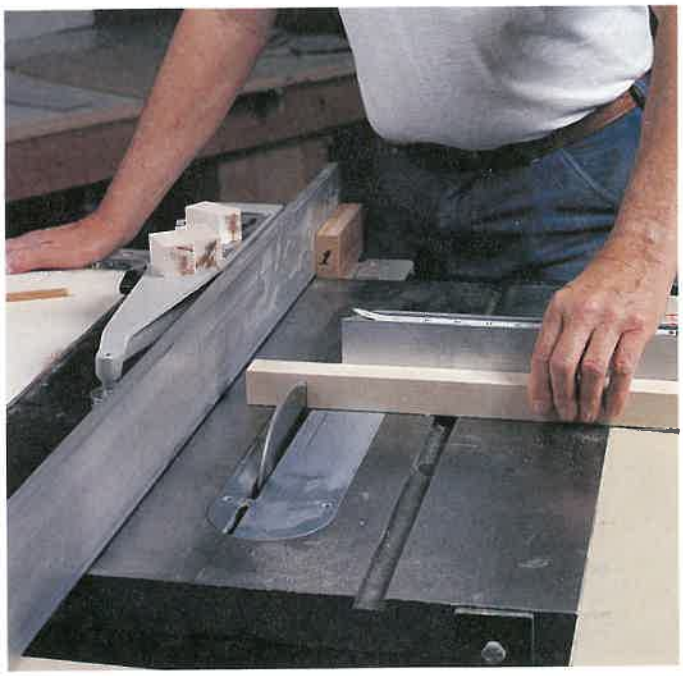
Figure 21-15. Use an adjustable stop attached to a sliding table for cutting duplicate panel parts to length. Guards are removed to show procedure. (*Chuck Davis Cabinets*)

¼" (6 mm) above the material thickness. Make a test cut to determine chipping on the bottom of the workpiece. Adjust the blade height up or down to determine the height at which the chipping is minimal. Use the rip fence or miter gauge as for sawing lumber.

Beveling

Beveling is sawing with the blade tilted. This typically is done as a joint making or shaping operation. On most table saws, the blade tilts up to 45° in one direction only. Some manufacturers build two similar models of the same saw, one tilts to the left and the other tilts to the right. For saws equipped with an accurate tilt scale, set the angle with the scale. Otherwise, the blade angle can be set with a T-bevel (see **Figure 21-17**), protractor, or triangle. Plan beveling operations so the blade tilts away from the fence or miter gauge. Cleaner cuts may result in some materials as the blade's teeth will enter at what will be the outside corner, leaving any chipping or tear out for the inside corner. You want the waste to remain on the table below the blade. If the table tilts toward the miter gauge or fence, the excess falls onto the moving blade and could kick back.

With a bevel cut edge, the workpiece dimensions differ on the top and bottom faces. Usually, the longer of the two faces is dimensioned on the drawing. It is difficult to set the ***rip fence*** or position the workpiece accurately against the ***miter gauge*** for a bevel. You should estimate the dimension, make a test cut, and then make the final cut.



A

B

Figure 21-16. A—Stop block next to the rip fence determines the length of parts cut to duplicate lengths. B—Add the desired length of the parts to the thickness of the stop block and set the rip fence scale to the total. Guards are removed to show these procedures. (*Chuck Davis Cabinets*)

For rip beveling, estimate the distance from the blade to the fence. See **Figure 21-18A**. Start a saw kerf 2" (51 mm) into a test piece that has been surfaced and squared. Measure the width and make adjustments so the workpiece will be the desired width.

Figure 21-17. First set the T-bevel angle with a protractor and then set blade tilt. (*Chuck Davis Cabinets*)

For crosscut beveling, it is best to make test kerfs on the waste side of your cutting line. See **Figure 21-18B.** Reposition your work against the miter gauge after each kerf until the cutting line aligns with the blade.

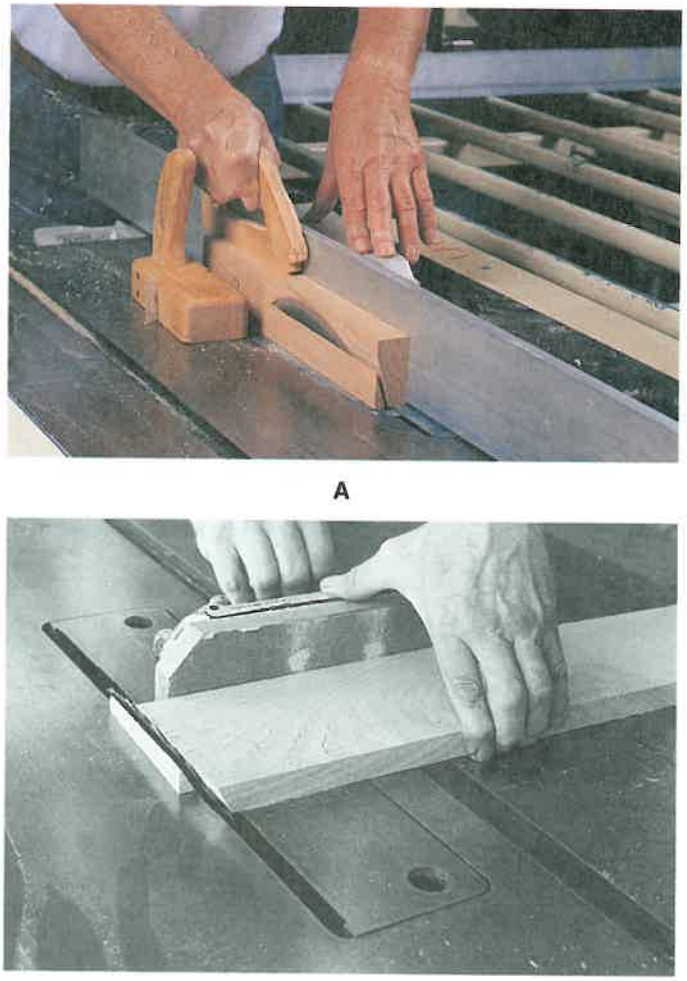
Mitering

Make ***miter cuts*** with the ***miter gauge***. See **Figure 21-19.** Set the blade square to the table. Adjust the gauge to the required angle. For sawing lumber at angles up to 45°, install a crosscut blade. Above 45°, a rip blade may be more effective.

Your workpiece may tend to "creep" along the face of the gauge when sawing. To prevent this, fasten an abrasive covered auxiliary wood face to the gauge.

Resawing

Resawing creates two or more thin pieces from thicker lumber on edge. This helps conserve wood. For example, you can get two ¼" (6 mm) thick boards from ¾" (19 mm) lumber. One or two passes are required to resaw with the table saw. If the stock width is less than the maximum blade height, resawing can be done with one pass. See **Figure 21-20.** If the stock width is greater than the maximum blade height, two passes are required. Cut just over halfway through on the first pass. See **Figure 21-21A.** Turn the material over with the same face against the fence. Separate the two pieces with a second pass. Use the planer to bring the workpieces to final dimension.



A

B

Figure 21-18. When beveling, feed stock so the excess falls off below the blade. Guards have been removed to show the operation. A—Ripping. B—Crosscutting.

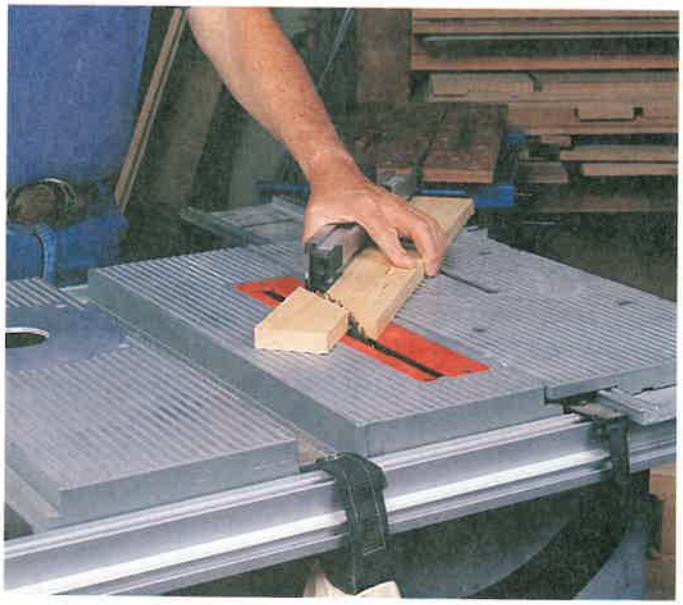


Figure 21-19. Sawing a miter. The guard has been removed to show the operation. (*Chuck Davis Cabinets*)

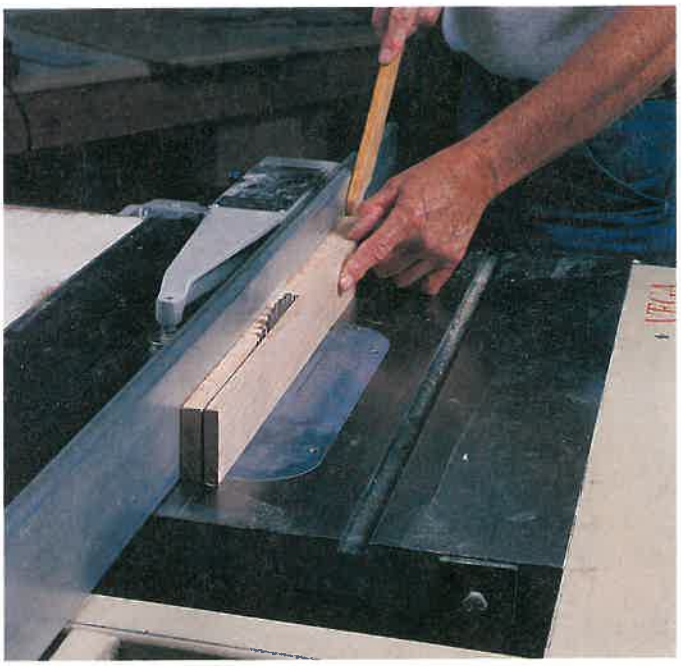
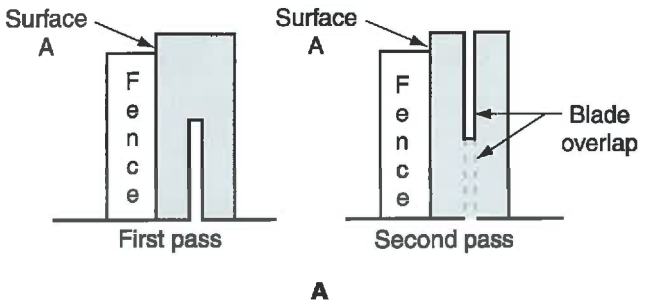


Figure 21-20. A one-pass resawing operation. Use push sticks to feed the material as your hand nears the blade. Guards are removed to show procedure. (*Chuck Davis Cabinets*)

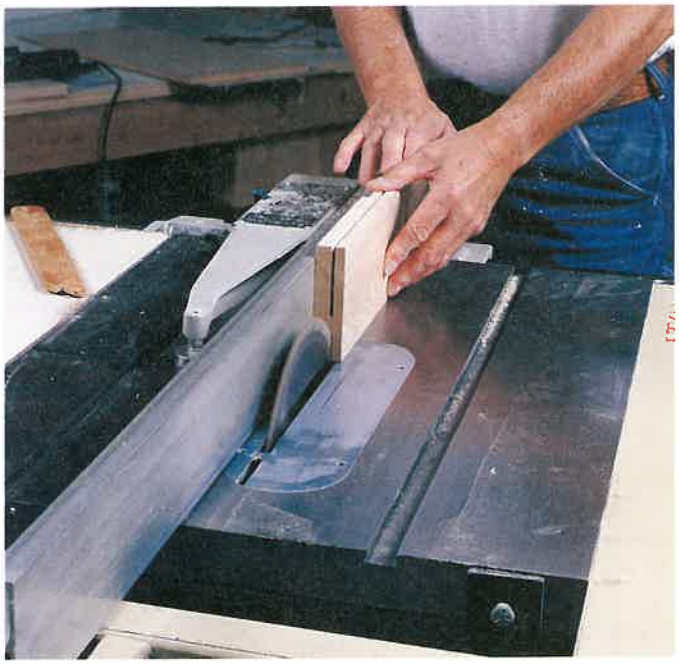
A blade guard cannot be used during the first pass of a two-pass resawing operation. A trunnion guard will not allow the lumber to feed past the splitter. A table-mount guard would also interfere. You must be very cautious when no guard is installed. Keep your hands away from the area around the blade by using one or two push sticks. See **Figure 21-21B.**

The two-pass resawing procedure is as follows:

1. Turn the switch off, then disconnect power to the saw.
2. Remove the guard for two-pass cuts only.
3. Adjust the blade to ¼" (6 mm) higher than half the height of the stock.
4. Lock the blade height and tilt adjustments.
5. Position the fence so that the blade will separate pieces of equal thickness.
6. If the material is more than 36" (914 mm) long, plan to have help or supports.
7. Make the first pass. Use push sticks when the end of the material comes within 12" (300 mm) of the blade.
8. Be cautious when the material clears the blade. Have a firm footing and stand to one side of the cutting line. Keep your eye on the blade as you withdraw your hands and push sticks.
9. Turn the material over end-to-end and feed it through with the same face against the fence.



A



B

Figure 21-21. A two-pass resawing operation. A—Set the blade height just over half the material width. Keep the same surface against the fence for both passes. B—Use push sticks to feed the material as your hand nears the blade. (*Chuck Davis Cabinets*)

Ripping thin strips

Thin strips of wood are often used for inlay work. Feed the material with push sticks when ripping 1" to 2" (25 to 51 mm) wide strips. A different sawing method is used when ripping strips less than 1" (25 mm). This is because the fence would have to be positioned too close to the blade. Rip strips less than 1" (25 mm) on the opposite edge of the board. This setup is shown in **Figure 21-22.** The blade guard is not used because it will interfere with the operation. Make sure the edges of your board are parallel. You must reset the fence after each cut. Joint the board's edge before you cut off the strip. This produces a surfaced strip, ready for veneering or inlay. Use push sticks when feeding the material. The strip can kick back if it becomes caught between the blade and table insert opening.

Think Safety—Act Safely when Using the Table Saw

- Wear approved eye protection.
- Remove jewelry; secure long hair and loose clothing.
- Stand in a comfortable position and to the side of the blade path.
- Turn the switch off, then disconnect the power when making repairs and removing or installing a blade.
- Always use the blade guard when ripping or crosscutting.
- Make sure that the blade teeth are pointed forward and the nut is tight.
- Tighten the fence clamp or miter gauge adjusting knob.
- Make sure the table insert is flush with the table.
- Blade should be sharp, properly set, and free of resin.
- Always think through an operation before performing it.
- Hold the stock firmly against the fence or miter gauge.
- Use a push stick for ripping material narrower than 4" (100 mm).
- Never operate a saw without the miter gauge, rip fence, or other guide.
- Adjust the saw blade to the appropriate height above the workpiece.
- Never reach across, over, or behind the blade.
- Do not use the rip fence as a cut-off guide. Clamp a clearance block to it.
- Remove the rip fence when crosscutting.
- Do not attempt to free work that is caught in the machine; stop the machine first.
- Provide support for a long or a wide workpiece before and after the cut.
- Do not look around when making a cut. Concentrate on the point of operation. Keep your fingers away from the blade.

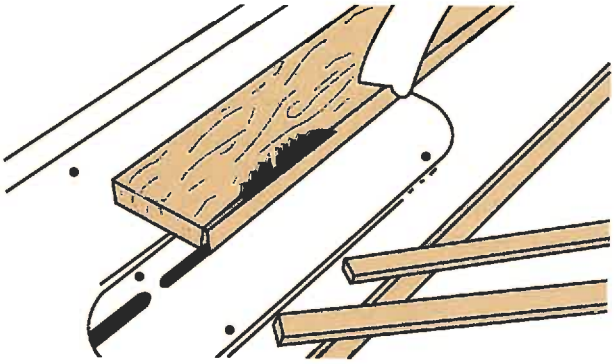


Figure 21-22. Ripping thin strips.

Tilting Table Saw

On some circular saws, the table tilts instead of the saw arbor. Multipurpose woodworking machines (*Chapter 28*), modern imports, and some older equipment are of this type. Operations, except beveling, are the same as the tilting arbor table saw. When tilting the table for beveling, follow these guidelines:

- Have the workpiece below the blade when using the rip fence. See **Figure 21-23A.** Prevent cut-off waste material from sliding into the blade. Another person may need to help you with long stock.
- Have the workpiece above the blade when using the miter gauge. See **Figure 21-23B.** The excess will slide away from the blade after the cut is complete.

Radial Arm Saw

A *radial arm saw* is a versatile machine. See **Figure 21-24.** Besides sawing, operations may include surfacing, drilling, shaping, and sanding. The radial arm saw is most noted for sawing stock to length. Imagine trying to crosscut a 12' (3.66 m) long piece of lumber with a table saw. This task is made easy with the radial arm saw.

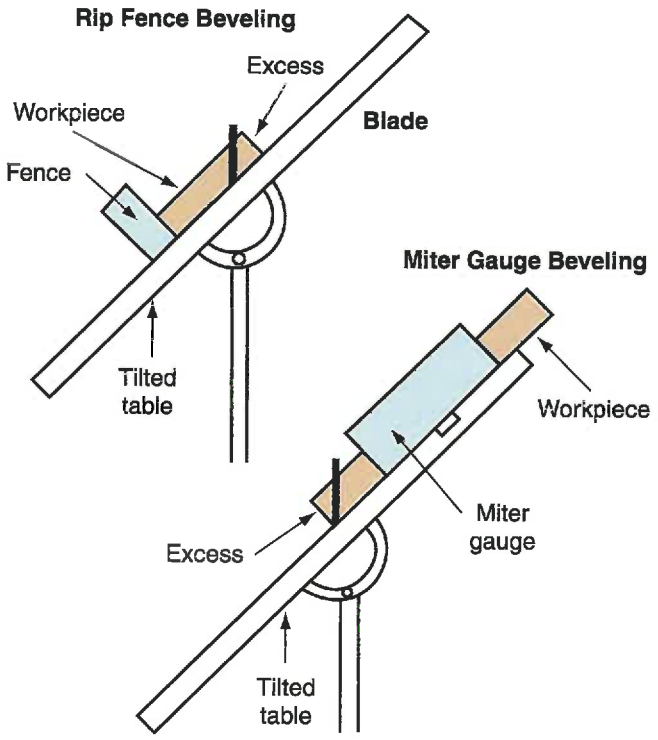


Figure 21-23. Beveling on tilting table saw. Guard not shown.

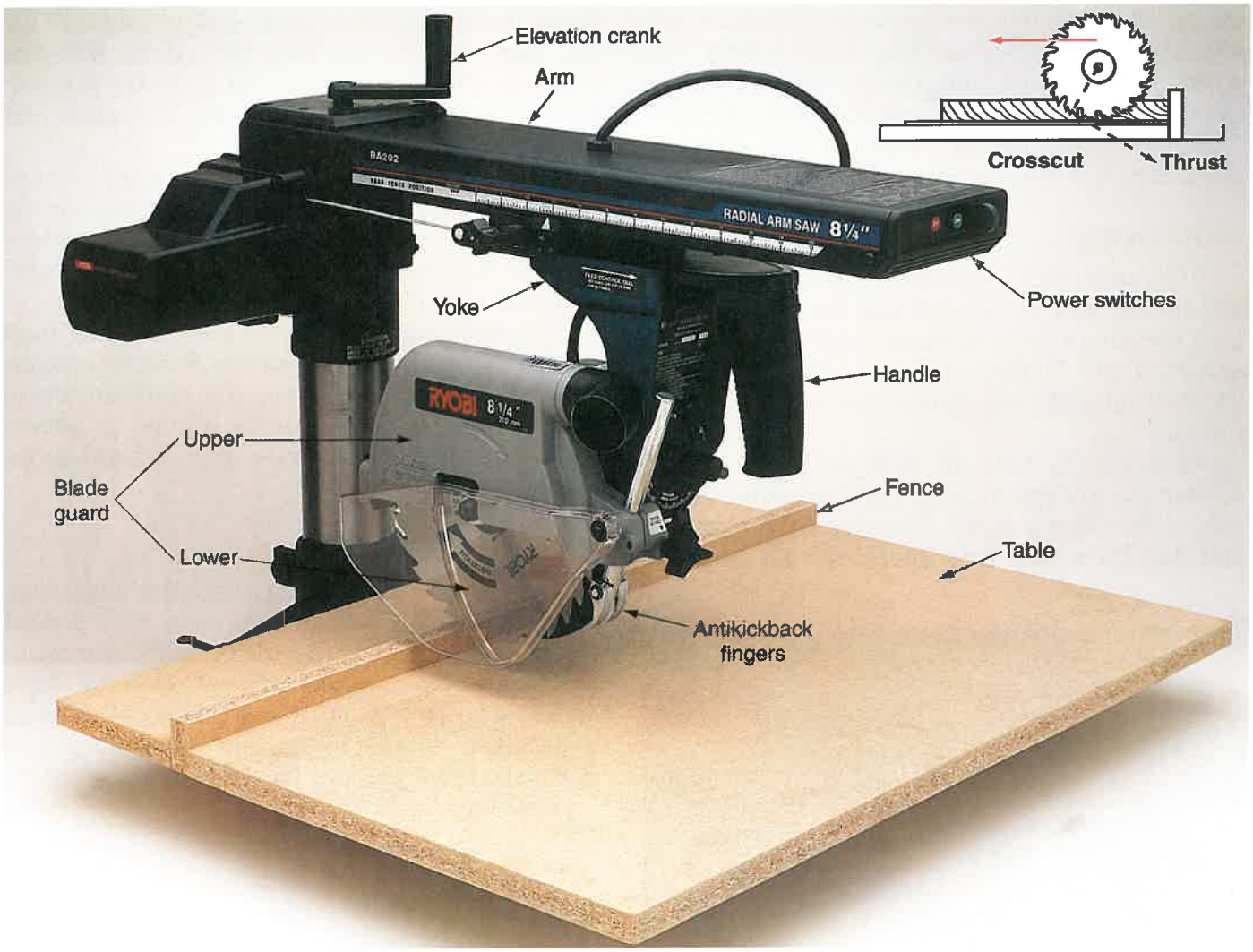


Figure 21-24. A variety of features and adjustments are found on the radial arm saw. (*Ryobi America Corp.*)

The radial arm saw blade, blade guard, and motor are above the table. All of these are mounted on a yoke that moves toward and away from you on the arm. The arm and/or motor assembly turns in several different directions. The entire frame can be on legs or mounted on a bench. Radial arm saws are sized according to blade diameter, from 8" to 16" (203 mm to 406 mm), with 10" (254 mm) being the most common.

Changing the blade

Blade changing is required when the blade is dull or when setting up for a different sawing operation. Radial arm and table saws may use the same blades. However, there is less tendency for the radial arm saw to *climb* if the blade has a face hook angle of 5° or less. To change the blade, first remove the guard. Secure the motor arbor so you can loosen the arbor nut. There may be a hex hole in the end of the shaft for an Allen wrench. There could be two flat surfaces behind the blade for an open-end wrench. If no method of holding the arbor is seen, clamp a handscrew to the blade above the teeth. Remove the old blade and place the new blade with the teeth pointed toward the fence. See **Figure 21-25.**

Once the blade is installed, tighten the arbor nut securely. Do not over torque the nut. This could strip the threads.

Saw setup

The versatility of the radial arm saw comes from its wide range of adjustments. The elevation crank, found on the column or machine frame, raises and lowers the arm. This sets the blade height. The arm pivots at the column to position the blade for miter cuts. The yoke rotates on the arm to position the blade parallel with the fence for ripping. The motor pivots 90° within the yoke for beveling. A locking mechanism is provided for each of these settings. The only machine part that can be allowed to move

during saw operation is the yoke. It slides back and forth on the arm for crosscutting and mitering. This setting, too, is locked for certain procedures, such as ripping. With all of these adjustable features, the radial arm saw must be frequently monitored to check that each adjustment remains true.

Crosscutting

The radial arm saw is well suited for crosscutting lumber and wood products. See **Figure 21-26.** Lock the arm in the 0° position. Lock the yoke pivot and bevel at 0°. With your left hand or a clamp, hold the material stationary against the fence away from the cut.

With the machine off, pull the blade until it touches the workpiece. Align the blade to the excess side of the cutting mark. Then, back the blade off and start the motor. Grip the handle. Pull the saw across the material just far enough to complete the cut. Then push the saw back through the kerf past the fence. Turn the saw off and allow the blade to coast to a stop. Then remove the workpiece and excess material.

Determine the maximum material width you can cut in a single pass. Pull the saw out to its farthest travel and measure from the fence to the point where the blade touches the table. This distance may vary from 12" to 24" (305 mm to 610 mm).

On some equipment, you push the saw back against the column. More recently, retractor systems have been added. The saw returns automatically to its normal position next to the column. It returns when the operator finishes the cut and stops pulling.

Figure 21-25. Changing a radial arm saw blade.

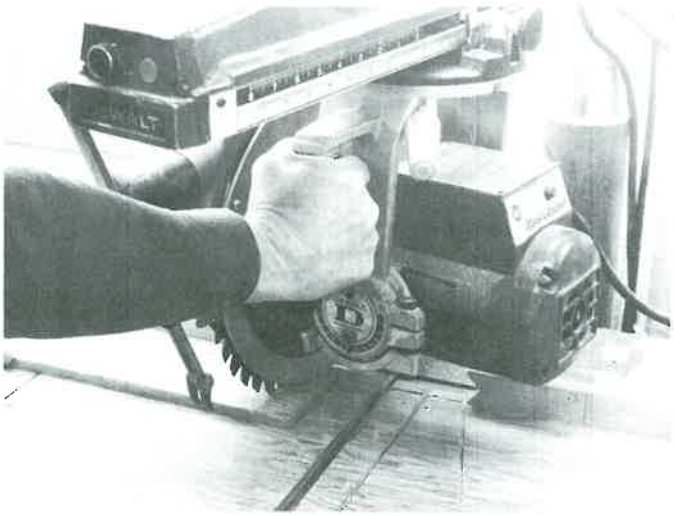


Figure 21-26. Crosscutting at 30° with a radial arm saw.

Crosscutting multiple parts

Cut multiple parts to length by attaching a stop. See **Figure 21-27.** Clamp it to the fence at the desired distance from the blade. Place each workpiece against the stop and make the cut. Turn the stop's adjusting screw to make minor changes in distance to the blade. Without a stop, you can clamp a block of wood to the fence. See **Figure 21-28.**

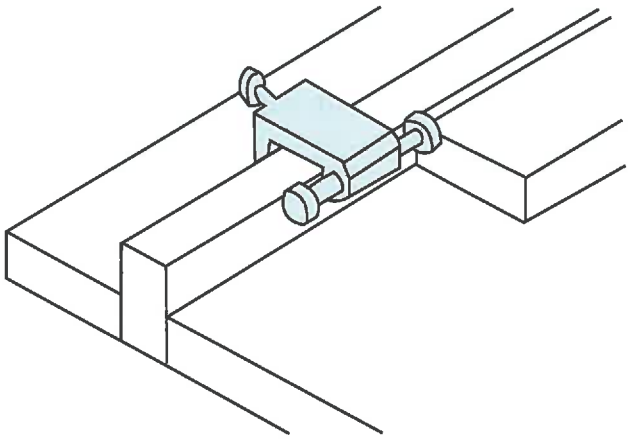


Figure 21-27. Top—A stop positions stock for sawing multiple parts to length. *(Black & Decker)* Bottom—Make minor changes by turning the adjusting screw.

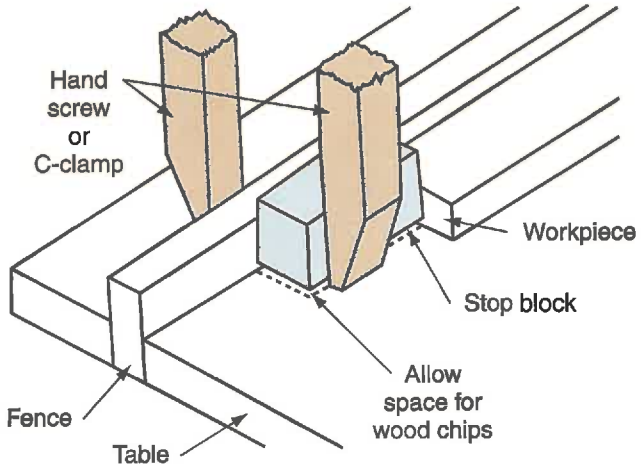


Figure 21-28. If a stop is not available, clamp a block of wood to the fence. Raise it slightly to allow dust and chips to pass under.

Crosscutting extra wide material

Material widths up to twice the saw's travel distance can be cut. Attach a stop to the fence at the desired length. Support the panel if it can tip. Cut across the material as far as possible. Return the blade to its column position. Turn the workpiece over and finish the cut. Saws with 24" (610 mm) travel will cut 48" (1220 mm) wide sheet material in two passes.

Mitering

Make ***miter cuts*** with the saw arm swung to the right or left. See **Figure 21-29.** Most saws pivot to 45° both ways. Right-hand miters (arm angled to right) are preferred. The motor does not obstruct your view of the cut. Install crosscut blades for miters. Cut a test board first to make adjustments to measurements and stops.

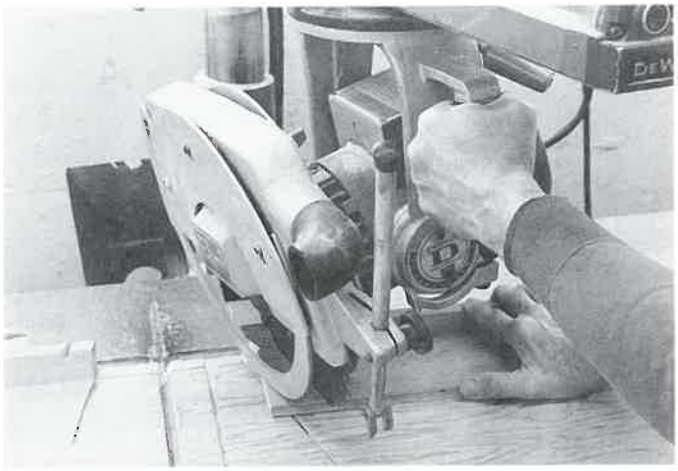


Figure 21-29. Compound mitering with the radial arm saw.

Ripping material

Ripping is done with the blade parallel to the fence. The yoke pivots left or right 90° and locks in place. Tighten the rip lock so the blade is the proper distance from the fence. The rip lock prevents the yoke from moving along the arm.

The two ripping modes are in-rip and out-rip. The ***in-rip mode,*** where the blade is between the motor and fence, is the most common setup. See **Figure 21-30A.** The ***out-rip mode*** allows wider parts to be cut. See **Figure 21-30B.** Notice that the direction of feed is opposite. Place the workpiece, not the excess, between the fence and the blade.

When a workpiece is 3" (76 mm) or narrower, use a special pusher board. See **Figure 21-31A.** Dimension "A" must be such that the workpiece is fed completely past the blade, but short enough to prevent the pusher board from passing under the antikickback device. See **Figure 21-31B.**

The ripping procedure is as follows:

1. Install a rip blade. The teeth should be about ¼" (6 mm) above the table.
2. Pivot the motor and blade assembly into the in-rip or out-rip mode.
3. Measure and lock the desired blade distance to the fence. Measure from a saw blade tooth set toward the fence.
4. Tilt the blade guard forward to protect you from flying wood chips.

Figure 21-30. Feed material against the rotation of the blade when ripping.

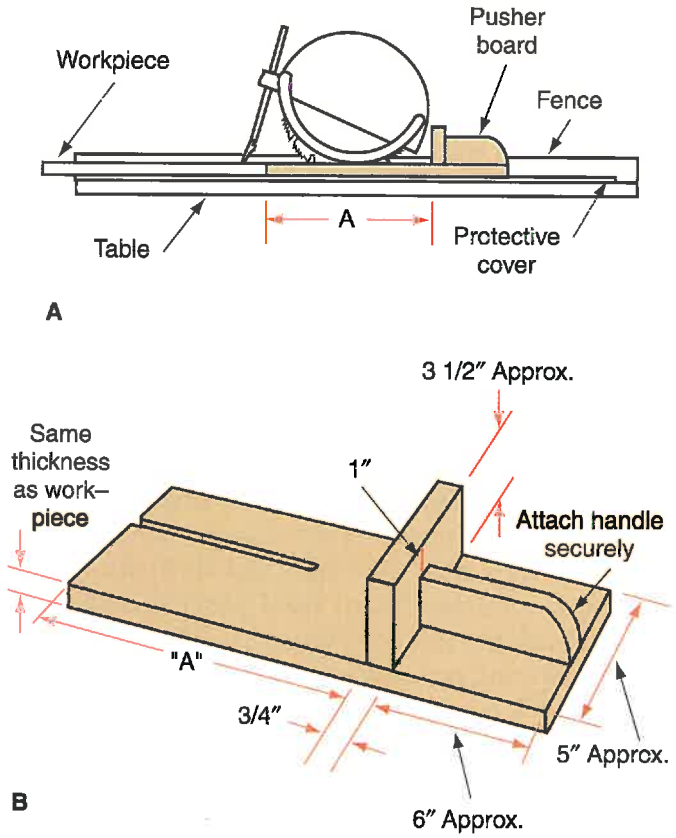


Figure 21-31. Use a pushboard when the workpiece will be 4" (102 mm) or narrower in width. (*DeWalt*)

5. Adjust the antikickback pawls 1/8" (3 mm) below the top surface of the material being cut.
6. Start the motor and let it reach full speed.
7. Lower the overarm until the teeth touch the table protector.
8. Feed the material against the blade rotation and along the fence until it is beyond the blade and antikickback device. Use a pushboard if the workpiece will be less than 3" (76 mm) wide.
9. Push the STOP button and allow the blade to stop before removing your work.

Beveling

The radial arm saw motor and blade assembly tilts 45° left and right for beveling. Beveling can be done in the crosscutting or ripping mode. See **Figure 21-32.** Select the proper blade for the operation you intend to perform. Feed against the blade rotation as you would for crosscutting or ripping operations.

Protecting the table

Every different saw setting makes another kerf mark in the saw table. This is because the saw blade is positioned 1/16" (2 mm) below the table surface

Figure 21-32. Beveling with a radial arm saw.

for through cuts. Over time, kerfs resulting from a number of different settings make the table rough. Resurface the table by placing a piece of ¼" (6 mm) hardboard on it. Screw or nail the hardboard to the saw table away from the blade's travel.

Kerf making

After replacing a damaged table protector or fence, you must recut saw kerfs. This should be done through the fence and across the table for crosscutting. Later, kerfs may be needed for miter and bevel settings. The procedure is as follows:

1. Turn the switch off, then disconnect power to the saw.
2. Raise the blade above the table protector.
3. Position the motor/blade assembly over the center of the table for the crosscut, miter, or bevel setting.
4. Tighten the rip and yoke locks.
5. Lower the blade until it touches the table protector. Then raise it 1/16" (2 mm). Note how far you turn the lever while raising the blade.
6. Tighten arm adjustments.
7. Connect power and start the saw. Allow it to reach full speed.
8. Lower the blade twice as far as you raised it. The cut will be 1/16" (2 mm) into the table protector.
9. Hold the handle securely and loosen the rip lock.
10. With a tight grip on the handle, push the blade slowly toward the column and cut through the fence.

A kerf mark is also necessary for ripping. Raise the blade above the table. Pivot the yoke into the ripping position. Set the miter scale at 0°. Move the yoke to the width of cut and tighten the rip lock. Turn the machine on and lower the blade 1/16" (2 mm) into the table.

Think Safety—Act Safely when Using the Radial Arm Saw

- Wear eye protection; remove jewelry; secure long hair and loose clothing.
- Hold stock firmly on the table and against the fence for all crosscutting operations. Support long boards and wide panels.
- Be certain that all clamps and locking devices are tight and the depth of cut is correct before starting the motor.
- Always return the saw to the rear of the table after completing a crosscut or miter cut. Do not remove stock from the table until the saw has returned and the blade has stopped.
- Maintain a 4" (100 mm) margin of safety.
- Shut off the motor, wait for the blade to stop, and disconnect power before making any adjustments.
- Clean the table of scraps or sawdust before and after using the machine.
- When ripping stock, it must be flat and have one straight edge to move along the fence.
- When ripping, always feed stock into the blade so that the bottom teeth are turning toward you.

Sawing Curved Lines

Stationary machines that cut curved parts include the band saw and scroll saw. Both machines saw with narrow blades which control the radius of the curve. See **Figure 21-33.** Choose a band saw for cutting large radius curves and large cabinet components. A scroll saw, with its smaller blade, is best for small radii and intricate curves.

Relief cuts

Relief cuts allow waste material to break loose as you saw your workpiece. Each cut is made through excess material almost to the cutting line. See **Figure 21-34.** Both band saw and scroll saw operations require relief cuts for making curves when:

- There is a sharp inside or outside curve.
- The curve changes direction: left to right or right to left.

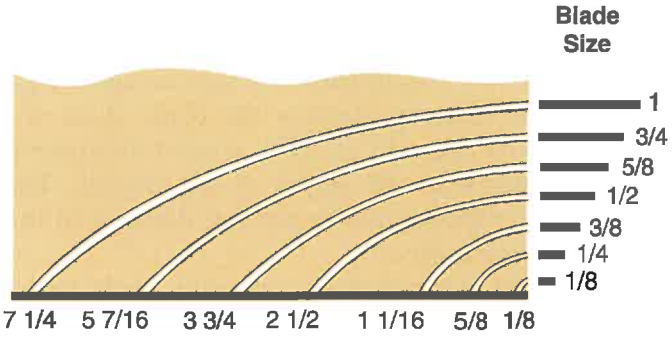


Figure 21-33. There is a minimum cutting radius for each band or scroll saw blade width.

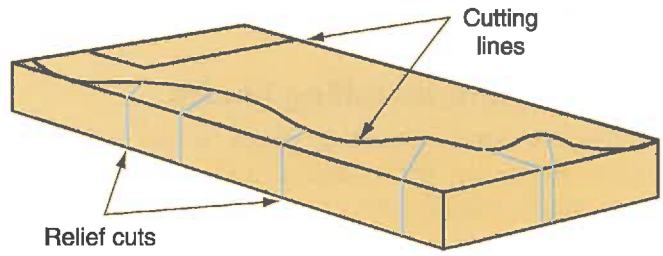


Figure 21-34. Relief cuts are made to irregular curves.

- Your cabinet part will be cut from a large piece of stock. The excess material may be difficult to control. Make relief cuts at least every 4" to 6" (100 mm to 150 mm).

When excess material is removed with relief cuts, there is less chance to twist or break the blade. With relief cuts, you do not need to withdraw the workpiece back through a long, irregular kerf.

Band Saw

A ***band saw*** is a very versatile machine. See **Figure 21-35.** Besides making irregular curves and arcs, it can rip, bevel, and resaw. Install a rip fence or use a miter gauge for these operations. With the appropriate jig, the band saw can cut complete circles.

The band saw consists of a continuous, thin steel blade that travels on two wheels. The blade is exposed where it passes through the table (the point of operation). The table tilts for beveling. ***Blade guides*** position and control the blade at the table. The upper set of guides are on the ***guide post*** above your work. For each different material thickness, the post is set ¼" (6 mm) above the material and held by a lock knob. The other set of blade guides is below the table.

Most band saws have two wheels. The bottom wheel drives the blade. The top wheel turns freely and is adjustable to control blade tension and alignment. Proper tension ensures the blade does not stray from the line of cut. With correct alignment, the blade tracks in the center of the wheels. The wheels have rubber tires to prevent damage to the set of the blade teeth.

The throat is the distance from the blade to the side frame. See **Figure 21-35.** This depth determines the widest cut which can be made. The throat depth is usually determined by the diameter of the wheels. See **Figure 21-36A.** However, there are band saws which have three wheels. They maintain a large throat depth, but use smaller wheels. These machines are noted by their frame shape. Refer to **Figure 21-39.**

Selecting and installing blades

Review your product plans when selecting blades. Knowing the material and radii of curves being sawn helps you choose the proper blade. Select blades according to width, length, tooth shape, blade set, teeth per inch (or points per inch), and blade gauge (thickness). These terms are discussed later in the chapter.

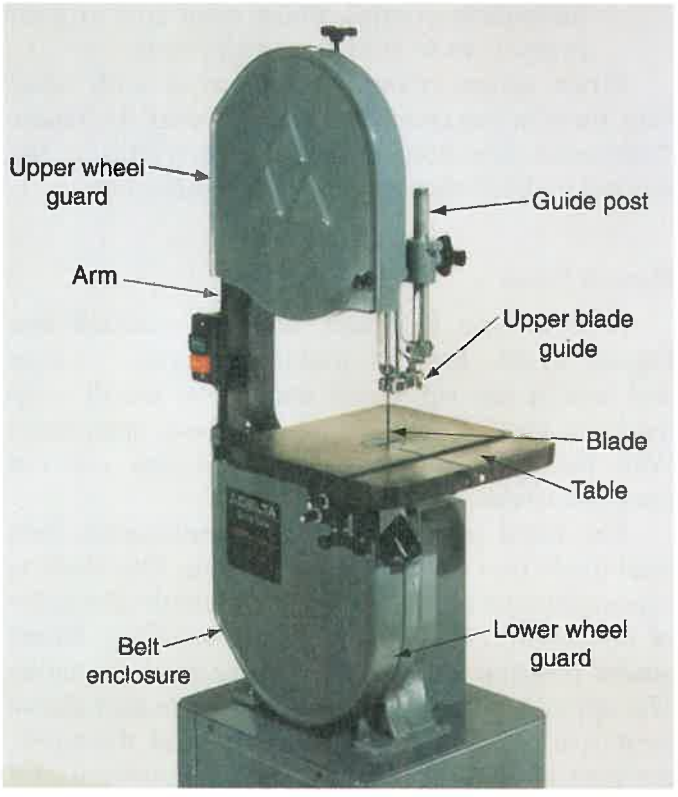


Figure 21-35. Features of the band saw. (*Delta International Machinery Corp.*)

The procedure for changing blades is as follows:

1. Turn the switch off, then disconnect power to the machine.
2. Remove or swing aside the upper and lower wheel guards. See **Figure 21-36A.**
3. Release the blade tension by turning the tension control knob. See **Figure 21-36B.**
4. Remove the table insert if necessary.
5. Remove the old blade from the wheels and guides, then slip it through the slot in the table.
6. Hold the replacement blade up in front of the machine. Be sure the teeth are pointed downward and toward you over the table.

A

B

Figure 21-36. A—Remove or swing aside guards to gain access to the blade. B—Loosening blade tension. (*Chuck Davis Cabinets*)

7. Slide the replacement blade through the table slot, between the guides, and onto the wheels.
8. Reset the blade tension. Most machines have a scale to show the correct tension for various blade widths. (See **Figure 21-36B.**)
9. Adjust the blade guides if the replacement blade is a different width. See **Figure 21-37.** The front edge of the side guides should be even or slightly in back of the tooth gullets. *They should never touch the teeth.* The rear guide (blade support wheel) should be 1/64" (0.4 mm) away from the blade.
10. Turn the upper wheel, by hand, three or four turns to see that the blade is tracking in the center of the wheels.
11. Replace the wheel guards and throat plate.
12. Reconnect power to the machine.
13. Start the machine. Allow it to reach full speed, then turn it off. Stop the machine with the foot brake if there is one.
14. Check that the blade location is correct for the saw being used. Refer to the operating instructions. If not, adjust the tracking control knob that tilts the upper wheel slightly to bring the blade back into alignment. See **Figure 21-38.**

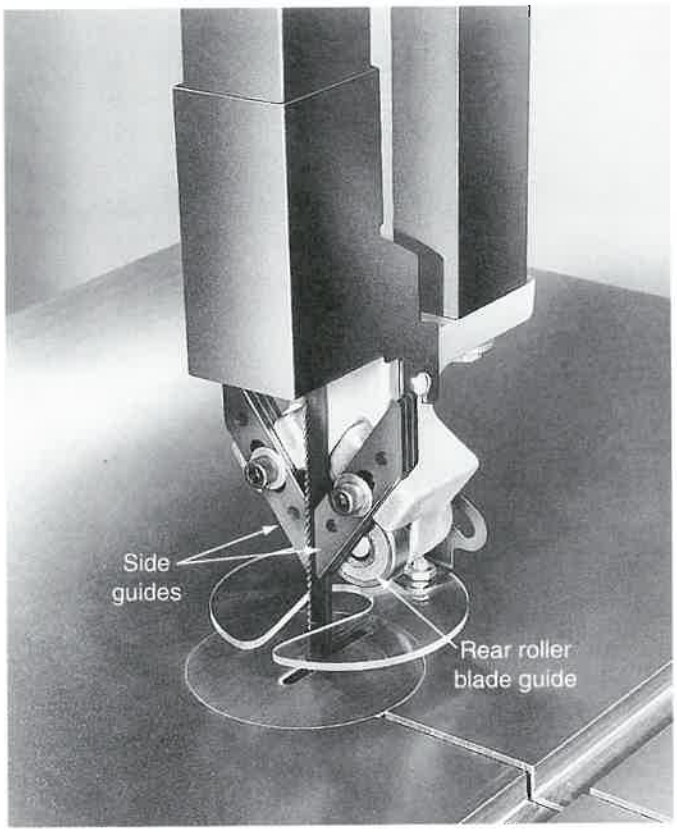


Figure 21-37. Side guides, behind the saw teeth, keep the blade from twisting or turning. The rear guide is 1/64" (0.4 mm) behind the blade. *(Rockwell)*

Band saw operation

Plan your sawing sequence before starting the band saw. Short and/or relief cuts are made first. Then determine whether the workpiece will be to the right or left of the saw blade. Saw on the waste side of the cutting line to allow for sanding.

Before making the cut, check your setup. Were all adjustments made? Is the guard ¼" (6 mm) above the workpiece? Are all locking devices secure? How will you control your workpiece and waste before and after the cut? Are you standing comfortably in place? Is there a brake within reach that stops the machine from coasting after it is turned off?

Large components are often difficult to cut. See **Figure 21-39.** The stock could strike the machine frame as you move the workpiece from side to side to follow the curve. If the frame interferes, slowly withdraw the material through the kerf. Be careful not to pull the blade forward from between the blade guides. It could bind, come off the wheels, and even break. More waste material may need to be cut off to feed the workpiece without hitting the frame. If the workpiece is just too large for the band saw, use a saber saw.

Curved-line sawing

The primary purpose of the band saw is to cut curved parts. The cutting radius depends on blade width and set. Refer to *Figure 21-33.* Also, make relief cuts where the curve changes direction. See **Figure 21-40.**

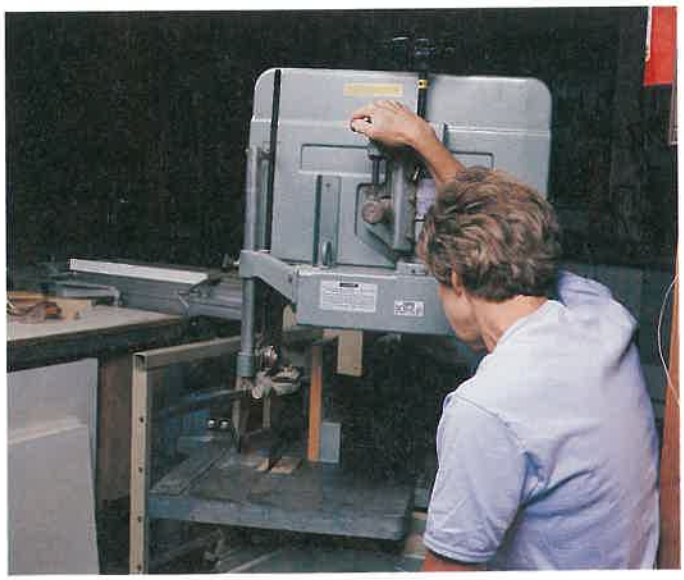


Figure 21-38. Tracking adjustment is found on the back of the machine behind the upper wheel. (*Chuck Davis Cabinets*)

When changing direction during a cut, do not push the workpiece against the side of the blade. Anticipate turning your work before you need to change the curve direction.

Straight line sawing

Ripping and crosscutting a straight line requires that you use some device to guide your work.

Figure 21-39. With large, curved workpieces, first cut away as much waste as possible to prevent it from hitting the machine frame. (*Delta International Machinery Corp.*)

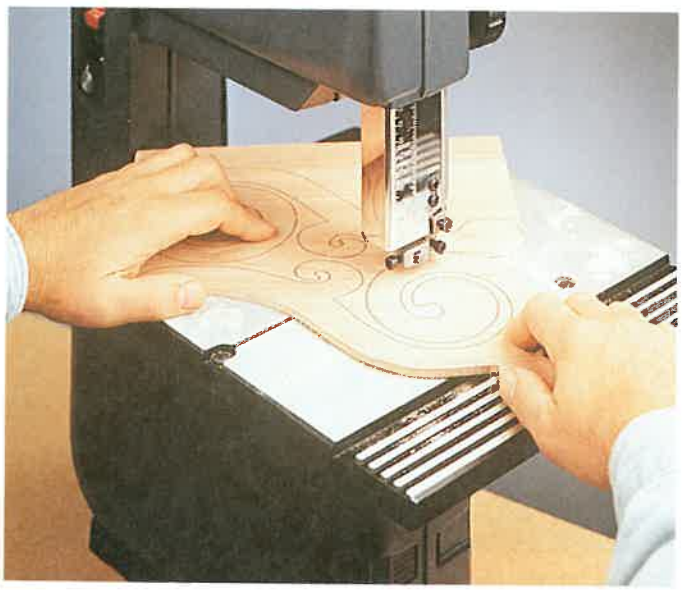
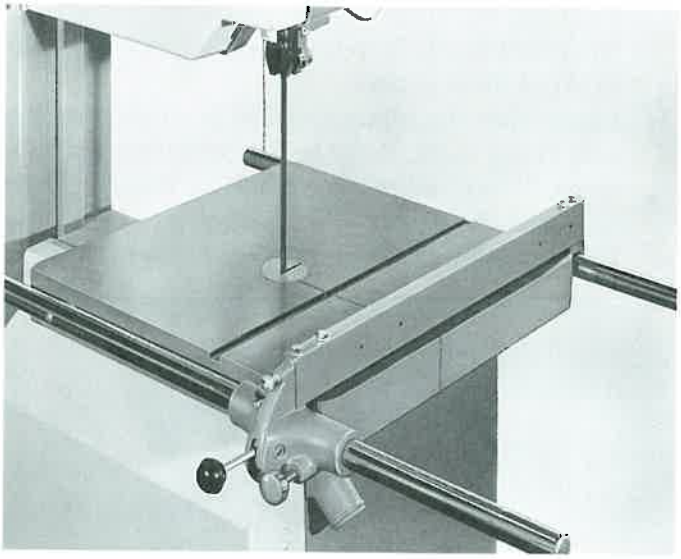


Figure 21-40. Guide the workpiece with both hands when sawing curves. (*Black & Decker Corp.*)

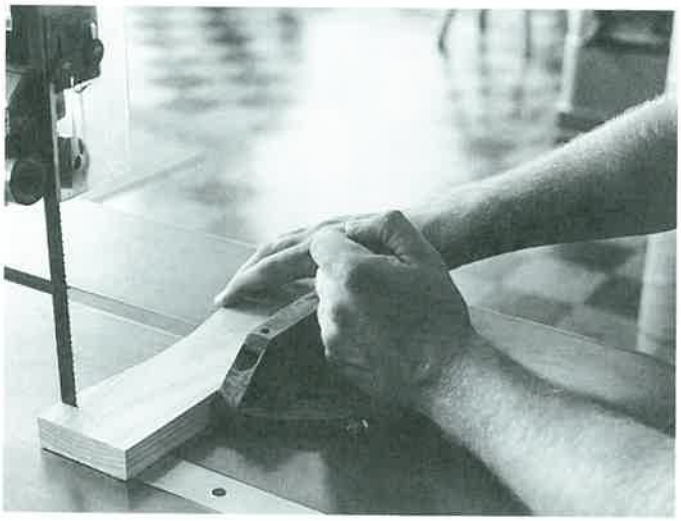
Attach a rip fence or clamp a straightedge to the table. See **Figure 21-41A.** Install a miter gauge for short cuts. See **Figure 21-41B.** For sawing multiple parts to length, attach a miter gauge stop rod or clamp a stop block near the front of the table as you would with a table saw.

Ripping thin strips

Thin strips, 1/8" to ½" (3 mm to 13 mm) wide, are often ripped for bent wood products and inlaying. Measure the desired dimension from the fence to the blade. It is better to cut strips with the band saw than with the table or other saw. Joint the edge before cutting. Usually the cut edge will be smooth enough for gluing.



A



B

Figure 21-41. Accessories are needed to saw straight lines. A—Rip fence. *(Rockwell)* B—Miter gauge. Blade guard and guide raised for photo. (*Chuck Davis Cabinets*)

Pocket cutting

A ***pocket cut*** is one where three sides of an opening are sawn. The edges of the pocket may be straight or curved. There may not be room enough for relief cuts. Several alternatives include:

- Saw straight into the pocket on each side. Withdraw the workpiece carefully after each pass. Then cut a curve as small as your blade size allows. Complete the pocket by sawing away any remaining waste. See **Figure 21-42A.**
- Drill two turn-around holes. These provide room in the corners for you to change the workpiece direction without twisting the blade. Clean up the corners with an extra cut or a file. See **Figure 21-42B.**
- It is possible that the inside corners of the pocket are curved as part of the cabinet design. In this situation, bore the holes with the proper radius bit. Then saw the waste material away. See **Figure 21-42C.**

Beveling

Band saw tables or heads tilt for bevel sawing. For tables, loosen the table tilt lock knob and adjust the angle according to the tilt scale. See **Figure 21-43.** If no tilt scale is offered, set and measure with a T-bevel. For a band saw with a tilting head, loosen the bevel lock knob, turn the handwheel, and adjust the tilt angle to the bevel scale. See **Figure 21-44A.** The scale is approximate, so check the angle before proceeding.

For straight bevels, you need a rip fence or miter gauge. Feed workpieces for curved cuts as you would if the table was flat. See **Figure 21-44B.** Once you begin the cut, continue only in one direction. Otherwise you would cut a reverse bevel. Remember, the kerf made on the other face differs from the cutting line you follow.

Sawing multiple parts to size

Multiple parts can be cut to size in a single operation. Stack and fasten workpieces together with nails located away from the cutting line. See **Figure 21-45.** Make relief cuts on each side of the nails and elsewhere as needed. Saw along the cutting line. The last two cuts should be those that free the parts from the nailed-together waste.

In addition, you can hold workpieces together with two-sided tape. This prevents blade damage caused by sawing through nails. However, tape will not hold if the lumber is warped.

For sawing duplicate workpieces with parallel edges, such as chair rails, attach a *round fence.* See **Figure 21-46.** Saw the first workpiece to establish the shape. Then secure the fence to the table a given distance from the blade. Hold the material against the fence as you feed through the cut. You could attach a small caster wheel to the fence. This prevents uneven motion caused by the sawn edge.

Resawing

Resawing with a table saw and fence was discussed earlier. Another method is to use a band saw and an auxiliary fence or a round fence. The width of material that can be resawed depends on how high the upper guide post rises. The blade becomes more flexible at the point of operation when the guide post is raised high.

Resawing on the band saw is a one-pass process. See **Figure 21-47.** The auxiliary fence is adjusted or the round fence is clamped away from the blade at a distance equal to the desired material thickness. Also mark the resaw line on the material. You may have to adjust your feed left or right

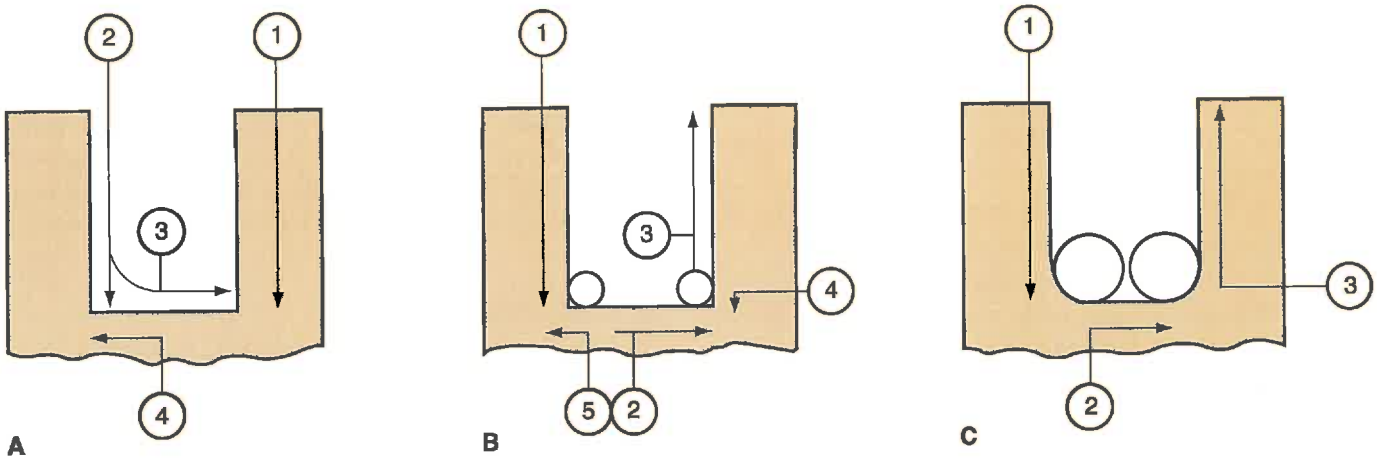


Figure 21-42. Series of drilled holes and kerfs for pocket cutting.

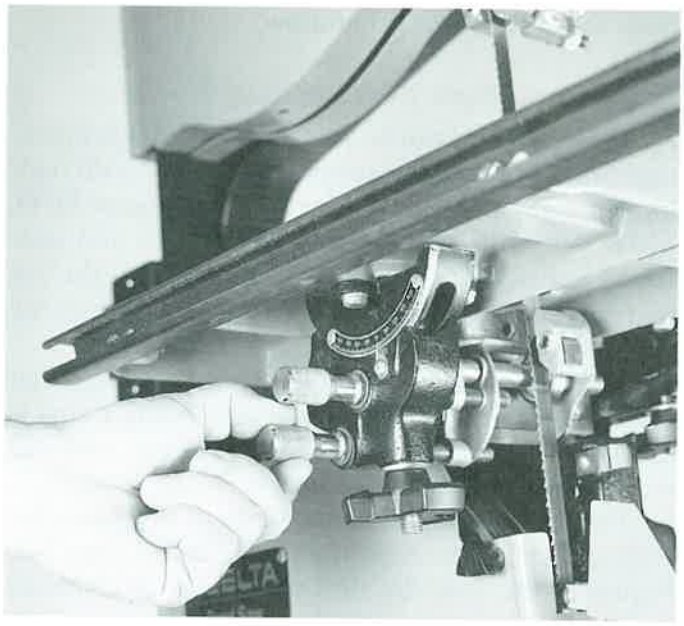
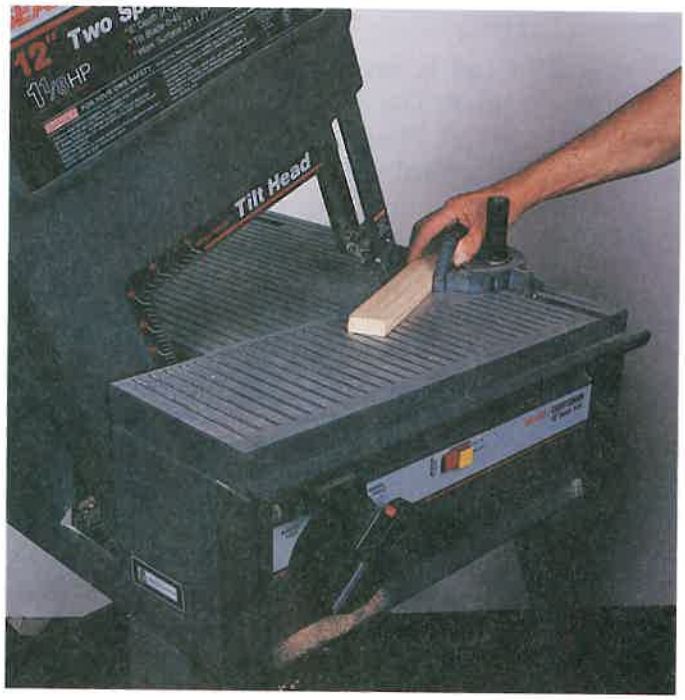


Figure 21-43. Adjust the table angle according to the tilt scale. (*Delta International Machinery Corp.*)

during the cut. This is necessary if the blade has more set on one side. Also, hard growth rings, knots, and soft wood between rings affects blade travel. Use a push stick as you near the last 2" or 3" (51 mm or 76 mm) of the workpiece. Support stock behind the table.

Think Safety—Act Safely when Using the Band Saw

- Fasten loose clothing, secure long hair, and remove jewelry.
- Always wear eye protection.
- If you hear a rhythmic click as the wood is being cut, there may be a cracked blade. Stop and inspect the machine.
- If the blade breaks, shut off the power. Remove it after the machine comes to a complete stop.
- Make sure you adjust to the proper tension.
- Make sure the teeth are pointing down, toward the table.
- Lock the upper guide, about ¼" (6 mm) above the work.
- Hold the stock firmly on the table as you cut.
- Maintain your balance as you cut.
- Make relief cuts as necessary.
- Keep your fingers away from the point of operation while the blade is moving.
- Do not cut a small radius with a wide blade without first making relief cuts.
- Minimize backing out of a kerf. This could pull the blade off the wheels.



A

B

Figure 21-44. Beveling on the band saw. A—A tilting head and a miter gauge is used to produce a compound bevel. (*Chuck Davis Cabinets*) B—A tilting table and fence may be used for straight bevel. (*Chuck Davis Cabinets*)

Scroll Saw

The ***scroll saw*** cuts small radius curves. Its thin, narrow blade saws intricate work, such as marquetry and inlay. The scroll saw operates much like the band saw. However, unlike the band saw, the scroll saw will cut out interior openings.

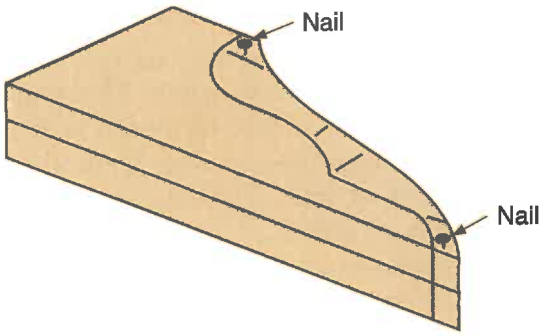


Figure 21-45. Stack material when sawing duplicate workpieces.

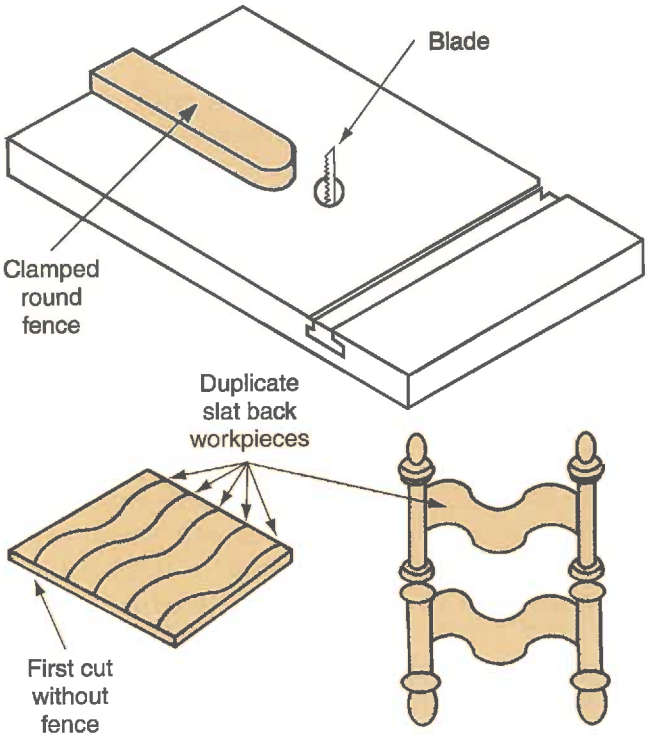


Figure 21-46. A round fence helps saw duplicate workpieces having gentle curves.

A

A

Figure 21-47. Resawing on the band saw is a one-pass operation. A—Hold material firmly against the auxiliary fence on a resaw band saw. (*Chuck Davis Cabinets*) B—Hold the material against a rounded auxiliary fence on other band saws.

Scroll saw features

Scroll saw features include a table, hold-down, blade guide, blade chucks, blower nozzle, and guard. See **Figure 21-48.** The table tilts for making bevel cuts. A hold-down keeps material from vibrating on the table. It is attached to the machine frame or to a guide post. The blade, held by two chucks, cuts reciprocally on the downward stroke. The lower chuck drives the reciprocal motion of the blade. The upper chuck is spring-loaded and retains blade tension. The blade guides support the blade so it does not break due to excess feed pressure. The blower nozzle is attached to an air supply line. It blows away chips so the cutting line remains visible.

There are two types of scroll saws. They differ in how they apply tension to the blade. The tension prevents the blade from bending on the return stroke. Tension in a sleeve design scroll saw is supplied by a spring-loaded sleeve in the upper chuck. See **Figure 21-48.** Tension is adjusted with a knob on the overarm beside the sleeve. With rear tension scroll saws, the entire overarm pivots with the blade motion. See **Figure 21-49.** Blade tension is adjusted at the rear of the machine. The advantage of rear tension saws is that the blade moves slightly

back from the workpiece. This helps prevent the workpiece from *jumping* up and down. The hold-down serves as a guard for rear tension scroll saws.

Scroll saw size is based on the distance from the blade to the back of the overarm. This is called the throat depth and may vary from 12" to 24" (305 mm to 610 mm). The throat depth limits the length of material that can be cut.

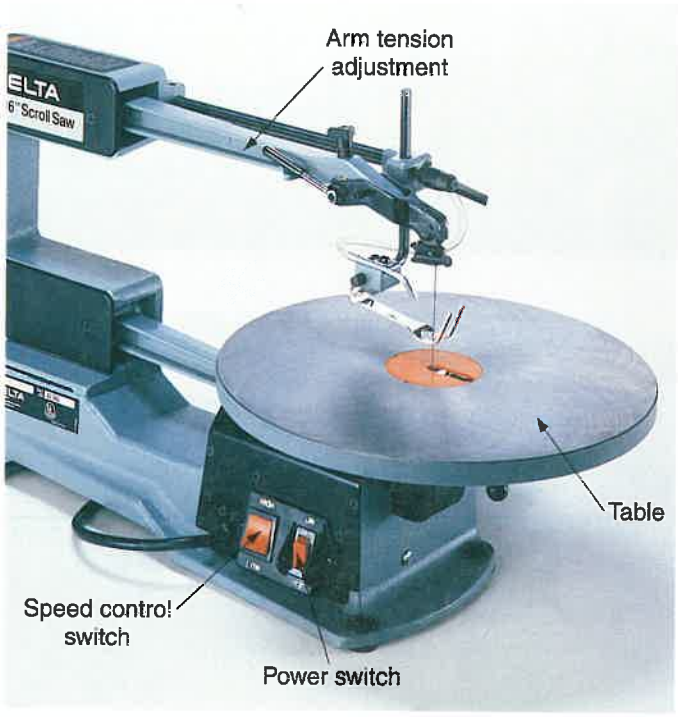


Figure 21-48. Features of a scroll saw. (*Delta International Machinery Corp.*)

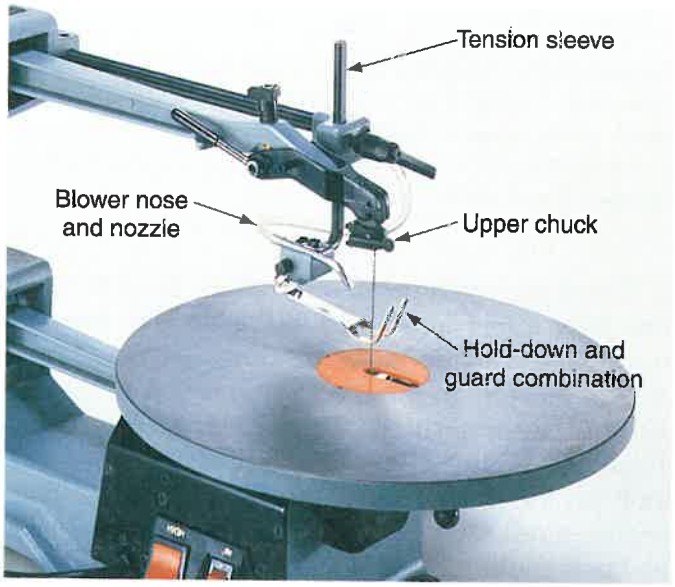


Figure 21-49. Rear tension scroll saw. (*Delta International Machinery Corp.*)

Selecting and installing scroll saw blades

Blades for scroll saws are very narrow and thus, are capable of sawing a small radius. The number of teeth per inch varies. A rule of thumb is to select blades that will have three or more teeth in contact with the wood at all times. The edge next to the kerf will not splinter as much.

The procedure to change a blade is as follows:

1. Turn the switch off, then disconnect power to the saw.
2. Remove the table insert.
3. Move the lower chuck to the top of its stroke by turning the motor shaft knob.
4. Loosen the thumb screws or set screws on upper and lower chucks.
5. Remove the old blade.
6. Slip the replacement blade into the lower chuck. Point the teeth downward and toward the front of the machine.
7. Align the blade with the slot in the blade guide. See **Figure 21-50.**
8. Tighten the lower chuck to secure the blade.

Note

If the blade extends above the upper chuck at this point, you must adjust the tension device. For sleeve-type saws, loosen the knob. Then raise the sleeve until the upper chuck is about ½" (13 mm) above the blade end. Tighten the sleeve clamp knob. For rear tension saws, adjust the tension knob until the upper chuck is positioned ½" (13 mm) above the blade end.

9. Pull the upper chuck down, insert the blade, and tighten the thumb screw.

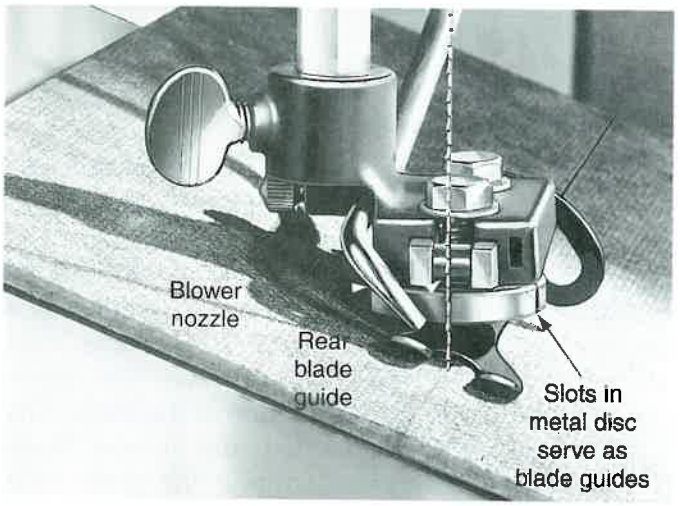


Figure 21-50. The scroll saw blade is controlled by blade guide slots in a metal disk and a rear guide. (*Delta International Machinery Corp.*)

10. Turn the motor shaft knob to raise and lower the blade one cycle. If the blade bends during either the cutting or return stroke, increase the tension. If the motor shaft knob is very hard to turn at the bottom of the saw stroke, release some tension.
11. Install the table insert.

On many machines, the blade guide is circular. It contains a series of variable size slots and a roller. The slots accommodate blades of different thicknesses. Rotate the guide to the proper slot for a given blade. The teeth on the blade must be in front of the guide slot so they are not damaged when the blade reciprocates. The small roller, behind the blade, rotates with the blade.

Scroll saw setup

Preparing to use the scroll saw requires just a few simple steps. For saws having a guide post, lower or raise the post so material can pass under the hold-down. The scroll saw may have one of three speed adjustments.

- ***Electronic.*** A speed knob adjusts the speed, which is displayed in a digital readout.
- ***Variable.*** A variable speed scroll saw adjusts while the machine is running.
- ***Pulleys.*** A belt is tracked over opposing step pulleys. Make sure that the switch is off and power is disconnected while you move the belt.

Scroll saw operation

There are two types of cuts made with the scroll saw. One is around or through the workpiece, typically called an ***outside cut***. The other is an ***interior cut*** for cutouts.

Outside cuts

The procedure for outside cuts is very similar to the band saw. For outside cuts proceed as follows:

1. Plan your sequence for making relief cuts. Even though the scroll saw has a narrow blade, relief cuts may help when cutting small radius curves.
2. On tension sleeve scroll saws, lower the hold-down until it rests on the material. Press lightly on the blade guard, then tighten the guide post. The hold-down on some rear tension saws adjusts automatically to the workpiece thickness.
3. Aim the air nozzle at the point of operation.
4. Adjust the blade speed if necessary. Saw thick and hard materials at slow speeds. Faster speeds and fine tooth blades are appropriate for thinner materials.
5. Fine tooth blades leave smooth cut edges.
6. Start the machine and proceed with your cutting sequence. Relief cuts prevent having to back the blade out of a long saw kerf.

Beveling

Beveling on the scroll saw is much like the band saw operation. Tilt the table, then adjust the hold down to the tilt angle. Refer to *Figure 21-49*. Keep the workpiece on the same side of the blade until the cut is complete.

Interior cuts

The scroll saw cuts interior openings easily. Since the blade is not a continuous loop, it can be threaded through a hole in the workpiece. See **Figure 21-51.** After you drill holes in the waste section, proceed as follows:

Figure 21-51. When cutting interior curves, free the top end of the blade and thread it through a predrilled hole.

1. Turn the switch off, then disconnect power to the scroll saw.
2. Raise the chuck to the top of the stroke by turning the motor shaft.
3. Loosen the upper chuck clamp to free the blade.
4. Bend the blade slightly to slide it through the hole drilled in your workpiece.
5. Place the material on the table and rechuck the blade.
6. Make sure the hold-down presses lightly on the material.

7. Holding the material down with one hand, press the START button.
8. Continue with the inside cut. If there are sharp curves and inside corners, relief cuts may be needed. See **Figure 21-52.**
9. When finished with the cutout, stop the machine, disconnect power, and loosen the top chuck to free the blade. Repeat the procedure for additional cutouts.

Using saber saw blades

A saber saw blade may be installed in the scroll saw's lower chuck. See **Figure 21-53.** It is especially helpful for making cutouts. You do not have to unchuck the top part of the blade to move from one cutout section to the hole drilled in the next section. A blade guide is still attached on tension sleeve scroll saws. Select the proper blade guide slot, attach it to the guide post, and lower the assembly next to the blade. Feed material as you would when using the scroll saw blade. Since the saber saw blade is thicker and wider, the minimum cutting radius will be increased.

Think Safety—Act Safely when Using the Scroll Saw

- Fasten loose clothing, secure long hair, and remove jewelry.
- Wear safety glasses, goggles, or a face shield.
- Make sure the saw blade teeth point down.
- Make sure the proper blade size and type is installed.
- Keep the floor around work area clean and free from sawdust and scraps.
- Change blades (and speed on machines having step pulleys) with switch off and the power disconnected.
- Check all adjustments by rotating the motor by hand before turning power on.
- The hold-down must press lightly on the material being cut.
- Stop the machine before removing excess stock from the table.
- Do not attempt to saw large stock without means of support.
- Hold material firmly and feed it into the blade at a moderate speed.
- Make relief cuts before cutting curves.
- Shut off the power and let the machine come to a complete stop before leaving it.

Figure 21-52. Completing an interior cut.

Selecting Blades

Blades, regardless of the machine they are on, are designed to cut efficiently and effectively. Selecting the proper blade is an important part of sawing. Using the wrong blade may ruin the workpiece, dull the blade, or cause unnecessary operations on the jointer. For example, crosscutting with a rip blade creates problems. Rip teeth are larger and have a different cutting angle that may splinter the wood. The edge is left rough and makes the wood look splintered.

The blade you choose depends on the sawing operation. You may be sawing lumber or plywood across or along the grain. You could also be cutting nongrain composites such as hardboard, particleboard, and even plastic.

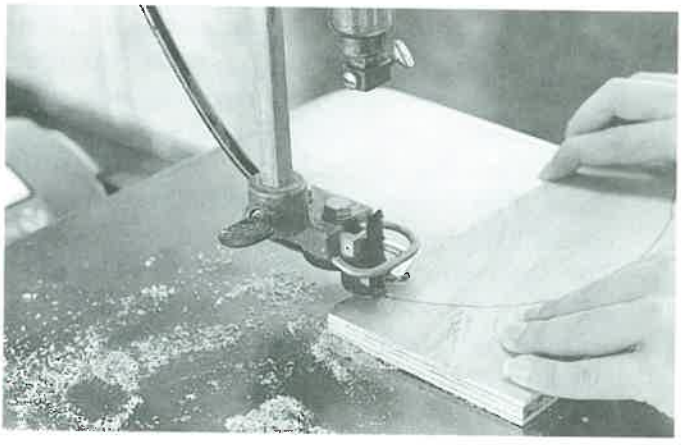


Figure 21-53. A saber saw blade can be installed in the bottom chuck of most scroll saws.

After making a cut, inspect the cut edges of the workpiece. Look to see how rough or smooth they are. There could be burn marks from using a dull blade, improper adjustment of the rip fence, or advancing the blade too slowly. Inspection helps determine how well the blade is performing.

Saw blade performance is based on tooth design and chip load. Chip loading is the amount of material in the gullet of each tooth. Chip load depends on the:

- Number of teeth per inch.
- Size of the gullet
- Speed of the blade.
- Rate of feed.

Chip load is a factor for all types and styles of blade. If wood chips totally fill the gullet, the blade cuts poorly. This is because there is no more room in the blade to hold sawn chips. You can feed faster with large tooth blades, yet the sawn edge will be rougher. However, too much pressure causes the blade to heat up due to increased friction. Excess heat can remove temper from a blade.

Blade quality relates mostly to the life of any blade used properly. Select carbide-tipped, stainless steel, alloy steel, or high-carbon steel blades.

Circular blade

Circular blades are used on table saws, radial arm saws, power miter saws, and various portable power saws. Important blade specifications include blade diameter, tooth design (hook angle, cutting edge shape, and number of teeth), kerf width, and the size of the arbor hole.

Diameter

Machines are made to use blades with a wide range of diameters. Machines are described in terms of the maximum blade diameter installed in the machine (10" table saw, 7¼" portable circular saw, for example). Smaller diameter blades reduce the maximum depth of cut. Most 10" (254 mm) blades mounted on a 10" table saw will cut through 2" (50 mm) material at 45° and 3" (75 mm) material at 90°.

Hook angle

Hook angle refers to the angle at which the front edge of the tooth contacts the material. This angle is created between the tooth edge and a line that extends from the tooth point to the arbor hole. Rip blades may have a 10°, 15°, or 20° hook angle. Blades designed for power miter, radial arm, and other pendulum type saws generally have less hook and some even have 0° or a negative hook angle. The negative angle gives you greater control over the feed rate.

Cutting edge

There are various standard blade cutting edges. The cutting edges are determined by the tooth shape. See **Figure 21-54A.** The type of material and grain direction through which a blade will cut is based on the tooth shape. Teeth may be raker (square), chisel-like, or bevel shaped. See **Figure 21-54B.** Some combination blades may have teeth shaped several ways. For example, one tooth is square followed by several that are beveled.

The cutting edge of carbide tips are ground to various shapes, which are commonly referred to as ***grinds***. See **Figure 21-55.** The most popular grinds and uses are as follows:

- ***Flat top grind.*** The blade has larger gullets, fewer teeth, and will accept greater chip loads for higher feed rates. See **Figure 21-55A.** Excellent for ripping lumber when speed is more important than the quality of the cut.
- ***Triple chip and flat grind.*** Two shapes of teeth—alternating between triple-edge and flat top design for dual action cutting. See **Figure 21-55B.** The triple-edge teeth remove material from the center of the kerf, followed by the flat top raker to clean out remaining material from both sides. Excellent results in plywood and plastics. They are primarily used on power miter and radial arm saws. These blades with a negative hook angle are preferred for cutting non-ferrous metal.
- ***Alternate top bevel grind.*** Top bevel shaped teeth sever the material with shearing action alternately left and right. See **Figure 21-55C.** This grind is used for cross cutting or a combination of cross cuts and rip cuts. Blades of this design with a high number of teeth will produce a higher quality of finish cut in wood.
  Blades with a high angle of bevel (30°) will also be able to produce superior cuts on both sides of either thermofused melamine or HPDL panels. Use blades with a negative hook angle for improved control over feed rate.
- ***Alternate top bevel and raker grind.*** Two sets of alternate left and right top bevel teeth preceded by a raking action flat top tooth with large round gullet to ease chip removal. See **Figure 21-55D.** Another excellent choice for a combination blade.

Number of teeth

The number of teeth is an important aspect of blade design. The number does not distinguish a rip

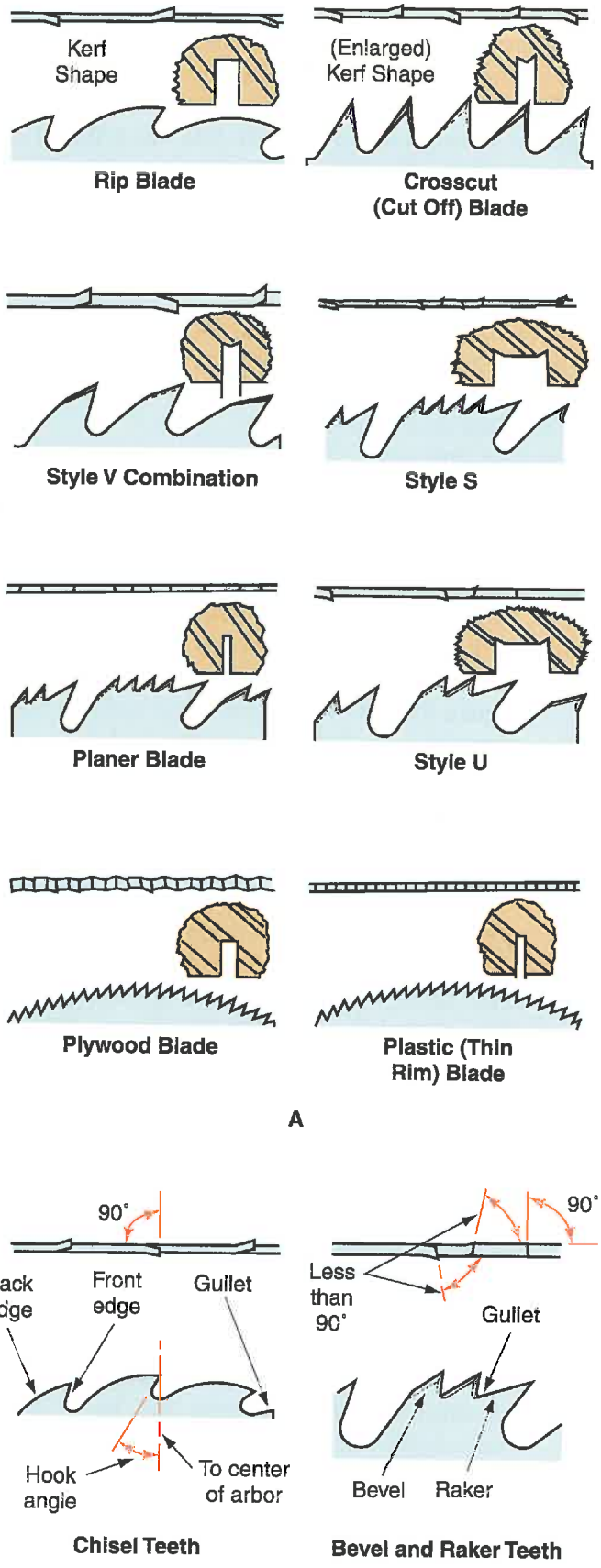


Figure 21-54. The cutting edge of a standard circular saw blade is determined by the shape of its teeth.

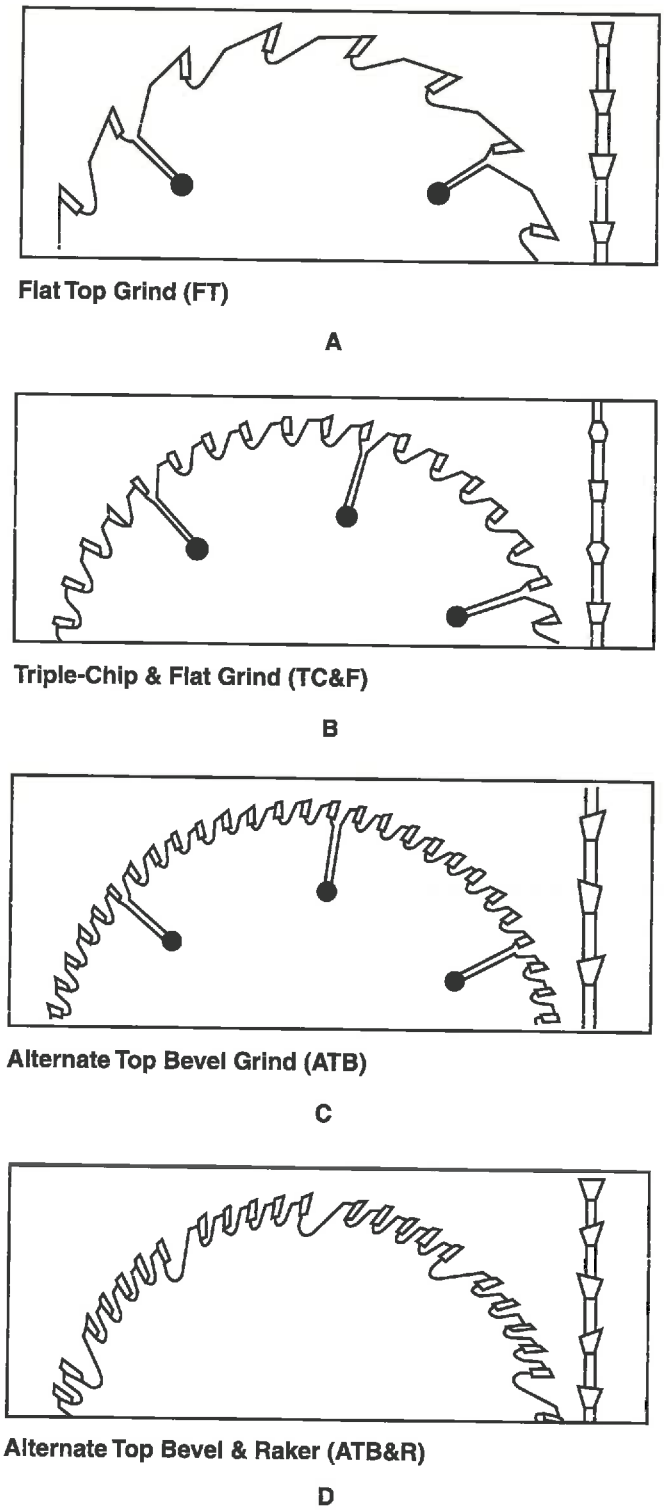


Figure 21-55. Four popular tooth designs. A—Flat Top Grind (FT). For cutting material with the grain. B—Triple-Chip and Flat Grind (TC&F). Primarily for use on power miter and radial arm saws. Blades with a negative hook angle are recommended for cutting nonferrous metals. C—Alternate Top Bevel Grind (ATB) For across the grain cutting. Higher quality of cut comes from blades with the highest number of teeth. D—Alternate Top Bevel and Raker (ATB & R) Excellent for a combination of cross and rip cutting. (*Delta International Machinery Corp.*)

blade from a crosscut or combination blade. Rather, it suggests the performance of a blade in thin materials. Generally the blade with the larger number of teeth will produce consistently smoother cuts. When cutting lumber on a table saw, adjust the blade height so at least two teeth are cutting material.

Kerf width

The width of the sawn kerf is generally larger on large diameter blades. This is due to the thicker plate used in the larger blade's construction. Standard kerf for a 10" (254 mm) diameter blade is 1/8" (3 mm). The thin kerf models have a 3/32" (2 mm) kerf design. The thin kerf design makes stock feeding exceptionally smooth, easy, and fast. Small horse power machines can handle more work with less strain on the motor and the operator. A common kerf for a 16" (406 mm) diameter blade is 11/64" (4 mm).

Arbor hole

The size of the arbor hole generally is larger on blades with a larger diameter. Commonly referred to as the bore, blades up to 10" (254 mm) in diameter have a 5/8" (16 mm) bore. Larger blades, such as 12", 14", and 16" (305 mm, 356 mm, and 406 mm), have a 1" (25 mm) bore.

Other considerations

Between each tooth is a *gullet*. It is where chips accumulate as teeth cut through the material. The chips absorb heat from the blade and are then thrown out when the tooth exits the stock.

Circular blades are either flat, hollow ground, or thin rim. See **Figure 21-56.** ***Flat blades*** have set to create a wider saw kerf. The teeth are bent slightly outward to create a kerf slightly wider than the blade. The kerf prevents the blade body from binding. A ***hollow ground blade*** has no set. It leaves a smoother cut edge on the workpiece. The thinner cross section of the blade reduces binding. However, binding and heating will occur if the blade is not raised 1" (25 mm) above the table. A ***thin rim (thin kerf) blade*** creates the narrowest kerf and thus, conserves material. However, heat buildup is a problem unless you are sawing veneer.

Carbide-tipped blades perform the same operations as standard blades. They remain sharp 10 to 20 times longer than regular blades. High-quality, flat steel is used for the blade body. Pieces of extremely hard tungsten carbide are brazed to each tooth.

Carbide-tipped teeth will be square, beveled, or look like they have a chamfer on one or both of the corners. See **Figure 21-57.** The chamfered tooth is called a ***double-chip*** or ***triple-chip tooth***. One chip is formed by each flat surface. Ripping may be done with square top or alternating square and triple-chip blades. Crosscutting most likely is done with beveled teeth. There are two styles of combination blades. They have one square (raker tooth) and two or four beveled teeth per set. Finer cutting blades for plywood, plastics, and particleboard may have alternating bevel teeth, alternating double- or triple-chip and beveled teeth, or alternating double- or triple-chip and square teeth.

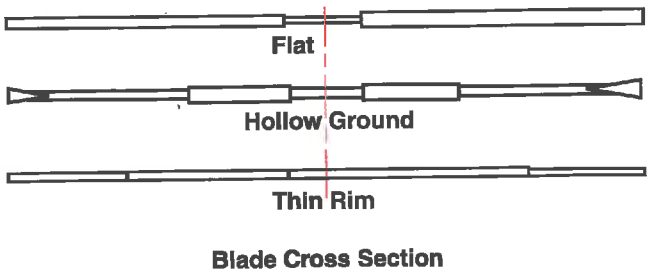


Figure 21-56. Circular blades are either flat, hollow ground, or thin rim.

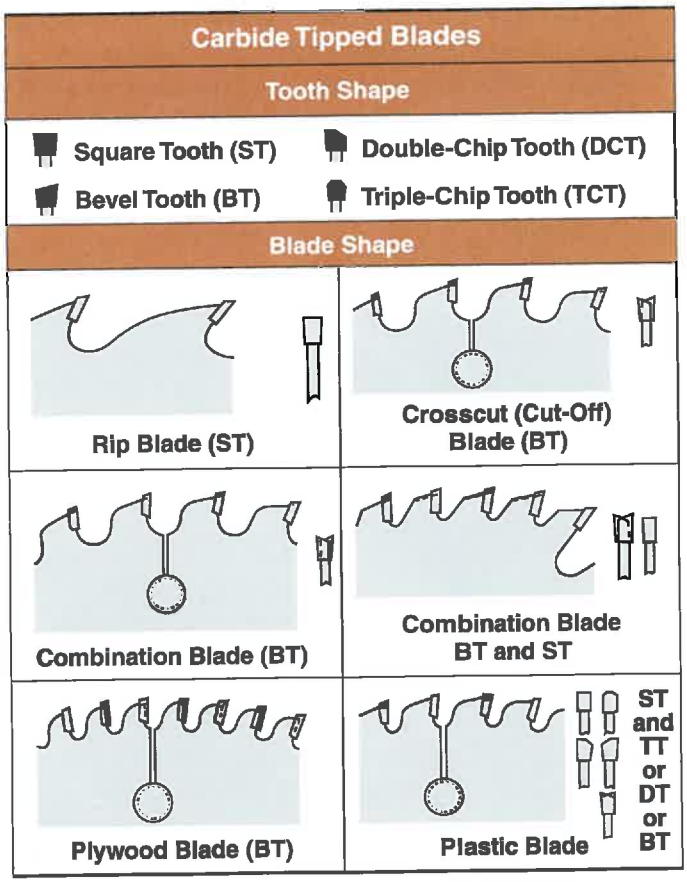


Figure 21-57. Tough, long lasting tungsten carbide-tipped blade out-perform standard blades. (*Peerless*)

Another form of carbide blade can be used on plywood, fiberboard, plastic laminate, fiberglass, and composition board. Rather than brazed teeth, this blade has hundreds of carbide chips bonded to the blade edge. See **Figure 21-58.** The chips are cut with an abrasive action rather than the typical chip removal process associated with toothed blades. These blades are reversible which can increase their usable life up to 25%. Set up this blade as you would one that is hollow ground.

Some blades (standard and carbide-tipped) may be designed with an expansion slot. See **Figure 21-57.** It relieves heat stress in the blade. A warm blade could warp and affect the smoothness and width of the kerf. On carbide blades over 12" (254 mm) in diameter, holes at the bottom of the expansion slots are fitted with aluminum plugs. These help reduce noise and vibration, resulting in a smoother cut.

Band saw blade

A band saw blade is an endless bonded loop of thin narrow steel with teeth on one edge. Select band saw blades according to various specifications. The length of the loop is critical. You may buy a blade of a given length, such as 12' (3.66 m). You could also buy a 100' to 500' (30.5 m to 152 m) coil, and cut and weld together your own blades.

Blade width is important. It may vary from 1/8" to 1" (3 mm to 25 mm) or wider. Blades 1/8" to ½" (3 mm to 13 mm) are used most often for sawing irregular kerfs. Wider blades are more appropriate for resawing.

Blades vary in hardness. Some inexpensive blades are made of untempered steel. Others may have a flame hardened cutting edge and possibly a hard tempered back.

There are several alternative tooth shapes and blade sets available. See **Figure 21-59.** The regular blade has a 0° hook angle and a straight front and back on each tooth. The hook tooth blade has about a 10° positive hook angle. The skip-tooth blade has a straight tooth front, 0° hook, and a long gullet. Regular and hook tooth blades have teeth set alternately left and right. The skip-tooth blade may have a raker tooth set. Rakers are chisel teeth placed between sets of beveled teeth. A third set type is the wavy tooth blade. Several teeth are set right and then left. They are separated by a raker tooth. A regular blade works best for wood only. The hook tooth cuts well on most wood, fiberglass, and plastic laminate. The skip tooth blade is better for soft woods and plastics. These may overload and clog other blades' gullets.

A carbide chip blade is also available. This blade will saw fiberglass, plastic laminate, particleboard, and ceramic tile. See **Figure 21-60.** It can be reversed to extend the life of the blade.

Scroll saw blade

The scroll saw uses several different blades also. See **Figure 21-61.** Standard blades cut in only one direction. They vary in width and number of teeth per inch (tpi). Common widths are 1/8" to ¼" (3 mm to 6 mm).

Figure 21-58. A carbide grit edge blade saws composite products as well as ceramics. The guard has been removed to show the operation. (*Remington Arms Co.*)

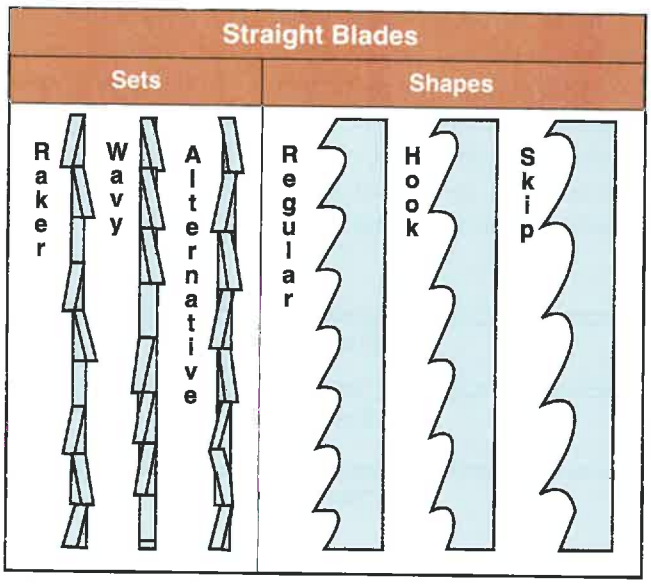


Figure 21-59. Band saw blades shapes and sets.

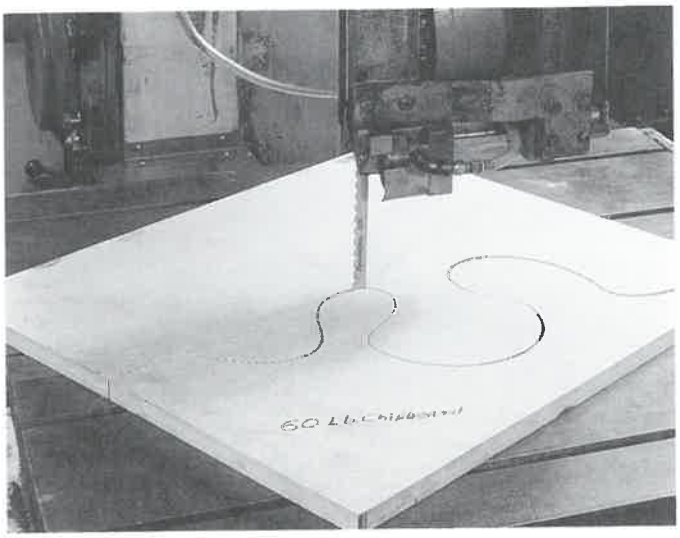


Figure 21-60. Carbide chip band saw blades are available for cutting composite materials and ceramics. Guard raised to show operation. (*Remington Arms Co.*)

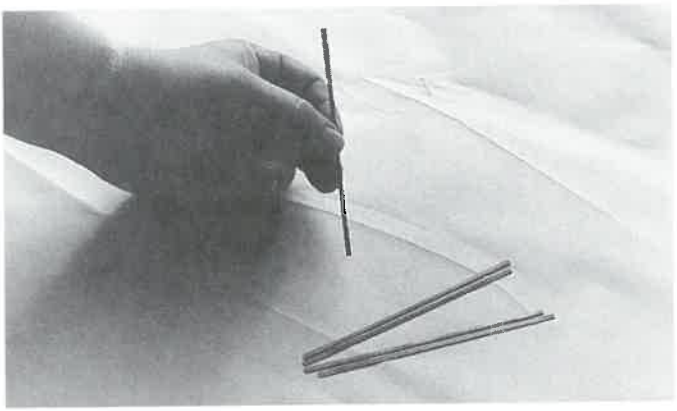


Figure 21-61. Scroll saw blades.

Scroll saw blades typically have 7 to 20 teeth-per-inch (tpi). They have beveled teeth that are alternately set. Normally, at least three teeth should contact the material at all times. A 7 tpi blade would be best for soft lumber with high moisture content. A 20 tpi blade, about 1/32" (1 mm) wide, is proper for veneer and other very thin material. The standard blade length is 5" (127 mm). In addition, a round blade with spiral teeth is available. You can move the material in any direction while cutting.

Maintaining Saw Blades

Saw blades should be sharp to the touch, have adequate set, and be free of rust or resin. Inspect them frequently for cracks (especially in the gullets), warpage, bluish color (sign of overheating), and missing or damaged carbide teeth. Proper maintenance may include cleaning and sharpening or discarding.

Clean blades with paint thinner. Oven cleaner may be used on more stubborn resins. Be sure to protect your hands with rubber gloves. Rust can be removed with oil and fine steel wool. Remove the oil and coat the blade with paste wax or silicone spray before storing it.

Blade sharpening is a time-consuming operation. You must decide whether to have blades machine sharpened accurately or try to do it less accurately by hand. Blade sharpening machines will joint, set, and file or grind the blades precisely. For detailed procedures for sharpening standard circular blades refer to the *Appendix*.

Hand sharpening is limited to jointing, setting, and filing. A small hand stone could be used to touch up a standard blade. However, hand sharpening is not recommended.

To determine if you can sharpen a given standard blade by hand, push a file across a tooth. If file marks appear, the blade may be sharpened. If not, the blade is too hard. Carbide-tipped and hardened-steel blades cannot be hand sharpened. Machine grinding is the only method to sharpen a carbide-tipped blade.

Maintaining Power Saws

Maintaining stationary power saws properly will increase their usable life. Inspect, clean, adjust, and lubricate saws periodically. The machine *must* be disconnected from electrical power before service. For complex repairs, refer to the owner's manual.

Table saw

Table saws should cut material accurately. Suppose you check a workpiece and find it out of square. This could indicate a table, miter gauge, or fence problem.

Suppose you are sawing using the miter gauge. You notice the workpiece pulls away from or feeds in toward the blade. The miter gauge slot may not be parallel to the blade. Check this by comparing readings with a dial indicator. See **Figure 21-62.** The dial should not move as you slide the miter gauge. (Be sure the blade is not warped. Install a new blade for the test.) To correct this problem, loosen and turn the tabletop slightly.

Suppose you are sawing using the rip fence. The workpiece pulls away from or rubs tightly against the fence. This indicates the fence is out of alignment. If the fence has been dropped at some time, one or more locking mechanism bolts or nuts may have slipped. Loosen them, move the fence to align it, and then retighten the bolts or nuts.

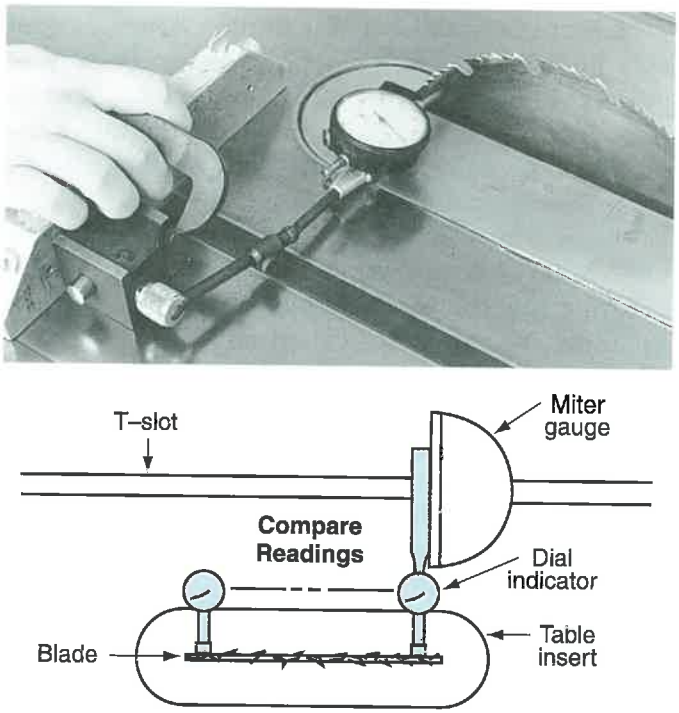


Figure 21-62. Check distance readings from the blade to the table to determine whether the arbor and table are aligned.

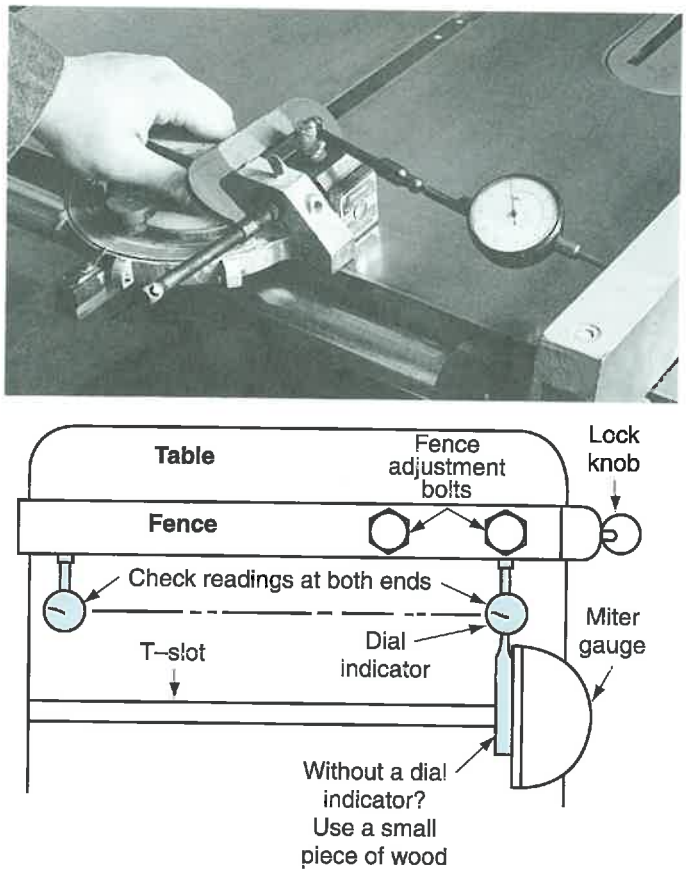


Figure 21-63. With the fence clamped, check the distance from the fence to a table slot at both the front and back.

Make accurate adjustments with a dial indicator. See **Figure 21-63.** Without the indicator, make the same comparisons with a wood block. However, this method is less accurate.

At times, handwheels become hard to turn. First, check to see that the lock knobs are loose. If they are, lubricate screw threads with silicone spray or powdered graphite. Sawdust will stick to oil and may create a gummy condition worse than before.

Your sense of smell is valuable around a table saw. The smell of rubber or varnish may be present. A rubber scent likely will occur when the belt is not tracking properly. The belt overheats and may harden. Then it can crack and probably break. An overheated motor has a definite varnish-like smell. Motors often have a built-in circulating fan. It can attract sawdust. Sawdust accumulation can slow the motor and cause overheating and possible burn out.

Rust appears on unpainted steel parts. Remove the rust with oil and steel wool or fine emery cloth. Wipe the oil away because it will stain your wood. Then coat the table and other parts with paste wax. Wax is less likely to be absorbed into the wood being sawed.

Radial arm saw

The radial arm saw has many movable parts. Rust, lack of lubrication, and excessive torque on levers are sources of maintenance problems. Check table and fence alignments before making cuts. Do so with a square, protractor, T-bevel, or other device. Machine scales may not be accurate.

The table may have to be leveled so the blade will be square. Do so by removing the table protector and wood top. Adjust the leveling bolts as necessary and reset the locknuts. See **Figure 21-64.**

Sometimes the saw kerf is not straight. The saw assembly movement bearings inside the overarm could be out of adjustment and allowing side play. Adjustment may or may not be possible. If not, the bearings will need to be replaced.

Band saw

With band saws, you must be able to apply the proper blade tension and adjust the tilt on the upper wheel. See **Figure 21-65A.** You also must be able to align the upper and lower blade guides and set the rear blade guide for different blade widths.

Blade tension

Blade tension is controlled by a tension control knob. See **Figure 21-65B.** It moves the upper

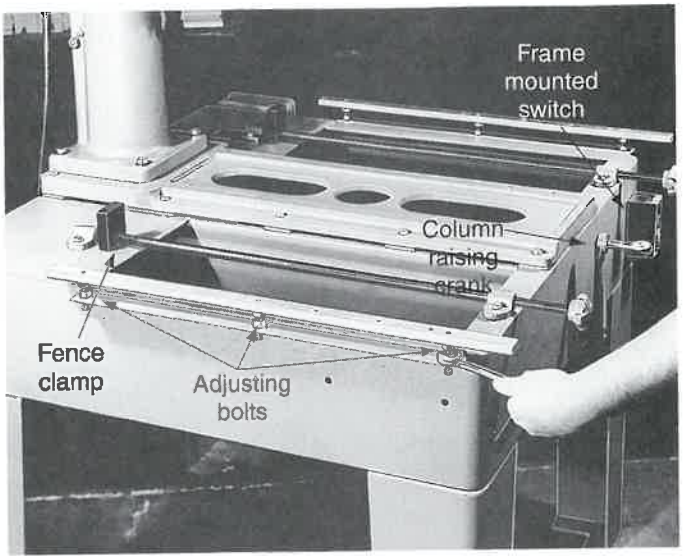


Figure 21-64. A radial arm saw table should be flat and level. Remove the table and adjust the bolts under the platform. (*Delta International Machinery Corp.*)

wheel toward or away from the lower wheel. Most machines have a scale and marker to note proper tension for a given blade width. Proper tension is reached when the marker is aligned with the scale. When there is no scale, estimate the tension. Snap the back edge of the blade with your fingernail or thumbnail as you would a guitar string. A medium pitch ringing sound indicates approximate tension.

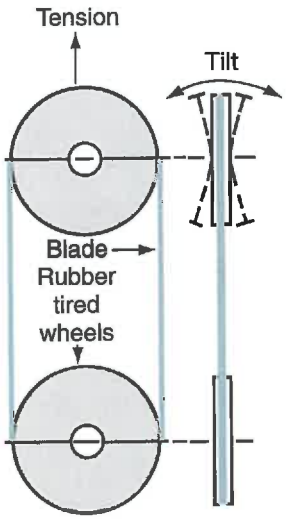
Blade tracking

The tracking adjustment moves the upper wheel toward or away from the operator. The adjusting mechanism generally is located on the back of the upper wheel housing. See **Figure 21-65C.** When a blade is installed with the proper tension, turn the upper wheel slowly. See that the blade remains centered on the tire. Turn the wheel at least three or four revolutions. Adjust the tracking knob or screw as necessary.

Side blade guides

Guides may be hardened pieces of steel or ball bearings on each side of the blade. See **Figure 21-66.** Fitting a blade between these guides is critical. Slip a piece of paper or tape between the blade and each side guide. If it moves freely, the guides have proper side clearance.

The teeth on the blade must never touch the hardened guides or bearings. If this happens, the blade loses its set. It may pinch in the kerf, heat up, and burn the material being cut.



A

B

C

Figure 21-65. A—The upper wheel on a band saw blade raises and lowers for tension adjustment and tilts for tracking adjustment. B—The tension control has a scale to indicate proper tension for various width blades. C—Tracking adjustment. *(Chuck Davis Cabinets)*

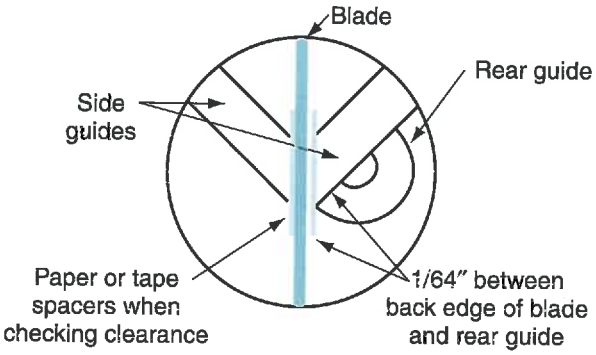


Figure 21-66. Set steel and ball bearing guides so the blade travels freely.

Rear blade guide

A rear guide is behind the blade. There should be 1/64" (1 mm) between it and the back of the blade. This adjustment may be made by moving the guide.

Blade repairing

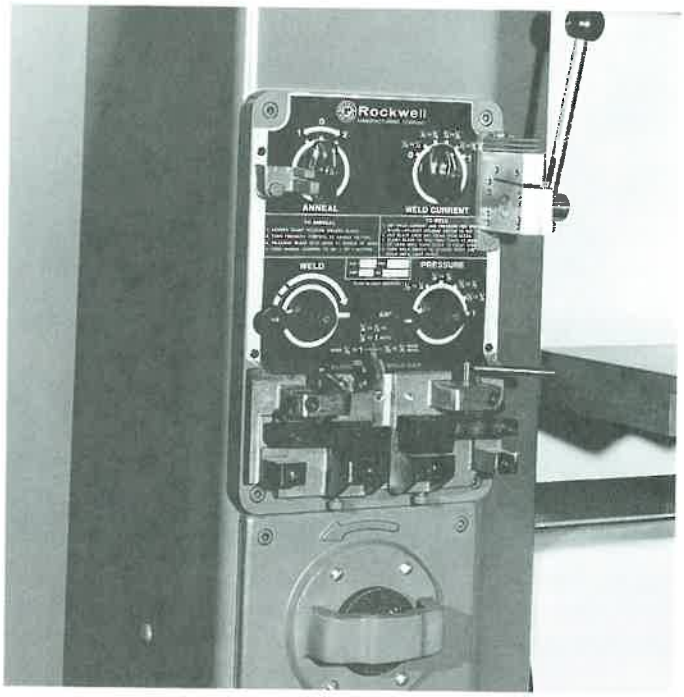
Broken band saw blades are repaired by welding the ends together. Some saws have welders attached. Otherwise, use a separate blade welding unit. These tools come with instructions on how to weld blades. See **Figure 21-67.**

You can make a jig and braze blades. See **Figure 21-68.** Obtain the following supplies and equipment.

- Grinder.
- Hard solder.
- Hard soldering flux.
- A small propane torch or other fuel source.
- Two small c-clamps.
- A flat file.

To repair a blade by hand, proceed as follows:

1. Grind the broken ends square with a 45° bevel to the face.
2. Clamp the blade ends together over the open part of the jig. The bevels must touch each other.
3. Apply a small amount of brazing flux across the joint.
4. Apply heat under the blade until the flux melts. It will look like liquid glass.
5. Place a pinhead size piece of hard solder on the flux. With a pair of tweezers, locate it exactly over the joint before the flux hardens.
6. Reheat the joint, flux, and solder. The solder will melt suddenly and flow throughout the beveled joint.
7. Chip off excess flux after the blade cools.
8. File away any solder that remains on the blade surface. The blade must fit between the blade guides. Therefore, this step is important.



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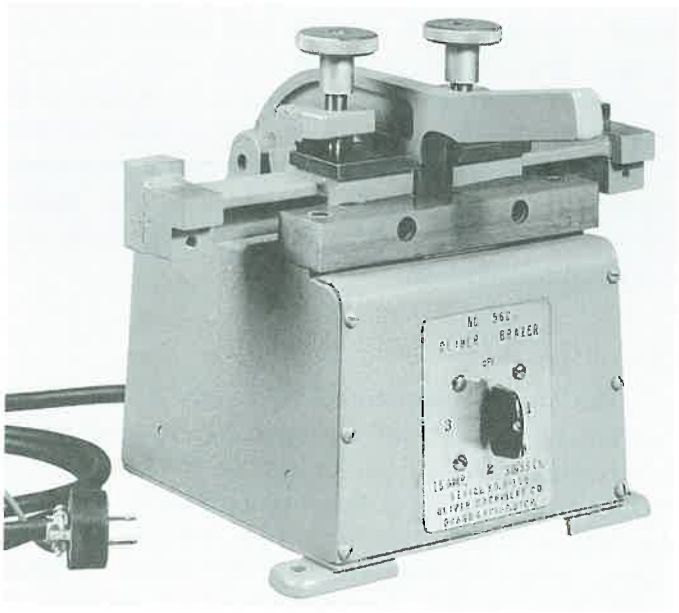


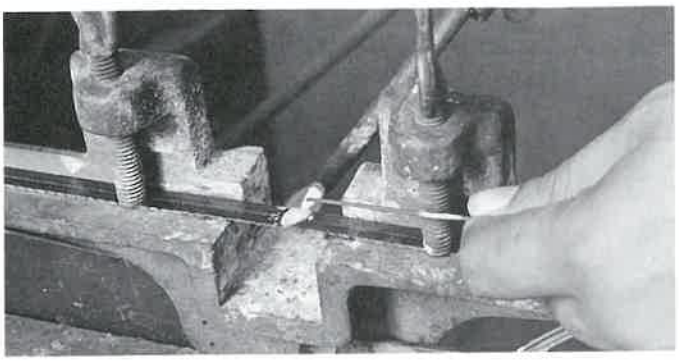
B

Figure 21-67. A—Blade welder attached to the band saw. (*Rockwell*) B—Separate blade welding unit. (*Oliver Machinery Co.*)

Storing a band saw blade

Band saw blades can be coiled for storage. They may be hung or boxed easily when coiled into a triple loop. See **Figure 21-69.** To coil the blade, proceed as follows:

1. Hold the blade vertically in front of you with both hands. One hand is in the center of each side of the loop. Thumbs are up and on the outside of the blade.



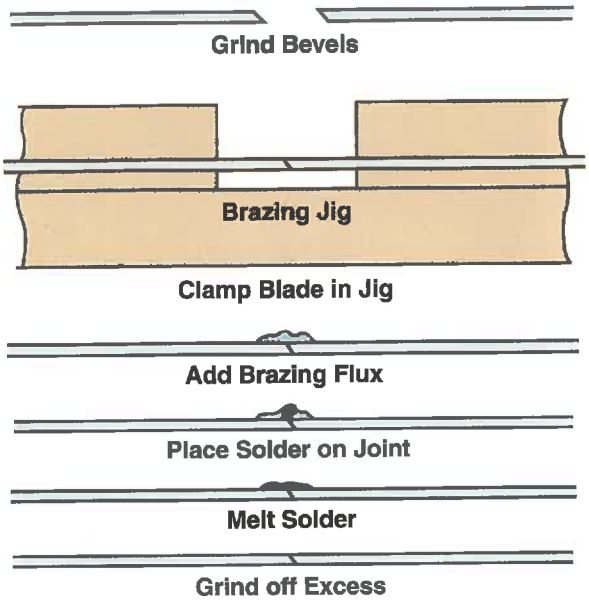


Figure 21-68. Top—Repairing a band saw blade clamped in a jig. Bottom—Steps to repair the blade.

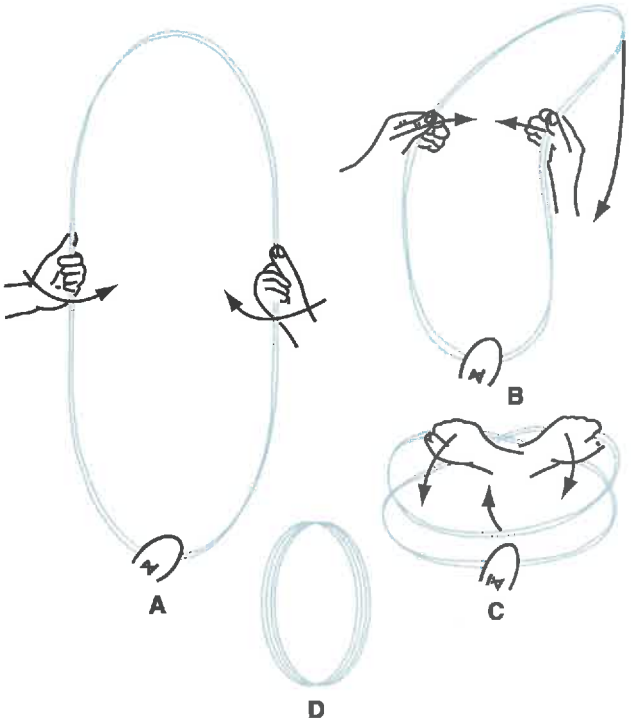


Figure 21-69. With practice, you can coil a band saw blade into three equal loops.

2. Fingers are curled toward you on the inside gripping the blade.
3. Turn both wrists so you can see your thumbnails. The blade begins to twist.
4. While turning, bend your wrists downward. The top of the loop moves away from you and drops toward the floor.
5. Bring your wrists together and cross them without changing your grip.
6. As you cross your wrists push them toward the floor.
7. The top of the loop in Step 1 will curl back toward you and the three-loop coil will form.

Scroll saw

Scroll saws are maintained like other machines. Be sure to:

- Select the proper blade guide slot for the blade being used. It guides the blade and prevents tooth damage.
- Set the tension sleeve or rear tension device as described earlier.
- Check the oil level periodically in the housing under the saw table. Oil prevents wear and heat build-up.
- Add a small amount of oil or graphite in the tension sleeve or rocker pins. This will prevent excessive wear.

Some scroll saws have an air pump, hose, and nozzle. This assembly blows off chips to keep the cutting line visible while sawing. Check the airflow periodically because the pump could get damaged or the hose could be loose or broken.

Think Safety—Act Safely

Follow all safety guidelines as you work. Have a firm footing and keep your distance from the point of operation. Use your senses of sight, sound, touch, and smell to detect potential problems. See **Figure 21-70.**

Summary

Sawing is a fundamental process in cabinetmaking. Stationary power saws cut lumber and composite materials to component sizes. Choose a saw and proper blade according to the material and direction of cut. For sawing straight parts, choose a table saw or radial arm saw. For cutting curved components, select a band saw or scroll saw.

The saw blade makes a big difference in the edge. The proper saw blade makes the operation efficient. Selecting the wrong blade may result in a splintered surface or burnt edge.

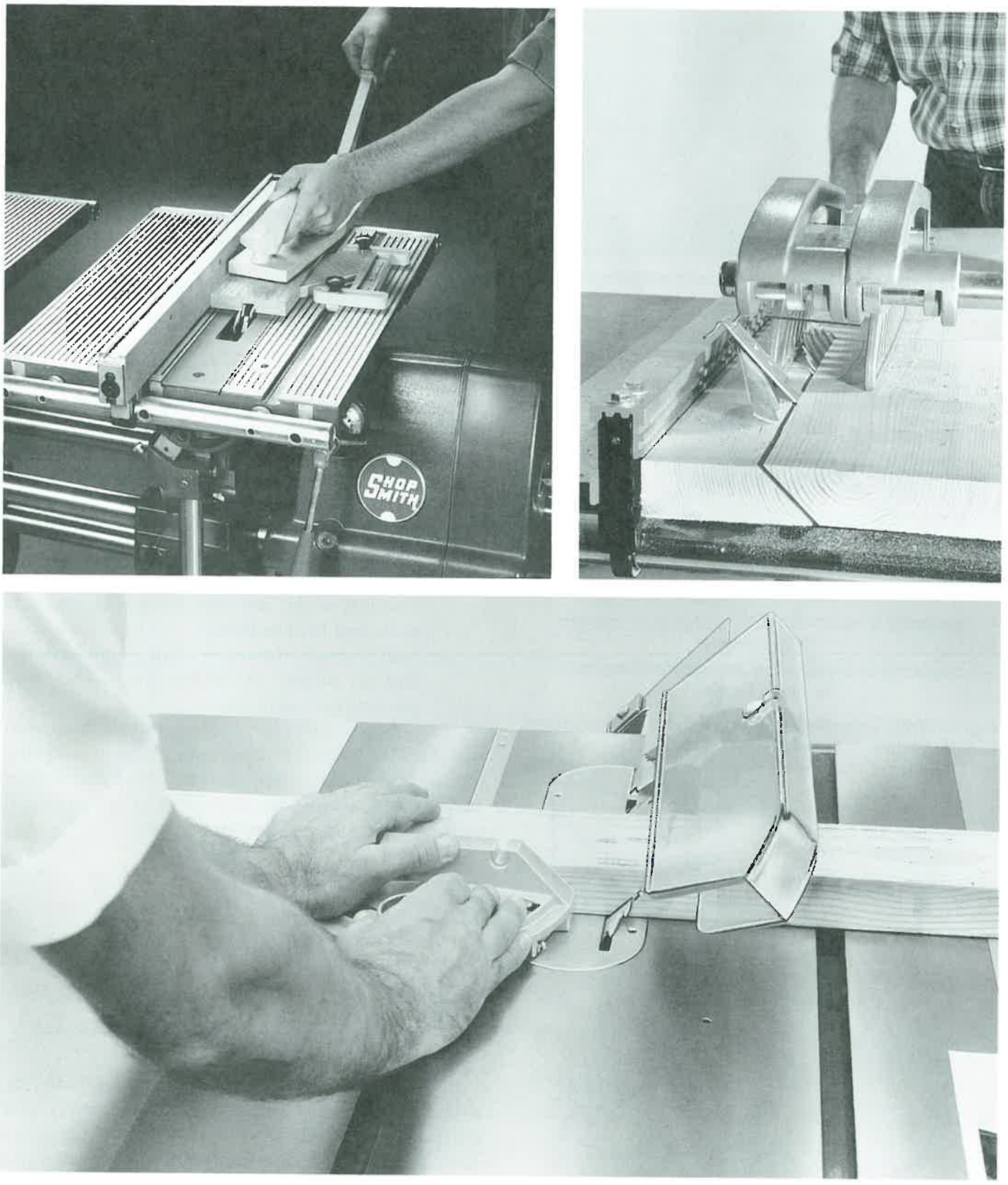


Figure 21-70. Safety Reminder: Saws are versatile tools that work best when proper attention is given to safety. In all cases, proper clothing is important. Wear a short sleeved shirt or roll the sleeves above the elbow. Remove rings. Top left—Proper use of a saw for cutting a dado. Operator is using a feather board, push stick, and pusherblock to control the workpiece. Top right—Proper technique for ripping keeps hands away from the blade. Guard, splitter, and anti-kickback device are in place. Bottom—Proper cross cutting procedure. Operator keeps hands well away. The operator uses miter gauge to push workpiece, has guard in place, and stands well away from the path of any flying wood chips. (*Shopsmith, Inc. and Delta International Machinery Corp.*)

To saw efficiently, blades must be sharp. Jointing, setting, gumming, and filing (grinding) are all steps in sharpening. Some blades can be hand sharpened. However, it is best to have blades sharpened by a professional with the appropriate machines. Also maintain machines properly. Inspect, clean, adjust, and lubricate them periodically.

Test Your Knowledge

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

1. List two saws you might choose for straight-line cutting.
2. Describe how you adapt a saw designed for cutting curved lines to cut straight.
3. The slot made as a saw blade cuts through the material is called a(n) _____.
4. List three methods of guiding material past the blade on a table saw.
5. What table saw safety feature helps prevent material from being thrown back toward the operator?
6. List three blades you might select for cutting ½" (13 mm) lumber across the grain.
7. Which direction do you turn the table saw arbor nut to loosen it?
8. Describe two setup procedures for positioning the table saw blade.
9. A hollow ground blade is generally set _____ higher above the material than a flat blade.
10. Name two methods of controlling part length when cutting duplicate parts on a table saw.
11. On a table saw, the _____ is tilted for beveling.
12. When is resawing on the table saw a one-pass operation?
13. What radial arm saw adjustment does the elevation crank perform?
    a. raise or lower the blade
    b. position the blade for a miter cut
    c. position the blade for ripping in the in-rip mode
    d. position the blade for beveling
14. Describe the procedure for crosscutting a 4′ by 8′ (1220 mm by 2440 mm) sheet of plywood on the radial arm saw.
15. The _____ _____ controls the curve radius that can be cut on a band saw or scroll saw.
16. To saw a component with sharp inside or outside curves that change direction, _____ _____ are necessary.
17. What adjustment is made when the band saw blade travels to one side of the wheels?
18. Describe how a scroll saw can cut interior holes and cutouts.
19. What characteristics would you look for to select the following circular blades?
    a. rip
    b. crosscut
    c. combination
    d. planer
    e. plywood
    f. triple-chip carbide-tipped
20. List three common shapes of band saw blades and the materials they cut.

This band saw is used to make irregular curves and arcs, and it can also rip, bevel, and resaw. *(Clausing Industries)*

22

Sawing with Hand and Portable Power Tools

Objectives

After studying this chapter, you will be able to:

- Select and use handsaws.
- Select and use portable power saws.
- Follow the maintenance requirements for hand and portable power saws.
- Sharpen handsaws.

Important Terms

backsaw
circular saw
combination saw
compass saw
coping saw
dovetail saw
keyhole saw
offset dovetail saw
reciprocal saw
saber saw

Stationary power saws are used by most cabinetmakers. However, there are a few situations when you will select a handsaw or portable power saw instead of a stationary machine. See **Figure 22-1.** For some cuts, stationary saw setup time may take too long. Other times, you may be installing on-site architectural base, trim, and other woodwork where stationary machines are not available. Refer to *Figure 12-45* for the sawing characteristics of various wood species.

Figure 22-1. Portable power tools, such as this saber saw, are often an excellent alternative to stationary power tools. *(Robert Bosch Power Tool Corp.)*

Handsaws

Handsaws described here fit in one of two groups: narrow or wide blade. Those with wide blades are designed to cut straight for short distances. These include: combination, backsaw, dovetail, and offset dovetail saws. Those with narrow blades are best for sawing curved workpieces. These include compass, keyhole, and coping saws.

Handsaws should be limited to cutting lumber and low-density manufactured wood products, such as plywood. Bonding resin contained in high-density fiberboard or particleboard dulls the blade quickly. Sawing these materials also takes much time and effort. Instead, use a portable power saw with a carbide blade.

Sawing straight lines

There are four saws typically used for sawing straight lines. These saws are the combination saw, backsaw, dovetail saw, and offset dovetail saw.

Combination saw

The ***combination saw*** rips on one edge and crosscuts on the other. See **Figure 22-2.** A unique feature of this saw of oriental origin is that it cuts on the pull stroke. Most saws cut on the push stroke. These saws are used to cut mortises, grooves in the mid-panel, and sliding dovetails. They are useful for working into restricted areas without damaging adjacent work.

Backsaw

A ***backsaw*** makes smooth and accurate straight cuts. See **Figure 22-3A.** The saw may be 10" to 30" (254 mm to 762 mm) long with 10 teeth per inch (TPI) to 15 TPI. Teeth per inch is also referred to as ***points per inch (PPI).*** There is a rigid rib on the back edge to keep the blade straight. Because of its accuracy, the backsaw is often used in miter boxes.

To use it, clamp workpieces horizontally and saw at a low angle, almost horizontal. A block of wood

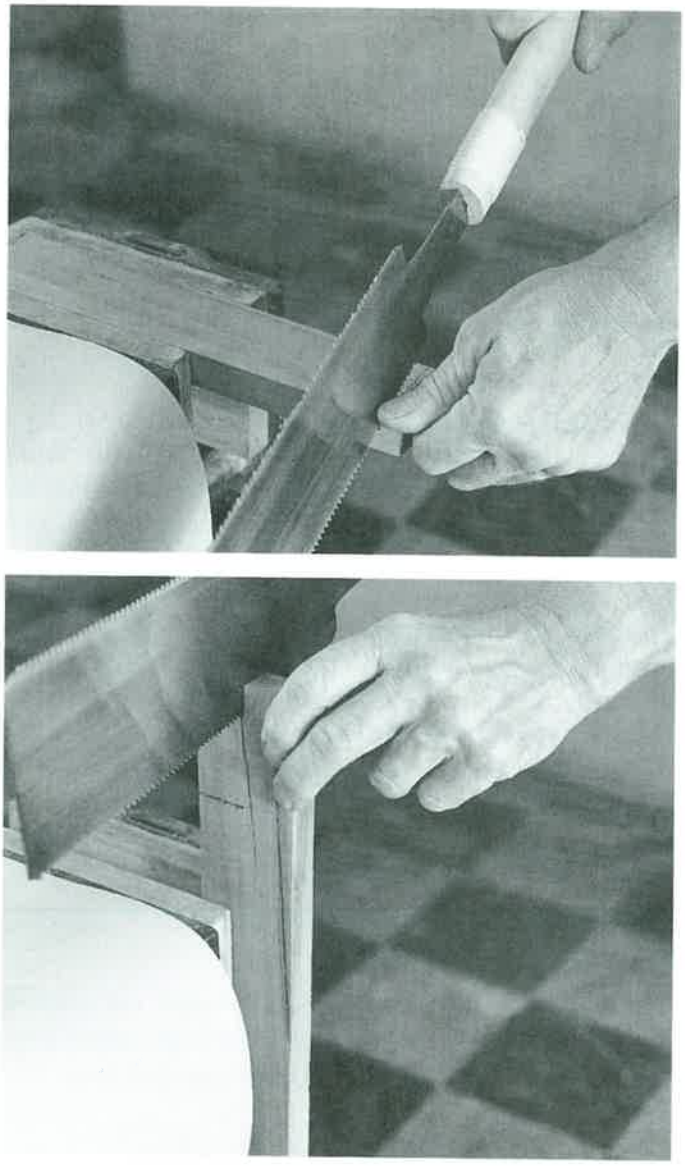


Figure 22-2. The pull-stroke combination saw can be used for both crosscutting and ripping.

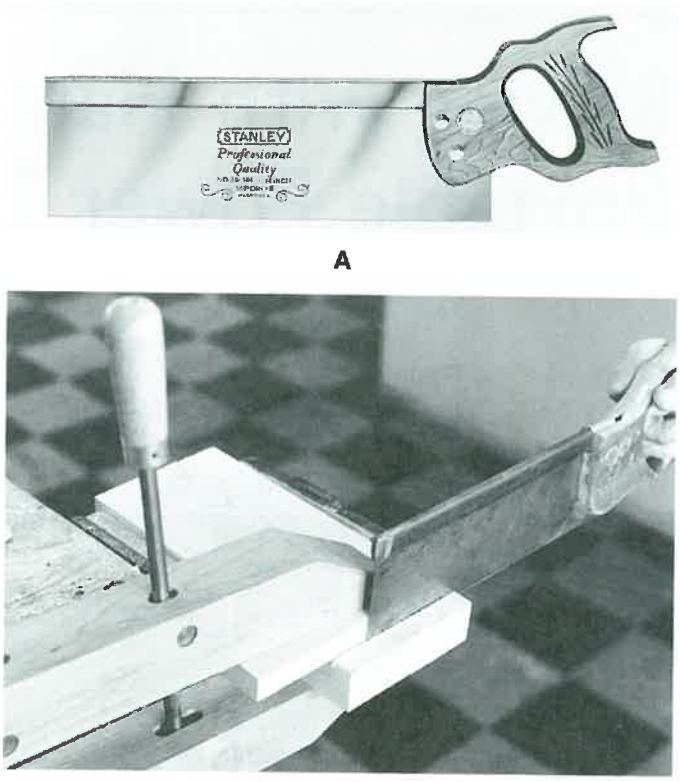
clamped parallel to the saw mark on the workpiece provides a guide. See **Figure 22-3B.** Keep the saw snug against the block to assure a straight cut.

Dovetail saw

The ***dovetail saw*** looks much like a narrow backsaw. See **Figure 22-4A.** Typically it is 10" (254 mm) long with 15 TPI to 21 TPI. The name comes from the dovetail joint, which the saw was originally made to cut. See **Figure 22-4B.**

Offset dovetail saw

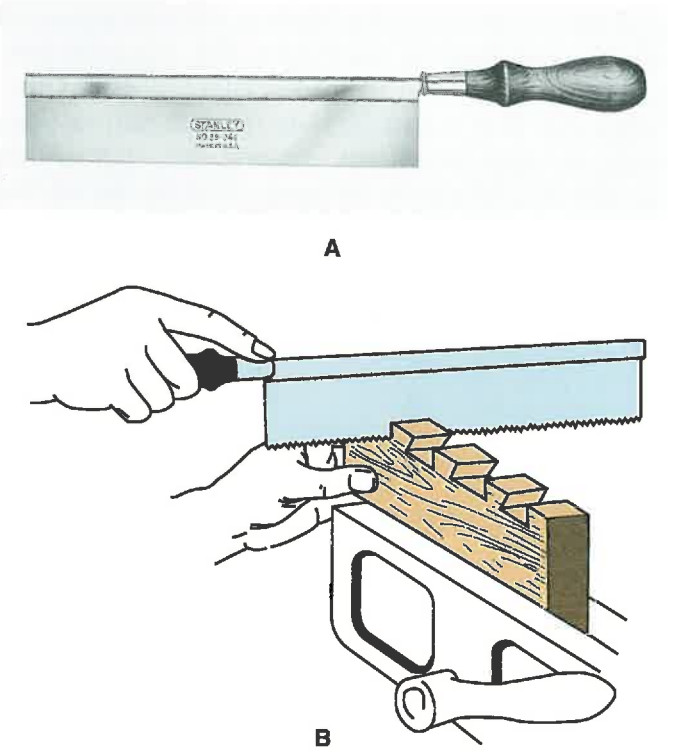
The ***offset dovetail saw*** is designed to cut flush with a surface. See **Figure 22-5.** The handle is offset from the saw blade. A reversible handle permits sawing flush on either the left or right side.



A

B

Figure 22-3. A—The backsaw has a rib that keeps the blade rigid. *(Stanley Tools)* B—A block of wood clamped to the workpiece can be used as a guide.



A

B

Figure 22-4. A—Dovetail saw. *(Stanley Tools)* B—The saw is named after the dovetail joint that it was designed to cut. *(Porter)*

Sawing curved lines

Handsaws for curved lines have narrower blades than those for cutting straight. This allows the blade to change direction as it cuts through the workpiece. The three saw styles used for sawing curved lines are the compass, keyhole, and coping saws.

Compass and keyhole saws

Compass and ***keyhole saws*** look very similar. They both cut curves. See **Figure 22-6A.** Most people consider compass and keyhole saws the same tool. However, the compass saw has 8 TPI or 10 TPI. The keyhole saw is finer, with 12 TPI or 14 TPI. Kerf edges will be smoother if a keyhole saw is used.

The blade is tapered. Long saw strokes allow you to cut larger curves. You can cut a smaller radius curve using the narrower end of the blade with short strokes. See **Figure 22-6B.** Some manufacturers produce nested saws. These have one handle and a number of different size blades.

Compass and keyhole saws will cut out interior holes and curves. See **Figure 22-6C.** Drill a hole in the area to be removed. Make the hole larger than the narrow end of the blade. Then insert the blade and saw the contour.

Coping saw

The ***coping saw*** is a versatile curve cutting tool. It consists of a handle, frame, and removable blade. See **Figure 22-7A.** Blades may vary from 5 TPI to 32 TPI. A slotted pawl at each end of the frame holds the blade. Frame throat depth, the distance from the blade to the frame, is either 4 5/8" or 6" (117 mm or 152 mm). It determines how far you can saw into the workpiece.

To install a blade, loosen the threads on the handle. Fit the blade with the teeth pointed toward the handle and retighten.

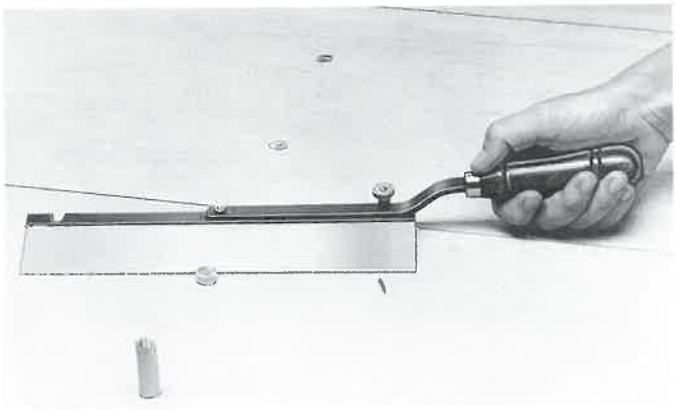
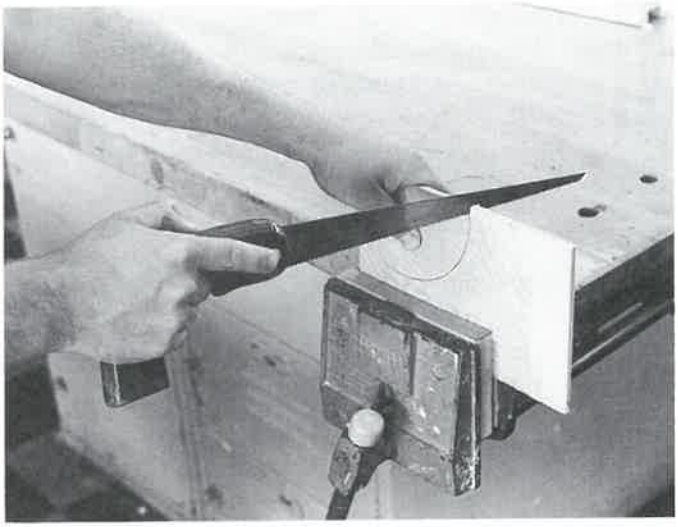


Figure 22-5. The offset dovetail saw can cut flush with the surface. *(Brookstone)*



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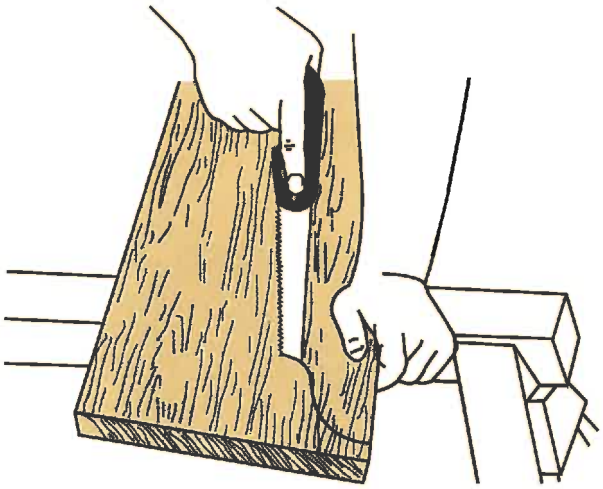

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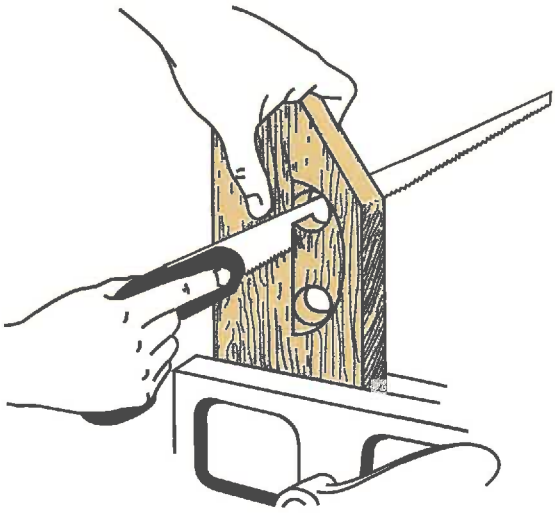
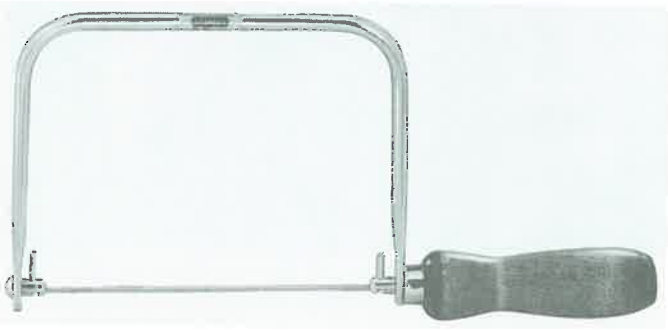


C

Figure 22-6. A—Compass and keyhole saws are used for large radius curves. B—The narrow end of the blade will cut a smaller radius curve. C—Holes must first be drilled before cutting internal curves. *(Porter)*

The pawls turn and allow the blade to cut in different directions. The saw can cut away from you, to the left or right, or back toward you. See **Figure 22-7B.** Coping saws cut on the pull stroke so that less pressure is applied to the blade. Otherwise, the blade is likely to break.



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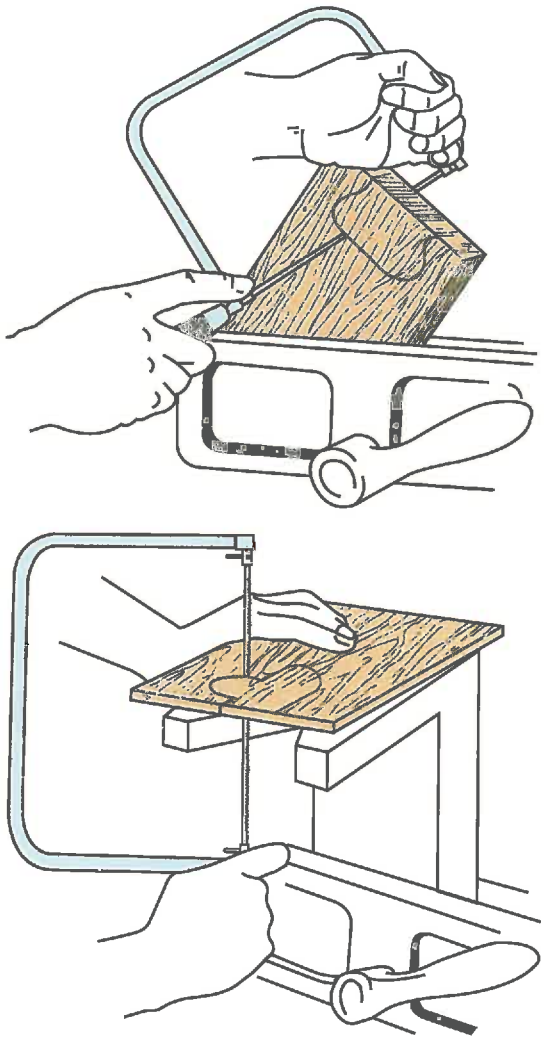


B

Figure 22-7. A—The coping saw has a narrow blade held by a frame. *(StanleyTools)* B—This saw is excellent for small radius curves and internal cutting. *(Porter)*

Coping saws are used for cutting copes at the end of material that is to meet a piece of irregular shape. The most common is coping the end of crown molding where it meets another at an inside corner. Coping is preferable to a mitered corner due to shrinkage that tends to open a mitered corner. When the coped corner is opened, the uncut end remains.

Coping saws are often used for cutting out small internal areas. Drill a small hole in the cutout space. Slip the blade through the hole and secure it in the frame. Then saw the contour.

Sawing by Hand

To saw accurately by hand, select the proper saw. Then, use the proper procedure for that particular saw.

Selecting handsaws

When selecting a handsaw, consider the workpiece you are making. Then, select a wide blade saw for straight cuts and a narrow blade saw for curved cuts. Also decide the teeth per inch needed. More teeth produce a smoother edge.

Another consideration is the thickness of the material you are cutting. Always try to have three or more teeth in contact with the material. For example, a 5 tooth per inch saw should not be used with ¼" (6 mm) wood. Only two teeth would touch the material at one time. This can cause chipping.

Sawing properly

Use reciprocal (back and forth) motion when sawing by hand. Move the saw in a straight line. Most handsaws are held at 90° to or parallel with the workpiece. However, the angle will vary with the saw used. For example, keep the rip saw at a 60° angle and a crosscut saw at a 45° angle. See **Figure 22-8.** Saw with a full stroke as much as possible. Your stroke may be limited on curved cuts. If the saw teeth are sharp, only slight pressure should be necessary.

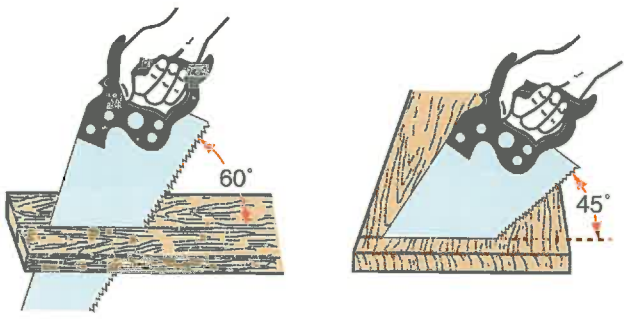
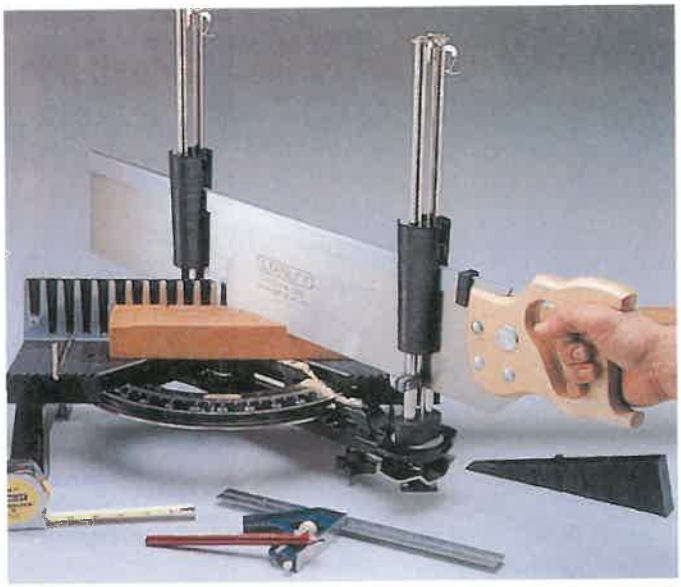


Figure 22-8. Ripping should be done at a 60° angle, while crosscutting is at a 45° angle.

The steps in sawing apply generally to most or all handsaw operations. To saw properly, proceed as follows:

1. Select the correct saw according to type of cut.
2. Align the blade beside your thumb at the saw mark. For precision cuts, clamp a straight board along the mark.
3. Start the kerf by pulling the blade on the return stroke across a corner.
4. Apply slight downward pressure to keep the blade from jumping out of the kerf.
5. Relax the pressure on the back stroke. No cutting is being done.
6. Use a guide if possible to maintain alignment. A miter box or jig could be helpful. See **Figure 22-9.**
7. Shorten the stroke and reduce pressure as you near the end of the cut. Also support the part being cut. This prevents the workpiece from falling or splintering.



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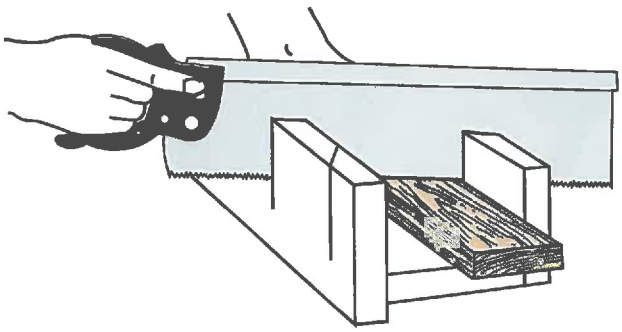


B

Figure 22-9. A—Miter box with blade guides and angle lock. *(Stanley Tools)* B—Homemade miter box. *(Porter)*

Portable Power Saws

Power tools are preferred over hand tools for sawing. They are lightweight and easily guided over the material. Like stationary power and handsaws, the blade shape determines whether the tool will cut straight or curved lines.

Plan your sawing sequence before starting to cut. Mark all cuts, including relief cuts when sawing curves. Plan how you will control the saw, workpiece, and the excess being removed. This can pose a problem with portable tools because you must hold the saw, workpiece, and excess. Decide how to support the material before and after it is cut.

Several options include:

- Use a sawhorse.
- Secure the material in a vise. Also consider using clamps.
- Saw over the edge of a bench.
- Raise the workpiece on scrap material so the blade clears the bench.

Sawing straight lines

There are two basic portable tools for sawing straight lines. They are the portable circular saw and power miter saw. A saber saw (reciprocal saw) will cut straight if placed against a straight edge using a blade with wide set teeth. These are more suited for curved sawing, but a skilled operator can saw straight enough for most purposes.

Circular saw

The ***circular saw*** is a versatile cutting tool. It can be set up for ripping, crosscutting, mitering, and beveling. It may even be used for cutting joints. The portable circular saw is not as accurate as stationary tools. However, it is excellent for cutting lumber and paneling to approximate size. A specific type of portable circular saw, a power miter saw, may be used to make accurate cuts. See **Figure 22-10.**

Circular saws are classified by the largest blade diameter that can be installed. Sizes range from 3¾" to 16" (95 mm to 406 mm) in diameter. Most portable saws use a 7¼" (184 mm) blade. See **Figure 22-11.** An important feature is the maximum thickness of material that can be sawed. This specification usually is listed for both 90° square cuts and 45° bevel cuts.

A wide range of blades is available, including rip, crosscut, combination, paneling, and others. The number and style of teeth determine what material the blade is suited to cut.

Another saw feature is a clutch that stops the blade under a number of conditions. These include dull teeth, inadequate set, resin buildup, high

moisture content in lumber, unsupported workpiece, and trying to turn the saw while cutting. These conditions all could result in the blade burning the wood or binding in the saw kerf.

Saw setup

There are two adjustments on the portable circular saw. One tilts the blade from 0° to 45°. The other moves the base to expose more or less of the blade. This allows you to set the recommended blade depth 1/8" (3 mm) greater than the material thickness, the safest depth setting. A blade set for a deeper cut can reduce loading and lets the saw work easier. However, when fewer teeth contact the workpiece, there is a greater chance of splintering.

Inspect the blade before you begin the operation. Be sure the correct blade is installed and it is sharp.

Figure 22-10. A portable power saw is a handy tool for rough-cutting lumber. *(Vermont American Tool Co.)*

Blade changing

To install a different blade, proceed as follows:

1. Turn the switch off and disconnect power to the saw.
2. Lay the saw on its side. (Notice the direction the teeth are pointing.)
3. Secure the blade so it cannot turn. Some saws have an arbor lock. This prevents the motor shaft from turning. For those with no lock, insert a block of softwood between the teeth and base. You might also clamp a C-clamp or handscrew to the blade.
4. Remove the retaining screw or nut. It will have right- or left-hand threads.
5. Swing the retractable guard around from beneath the saw base.
6. Slide the blade out through the slot in the base.
7. Wipe chips from the arbor where the replacement blade will sit.
8. Install the replacement blade. The teeth should point upward toward the front. Make sure the blade seats properly and the arbor hole matches the arbor. See **Figure 22-12.** Instructions are printed on some blades for matching the blade hole.

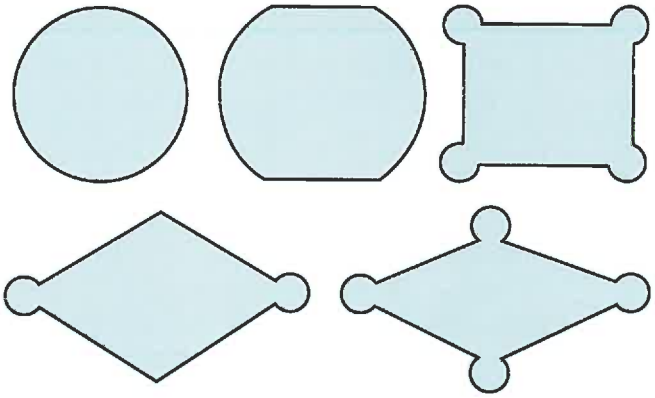


Figure 22-12. Saw manufacturers often use exclusive arbor shapes.

A B C

Figure 22-11. Three circular saws. A—3 3/8" (88 mm) battery powered model. B—7 ¼" (184 mm) is most common. *(Makita U.S.A., Inc.)* C—16 3/8" (416 mm) *(Makita U.S.A., Inc.)*

9. Replace and tighten the retaining screw or nut. Secure the arbor or blade as you did when loosening the nut.
10. Allow the guard to swing back into position and reconnect electrical power.

Saw operation

Circular saws cut lumber, paneling, and manufactured composite products. The direction of the grain in lumber and plywood usually determines which blade you use. Carbide tipped blades work best when sawing composite material.

Circular saws cut in an upward direction. Splintering occurs on the top surface, especially when crosscutting. Mark the cutting line to be sawed on the poor side of your work. If cutting paneling or plywood, have the prefinished or decorative face down.

Once the material has been marked, select depth, and bevel angle as necessary. See **Figure 22-13.** Loosen and tighten the knob for each and position the blade. Most saws provide a scale showing approximate depth and angle.

When ready to saw, align the indent or mark on the saw base with the marked line on the workpiece. See **Figure 22-14.** The greatest amount of material should be under the base. If you are making a bevel cut, the 90° base mark cannot be used because the saw will not enter the material on the line. See **Figure 22-15.** Some manufacturers provide two marks: one marks alignment when making a square (90°) cut, and the other is used for 45° beveling.

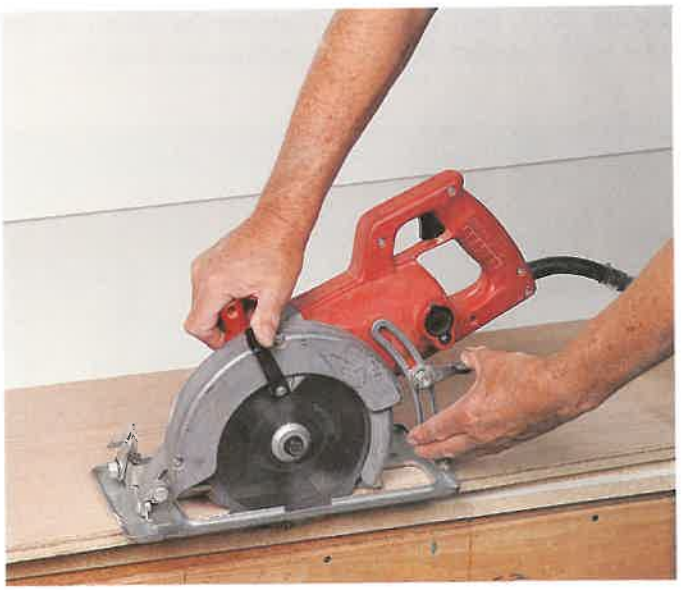


Figure 22-13. Set the blade 1/8" (3 mm) deeper than the material thickness. *(Chuck Davis Cabinets)*

Check the blade alignment before starting the saw. Most saws have a retractable guard. By moving the guard, you can see where the blade touches the material. Return the guard to its normal position before starting the saw.

Circular saws contain a trigger switch in the handle. Most have a knob or secondary handle to help guide the saw. Have a firm footing when using the tool. Keep the power cord clear of the material and away from your feet.

Back the saw ¼" (6 mm) away from the material and turn it on. Move the saw forward through the material, keeping it aligned with your mark. Support the excess as you reach the end of the workpiece cut. After completing the cut, wait until the blade stops before putting the saw down. Check to see that the

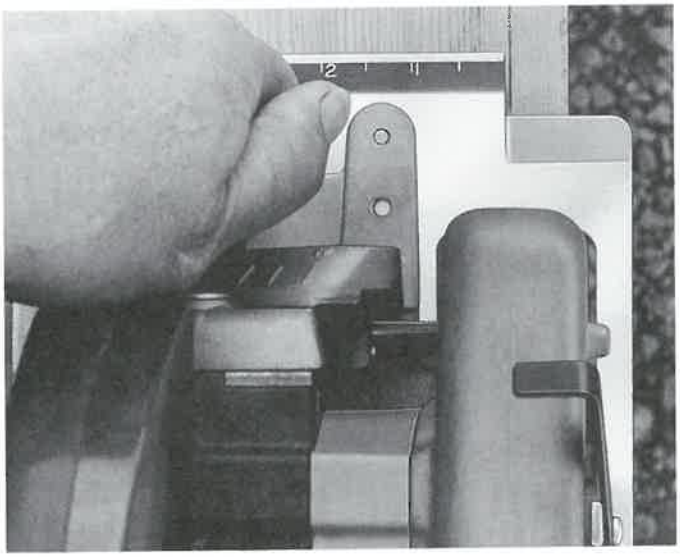
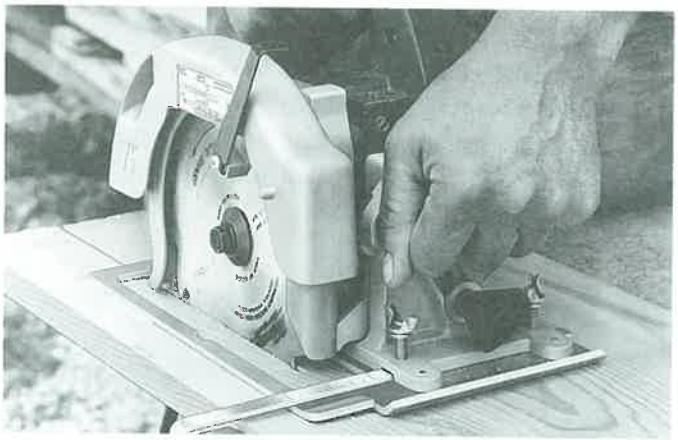


Figure 22-14. Align the saw notch with the line marked on the material. *(Milwaukee Electric Tool Corp.)*

Figure 22-15. It is difficult to align with a marked line when beveling. *(Chuck Davis Cabinets)*

guard has returned to its proper position. A splinter or loose knot could wedge the guard open.

Ripping lumber presents several problems for the operator. For a long workpiece, you must move along beside the saw. Using a rip fence or straight edge will help your accuracy. If no device is available, use the measurement marks on the saw base. See **Figure 22-16.**



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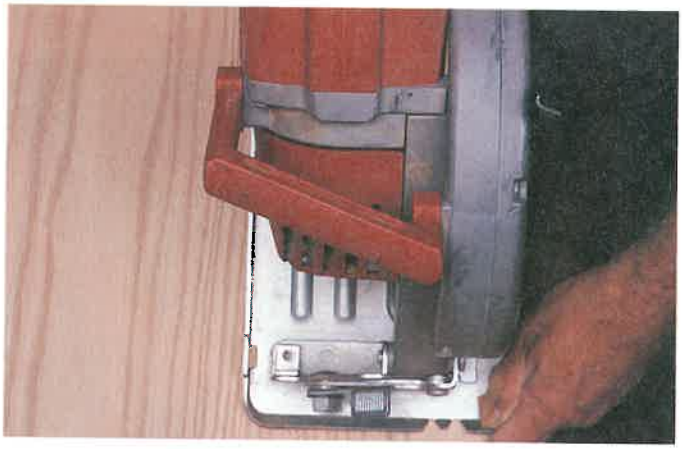


C

Figure 22-16. Three methods of guiding a circular saw. A—Using a saw guide. *(Milwaukee Electric Tool Corp.)* B—Clamping a straight edge. *(Chuck Davis Cabinets)* C—Guiding with your fingers. *(Chuck Davis Cabinets)*

On long lengths of lumber, the saw kerf may tend to close. This can cause the saw blade to bind. To prevent this, use one or more kerf spreaders. See **Figure 22-17.** They work much like the splitter on a table saw. You might use wooden wedges or screwdrivers as kerf spreaders.

Angled (miter) cuts may either be sawed free hand, or with an accessory. The one shown in **Figure 22-18** aligns and guides the saw.

Plunge cuts

Plunge cuts are made to cut slots or pockets in the material. The saw blade touches the surface first. See **Figure 22-19.** The procedure is as follows:

1. Preset the saw blade at **90°** and at the proper depth.

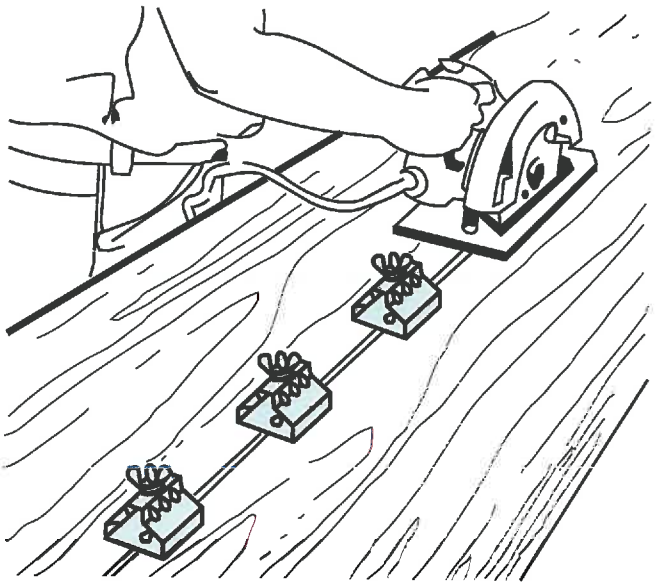


Figure 22-17. Kerf spreaders decrease the chance of the saw blade binding in the kerf. *(Adjustable Clamp Co.)*

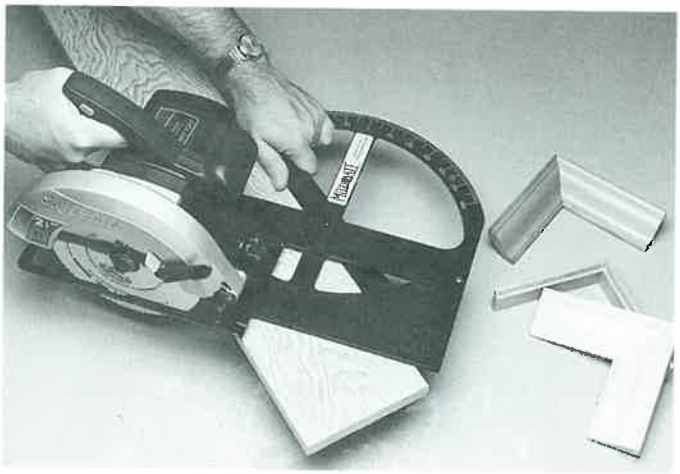


Figure 22-18. This circular saw accessory allows you to cut angles. *(Matrix Enterprises)*

Figure 22-19. Plunge cutting with a circular saw. *(Chuck Davis Cabinets)*

2. Place the front edge of the saw base on the material over the section to be removed. The saw blade should enter at about the middle of the line to be cut.
3. Rotate the retractable guard away from the blade. This can be hazardous. Keep your fingers above the saw base and away from the blade.
4. Start the saw with the teeth slightly above the material.
5. Lower the saw slowly until the base is flat on the material.
6. Release the guard and complete one-half of the cut.
7. Release the trigger switch and allow the saw blade to come to a complete stop.
8. Lift the saw out of the kerf and turn the saw around.
9. Insert the blade and saw to the other end of the line.

Power miter saw

The ***power miter saw*** is a precision crosscutting tool. See **Figure 22-20.** It operates similar to portable and stationary circular saws. However, it has a limited capacity in width of cut and depth of travel. For example, the capacity of a saw at a 0° cutting angle may be 3″ (76 mm) high and 4″ (102 mm) wide. At a 45° angle, it might handle material only 3″ (76 mm) high and 3″ (76 mm) wide. See **Figure 22-21.**

The saw cuts in a downward direction. The operator is protected by a plastic shield. While sawing, keep hands 4″ (102 mm) away from the point of operation. Clamp short workpieces.

Figure 22-20. Power miter saw set to cut molding. *(Chuck Davis Cabinets)*

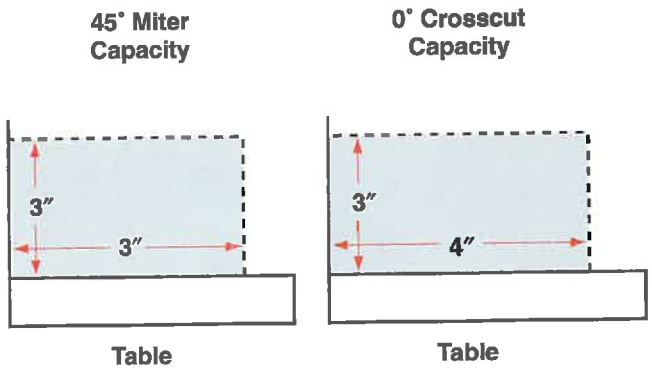


Figure 22-21. The compound miter saw provides the ability to bevel the cut. *(Ryobi America, Inc.)*

To operate the power miter saw, proceed as follows:

1. Be sure the material dimensions are within the saw's capacity.
2. Set the pivot handle to the desired angle.
3. Release the lock button if the saw is in a down position.
4. Place marked material on the saw table against the fence.
5. Align the cut by lowering the blade next to the cutting mark. Make sure the blade is on the excess side of the cutting mark.
6. Allow the blade to return to its normal position.
7. Hold the material against the fence with your left hand or a clamp.
8. Grip the saw handle firmly.
9. Turn on the saw. Allow the saw to reach full speed before cutting.
10. Push handle downward gently to make the cut.
11. When the cut is complete, release pressure. The saw will return to its normal position.
12. Release the trigger and allow the blade to stop completely. Some saws have an automatic brake that stops the blade quickly.
13. Remove the workpiece and excess.

Compound miter saw

Besides performing all the operations of a standard power miter saw, the ***compound miter saw*** is capable of beveling. See **Figure 22-22.**

Sliding compound miter saw

The ***sliding compound miter saw*** is a logical extension to the compound miter saw. See **Figure 22-23.** These saws may also be used to replace radial arm saws in small shops. In comparison to the radial arm saws, they are limited in width of cut and depth of travel. However, when compared to the power miter saw and compound miter saw, the capacity in width of cut is increased in some machines to about 12" (305 mm) with a reduction in depth to a maximum from 1¾" to 2 15/16" (44 mm to 75 mm). On a miter or bevel cut these dimensions are reduced.

Figure 22-22. The sliding compound miter saw provides greater crosscut capacity. *(Ryobi America, Inc.)*

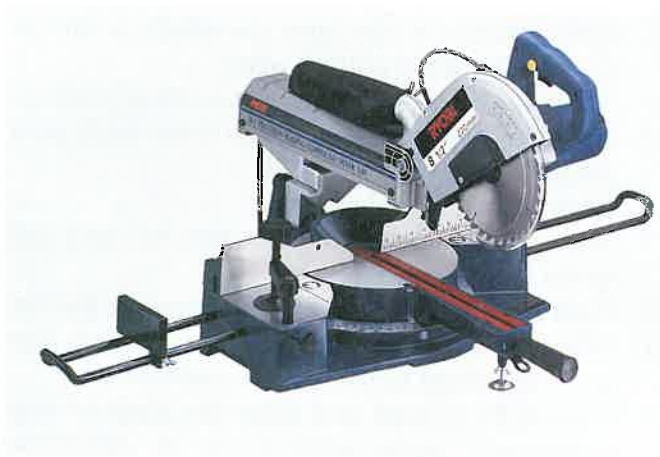


Figure 22-23. Most power miter saws have limited material capacity.

Some machines are designed to cut on the pull stroke using blades with a negative hook angle in the manner of a radial arm saw. Others are designed so that the carriage is to be extended fully, the blade pivoted into the stock, and then the carriage pushed through the material. The carriage is safely behind the fence at the completion of the cut.

Sawing curved lines

Two basic portable tools, the saber saw and reciprocal saw, are best suited for curved sawing, but a skilled operator can also make straight cuts using a straight edge.

Saber saw

The ***saber saw***, also called a bayonet saw, has many uses in the cabinetmaking shop. **Figure 22-24.** It can cut outside curves and internal holes. With the proper blade, you can cut wood, metal, ceramics, and plastics. With the proper jig, you can cut circles and arcs.

Saber saws offer many styles and features. Included are saws that:

- Are operated with one or two hands.
- Have single or variable speed.
- Saw in one or two directions.
- Cut only at 90° or bevel to 45°.
- Have blade shafts that may optionally operate in an orbital manner.

Saw setup

Know the capabilities of your saber saw. Be familiar with its settings and the type of blade it

Figure 22-24. Saber saw. *(Chicago Pneumatic Tool Co.)*

requires. Change blades when sawing different materials or when the blade becomes dull. Most blades for cutting wood have 6 TPI to 12 TPI. See **Figure 22-25.** A 10 TPI blade is adequate for most sawing. Select a finer tooth blade for thin material. Remember, at least three teeth should always contact the material. Not all blades will fit in every saw chuck. Different tool manufacturers may have their own style blades and chucks.

To change a blade on some saber saws, proceed as follows:

1. Turn the switch off and disconnect power to the saber saw.
2. Loosen the set screw(s) in the side of the chuck and remove the blade.
3. Install the new blade with the teeth pointed forward.
4. Tighten the set screws.
5. Reconnect electricity.

Saw operation

Saber saws cut on the upward stroke. Have the better surface of the material facing downward. For sawing curved lines, you should make relief cuts in the excess along the curve. See **Figure 22-26.** Straight cuts can be made by guiding the saw base along a straight edge using a blade having considerable set in the teeth. Bevel cuts can be made by tilting the saw on its base. Circles are best cut with a guide and pivot. See **Figure 22-27.**

You can plunge cut with a saber saw. See **Figure 22-28.** However, you must be careful because the blade can be broken easily. The procedure for a plunge cut is as follows:

1. Make sure the base is at 90° angle.
2. Rest the saw on the front edge of the base.
3. Align the blade with the marked line. Make sure the blade is on the waste side of your workpiece.

Figure 22-25. Saber saw blades for wood and metal. *(Vermont American Tool Co.)*

Figure 22-26. When making a series of circular cuts with the saber saw, use a line to guide the cut. *(Bosch Power Tools)*

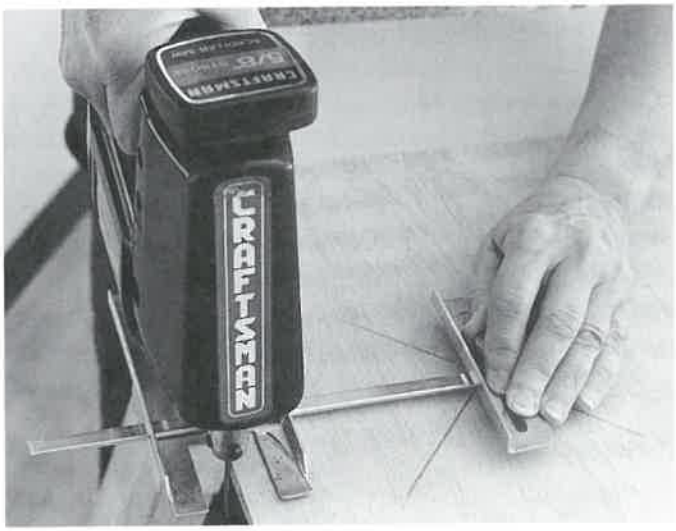


Figure 22-27. Saw accurate circles with a guide and pivot accessory.

Figure 22-28. Plunge cutting with a saber saw. The tip of the blade *must not bounce* on the material. *(Chuck Davis Cabinets)*

4. Tilt the blade to about a 60° to 80° angle, depending on blade length and length of saw base.
5. Hold the machine firmly against the material and start the saw.
6. Slowly pivot the blade downward into the material.
7. As contact is made and the blade begins its cut, move the saw in a slow forward motion until the blade cuts through.
8. After the blade cuts through the lower surface, place the base flat and go on with the cut.
9. When the cut is complete, turn off the saw.
10. Allow the blade to stop before removing it from the kerf.

Reciprocal saw

Rarely is the ***reciprocal saw*** used in cabinetmaking. It might come in handy for rough cutting when performing plumbing or electrical work in conjunction with installing cabinets. The saw resembles a heavy duty saber saw. See **Figure 22-29.** It typically has a wider and thicker blade, but can perform the same functions. There are one speed, two speed, and variable speed models. Saw dense materials at a slow speed and soft materials at a high speed.

The tool has a trigger, handle, and lock. A second handle is used for added control. The shoe rests on the material. It is comparable to the base on a saber saw. However, the shoe is always movable.

Saw setup

The only two setup steps for the reciprocal saw is shoe positioning and blade changing. Although the shoe is movable, it can be secured in two positions for different amounts of blade exposure. To change the blade, loosen the chuck set screw(s), replace the blade, and retighten the screw(s).

Figure 22-29. Reciprocal saw. *(Makita U.S.A., Inc.)*

Saw operation

Place the saw's shoe firmly against the material while cutting. Large radius, irregular, or curved cuts can be sawn without relief cuts.

There is one major difference between saber and reciprocating saw blades. On the saber saw, the teeth are in line with the shaft. On the reciprocating saw, the blade follows a different path. It is angled forward. This angle is called ***cant***. Cant allows the blade to be free of the saw kerf on the back stroke. The teeth do not rub the material, thus the blade stays sharp longer.

Maintaining Hand and Portable Power Saws

Little maintenance is needed for most hand and portable power saws. Handsaws should be kept free of rust by rubbing the blade with steel wool. A coat of wax or silicone will protect the blade from moisture and reduce friction while sawing. Inspect the handle screws periodically to see that they are tight.

Portable saws may or may not need lubrication. Some saws have *sealed* bearings and self-lubricating mechanical parts. These should not need lubrication for the life of the saw. Those that do, will have a maintenance label. Generally, you need to put heavy grease in worm gear drive mechanisms. There will be a removable plate or screw on the saw housing. Apply silicone lubricant to adjusting knobs, screws, and movable parts outside the motor and drive.

Keep all saws clean and free from moisture or resin buildup. Periodically check all power cords for deterioration and damage. Replace any defective parts.

Maintaining saw blades

Saw blades should have adequate set and be sharp to the touch. Keep them free of rust and resin. Inspect blades frequently for cracks (especially in the gullets), warpage, bluish color from overheating, and missing or damaged teeth.

Proper maintenance may include cleaning, sharpening, or discarding the blade. Clean resin from the blade with paint thinner or oven cleaner. Wear rubber gloves when working with hazardous materials. Remove rust with oil and fine steel wool. Then wipe away the oil and coat the blade with paste wax or silicone spray.

Blade sharpening is a time consuming and therefore costly process. You should decide whether to have the blades machine-sharpened accurately or do it by hand. This is the only method for sharpening a carbide tip blade. Many manufacturers of carbide tip blades provide sharpening service; your blade returns as good as new.

Summary

Hand and portable power saws are used when a stationary power saw is not appropriate or unavailable. Handsaws are best suited for cutting lumber and low density manufactured wood products. Power saws equipped with carbide tipped blades will cut through most any material.

Handsaws used in cabinetmaking for straight cutting include backsaws and dovetail saws for accurate cuts and jointmaking.

Portable power saws for cutting straight lines include the circular saw and power miter saw. These are used on construction sites for cutting, framing, lumber, and paneling. The power miter saw cuts trim and base. In cabinetmaking, you can saw standard stock and paneling to approximate sizes. Some jointwork can even be done with the power miter saw. It is accurate, but has limitations on the size of material it can cut.

Portable power saws for cutting curved lines include the saber saw and reciprocal saw. These two are somewhat similar. They both use a straight, flat blade and cut with short reciprocating strokes. The saber saw is more accurate, because you can control it better. The reciprocal saw is harder to handle, but is excellent for rough cuts. Most saws need relatively little maintenance. The blade should be periodically checked and discarded, if necessary. Portable power saws may or may not need lubrication. Check the maintenance manual or look for lubrication instructions on the saw housing.

Test Your Knowledge

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

1. Why are wide blade saws more suited for straight line cutting than are narrow blade saws?
2. List the two methods for specifying the teeth on a saw blade.
3. Rip saws are designed to cut _____ the grain.
4. Crosscut saws are designed to cut _____ the grain.
5. Which two handsaws are often used for joint making?
6. Would a coping saw or keyhole saw be the more appropriate tool for cutting a small radius curve?
7. How many saw teeth should always be in contact with the workpiece?
8. Circular saws are classified by _____ size.
9. What two adjustments to a circular saw might you make when preparing to cut a bevel?
10. When using a circular saw, should the decorative face of the material be facing up or down?
11. List three methods of guiding a circular saw when ripping a large sheet of plywood.
12. Saber saw blades for cutting wood have _____ to _____ TPI.

Shown is the proper technique for cutting with a handsaw. *(Vermont American)*

Surfacing with the Jointer and Planer

23

Objectives

After studying this chapter, you will be able to:

- Read wood grain to prevent chipping workpieces while surfacing.
- Set up and operate the jointer.
- Set up and operate the planer.
- Explain the sequence of steps to square workpieces.
- Maintain the jointer and planer.
- Sharpen jointer and planer knives.

Important Terms

fence
gib
gib retainer screws
infeed roller
infeed table
jointer
jointer/planer
jointing
outfeed roller
outfeed table
planer
planing
surfacing
table roller
thickness scale

Lumber faces, edges, and end grain are surfaced to produce flat and smooth cabinet parts. A high quality surface is obtained through the proper setup, operation, and maintenance of surfacing machinery. Practicing these skills will reduce the time you spend smoothing the product with abrasives or scrapers. The surfacing characteristics of various wood species are found in *Chapter 12*. Refer to *Figure 12-45*.

Jointers and planers are the principle machines for surfacing. See **Figure 23-1.** Suppose you begin with rough-sawn stock. One face is surfaced with a jointer. The other face is surfaced with the planer.

Jointing, followed by planing, brings stock to an even thickness. The amount of surfacing needed depends on the lumber. Lumber bought as S2S (surfaced two sides) may not need additional surfacing. Rough and warped lumber obviously will require much work.

Surfacing usually corrects lumber warpage. However, to eliminate warp, extra stock must be removed. Removing a cup or bow reduces the board's thickness. Eliminating crook reduces the board's width. The degree of warp limits the finished dimensions of both thickness and width for any given length of board.

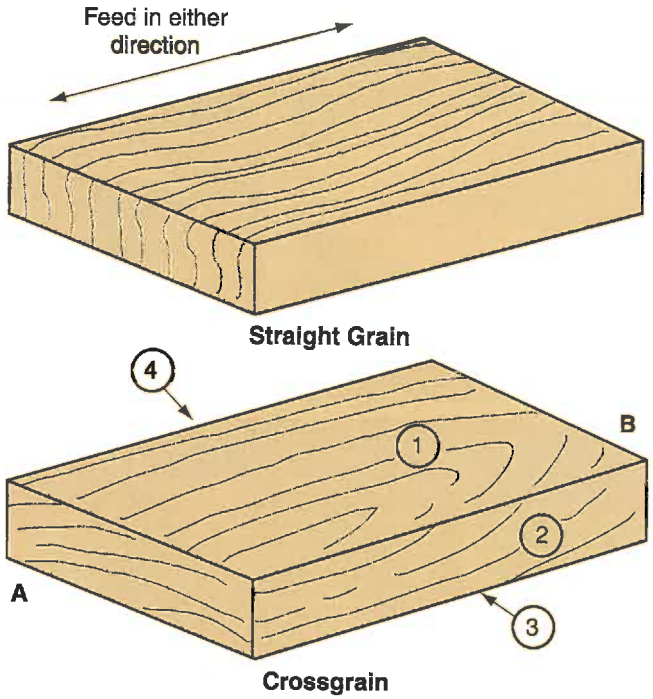
Figure 23-1. Surface lumber square on jointers and planers. *(Delta International Machinery Corp.)*

Reading Wood Grain

The results of surfacing can be disastrous unless you can *read the grain.* The grain pattern is the figure formed by cutting across the annual rings of a tree. This pattern will be different for flat-sawn, quarter-sawn, and other sawing procedures. These sawing processes produce lumber with either straight grain or crossgrain.

In lumber with straight grain, the lines formed by the annual rings run parallel to each other the full length of the board. In lumber with crossgrain, the grain angles or forms *V shapes*. Problems arise when surfacing crossgrain lumber. Feeding the wrong direction can result in the cutter chipping, tearing, or splitting the wood.

Proper feed directions are shown in **Figure 23-2.** Straight grain lumber can be fed in either direction, for faces and edges, on both the planer and jointer. Crossgrain lumber is fed so the cutter doesn't chip up the layers of wood growth. When surfacing faces, feed so the grain pattern *V shape* points away from the cutter. For edges, feed so the *V shape* points toward the jointer cutter.



Surface	Machine	End to Feed First
1	Jointer	A
2	Jointer	B
3	Planer	B
4	Saw/Jointer	B

Figure 23-2. Plane and joint surfaces so the grain doesn't tear.

Think Safety—Act Safely

Operating jointers, planers, and other power equipment for surfacing requires concentration and planning. Be attentive to your own actions. Plan your material handling steps thoroughly, both before and after processing the material. Always stay a reasonably safe distance from the point-of-operation. Other safety tips are:

- Wear eye protection.
- Remove jewelry and secure loose clothing.
- Have a solid footing.
- Use pushing devices for safer control of small workpieces.
- Know that 3" by 12" (76 mm by 305 mm) is the minimum dimension any workpiece should be for jointer, planer, or radial arm saw surfacing.
- Keep point-of-operation and other safety devices in place.
- Use fences on jointers and radial arm saws to guide your work.
- Know where to reach the STOP switch. In an emergency, you need it immediately without having to look for it.
- Stand slightly to the side of the workpiece being processed.
- Have someone help you handle long stock.
- Wait for the planer to coast to a complete stop before removing a wedged workpiece.
- Inspect your work regularly for defects indicating inaccurate machine adjustments.
- Maintain equipment properly for efficient surfacing.
- Control wood chips and shavings with an exhaust system.

Jointer

The ***jointer*** is a multipurpose tool for surfacing face, edge, and end grain. When squaring lumber, a face and edge are first jointed. The board is then cut to width and the edge jointed to remove saw marks. End grain may be surfaced after cutting workpieces to length.

Jointer components

The jointer consists of four major components, which are the cutterhead, infeed table, fence, and outfeed table. See **Figure 23-3.** Machine size is based on the maximum width of lumber that can be surfaced.

Cutterhead

The **cutterhead** has three or four knives that rotate at about 4000 ***revolutions per minute (rpm)*** to 5000 rpm. The length of the cutterhead, which varies from 4" to 12" (102 mm to 305 mm), limits the maximum width of lumber that can be surfaced. A movable cutterhead guard covers the point-of-operation.

Infeed table

Material is fed into the cutterhead by sliding it along the ***infeed table***. The depth of cut is set by raising or lowering the infeed table below the top of the cutterhead. This is done by loosening the infeed table lock and turning the infeed table adjusting handwheel. Look at the depth-of-cut scale for the amount of material to be removed. After setting the infeed table, retighten the table lock.

Fence

The *fence* guides the workpiece into the cutterhead. It can be angled to bevel edges. However, most often it is set square to joint at 90°. To tilt the fence, loosen the fence tilt lock and set the fence angle. You can also slide the fence across the cutterhead. This determines what portion of the cutterhead does the surfacing. Reposition the fence periodically when jointing narrow material. Slide and lock the fence over a different section of the cutterhead. This assures the entire knife width is used so dulling will occur more evenly and knives require sharpening less often. Loosen the fence lock knob, slide the fence, and retighten the knob.

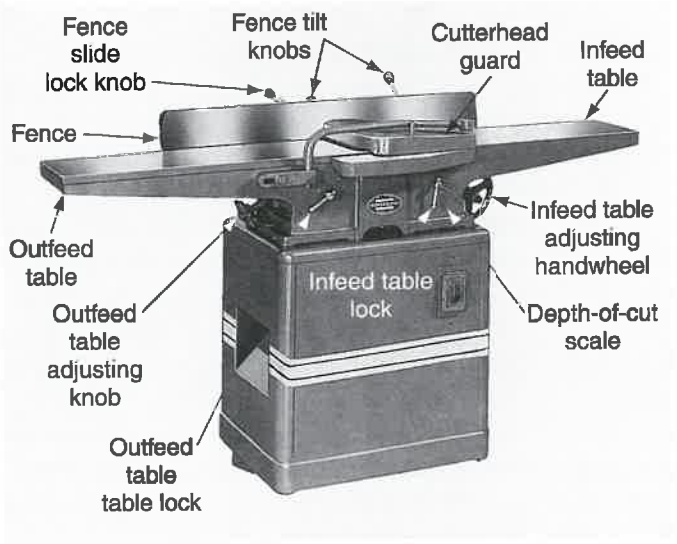


Figure 23-3. Components of a jointer. *(Powermatic)*

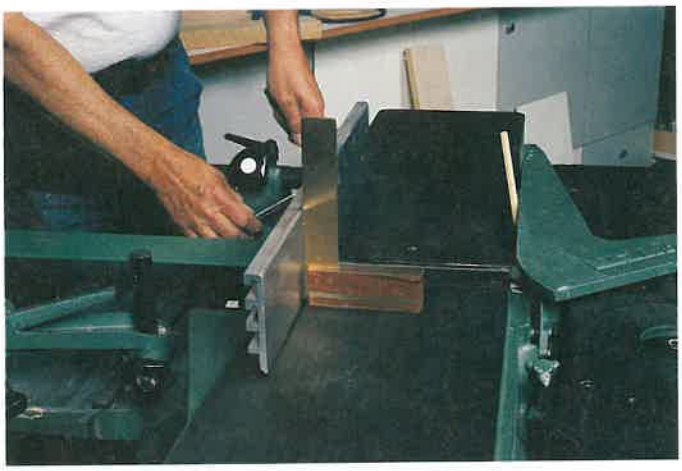
Outfeed table

The *outfeed table* supports the workpiece after it passes the cutterhead. The outfeed table should be set at exactly the same height as the cutterhead knives. Adjust the table by loosening the outfeed table lock and turning the table adjusting knob.

Preparing for jointer surfacing

There are several important decisions to make before operating a jointer. First, check the setup. Then decide how to feed the lumber.

Set the fence position perpendicular to the infeed table for a 90° (square) corner. Use a try or combination square to set the fence. See **Figure 23-4A.** For beveling, use a sliding T-bevel to set the fence angle. Some jointers have a fence tilt scale. See **Figure 23-4B.**



A

B

Figure 23-4. A—Set the jointer fence at 90° using a square. *(Chuck Davis Cabinets)* B—Some jointers have a fence tilt scale located at one end.

Set the depth of cut. Loosen the infeed table lock and turn the handwheel. The depth of cut may be 1/16" (2 mm) or less to remove saw marks. Set the depth according to the depth scale located under the infeed table. If there is no depth scale, look at the difference between the infeed and outfeed fence heights. (The outfeed table should be even with the cutterhead.) This is the actual depth of cut.

Select appropriate push boards or sticks. Have several different sizes and shapes available. Knobs or handles on the boards provide the safest control. See **Figure 23-5.**

Determine which faces or edges of the stock are to be jointed. Read the grain of the stock. Remember, you feed in different directions for edge and face jointing. Also inspect for warp. If the workpiece is warped, always place the concave (cupped) side against the infeed table. See **Figure 23-6.**

Figure 23-5. Use push sticks and push boards when jointing. Hold the board firmly against the table when face jointing. *(Delta International Machinery Corp.)*

Figure 23-6. The concave side of a cupped face should be placed down. *(Chuck Davis Cabinets)*

Check the workpiece length. It should be at least 12" (305 mm) long for jointing. Use a hand plane for shorter workpieces. The material should be at least 3" (76 mm) wide to hold it down with push boards when face-surfacing. Otherwise, use a push stick. The material should also be at least ½" (13 mm) thick. Thinner material could splinter.

Operating the jointer

Jointers are used first when squaring lumber. Normally, you will joint one face of a board, then one edge. Next, you surface the other face to final thickness with the planer. Then, you rip the board to width. You may wish to rip the board slightly oversize. Then return to the jointer and remove the saw marks. Once all faces and edges are flat and corners are square, cut one end square. Then cut the workpiece to length. You may cut the workpiece 1/16" (2 mm) over the length to allow for jointing end grain.

Jointing a face

To joint a face, proceed as follows:

1. Set the depth of cut at 1/16" (2 mm).
2. Set the fence to accommodate the workpiece width.
3. Be sure the guard will move freely when you push the lumber past the cutterhead.
4. Determine which direction to feed the workpiece. Refer to *Figure* 23-2.
5. Turn on the jointer.
6. Hold the front of the push board down with your left hand. Guide the workpiece forward with your right hand on the pusher handle. Press down lightly with both hands. When the pusher or workpiece reaches the cutter guard, it will push the guard aside. Keep both hands on the push board.
7. Feed the workpiece at a moderate rate. Rapid movement will tear or splinter the wood. If moved too slowly, burn marks will appear.
8. You may need to support the material beyond the outfeed table. Use a roller accessory at the outfeed table height, or have another person support the lumber.

If the workpiece is cupped, place that side down to prevent the material from rocking. Refer to *Figure 23-6*. If the material is cupped excessively, rip it in 3" (76 mm) strips, joint the faces and edges, then reglue it. Otherwise, you reduce the thickness of the stock too much when removing the cup.

Twisted stock will rock diagonally when placed on the infeed table. Hold the lumber with a push board. Keep the two rocking corners equal distance from the infeed table as you joint the workpiece. You may wish to hand plane the two high corners some before jointing.

Jointing an edge

To joint an edge, proceed as follows:

1. Set the depth of cut 1/16″ (2 mm).
2. Check to see that the fence is at a 90° angle to the table.
3. Set the fence to accommodate stock width.
4. Check that the guard will move freely when you push the workpiece past the cutterhead.
5. Determine direction to feed workpiece.
6. Turn on the jointer.
7. Hold down workpiece with your left hand. See **Figure 23-7.** Guide it forward with slight downward pressure of right hand. Use push sticks to keep hands over 4″ (102 mm) from the cutterhead.
8. Feed the workpiece at a moderate rate.

For a bow or crook, make sure you have just enough stock length needed for the cabinet part. Then, place the concave side against the infeed table. This prevents the material from rocking from end to end.

Jointing end grain

End grain may be surfaced on the jointer using a special procedure. Jointing the board's entire length will chip out the trailing edge. Again, the minimum length of cut should be 12″ (305 mm). Consider whether your table saw with its carbide blade will produce the quality of cut required. To joint end grain, proceed as follows:

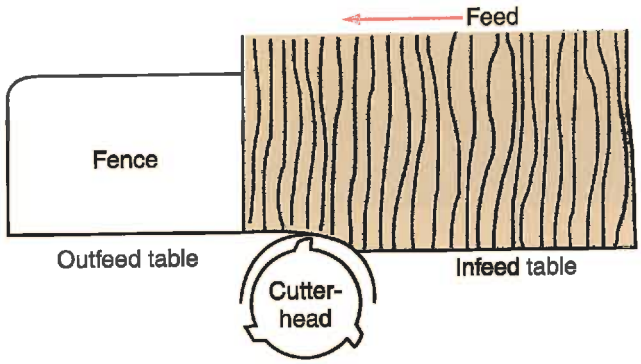
1. Set the depth of cut to 1/32″ (1 mm).
2. Hold the workpiece face against the fence.
3. Advance the end about 1″ (25 mm) into the cutterhead. See **Figure 23-8A.**
4. Lift and turn the workpiece around.
5. Joint the end. See **Figure 23-8B.** Apply pressure to the outfeed table as you near the 1″ (25 mm) portion you previously jointed.

Beveling

To bevel on the jointer, tilt the fence to the required angle. Then follow the edge-jointing procedure. See **Figure 23-9A.** For narrow strips, clamp a feather board to the fence or use push sticks. See **Figure 23-9B.**

It is more efficient to rip the bevel slightly oversize on the table saw. Then one or two thin cuts on the jointer will remove any saw marks.

Figure 23-7. Edge-jointing. Your left hand holds the workpiece against the fence. Your right hand does the feeding. *(Delta International Machinery Corp.)*

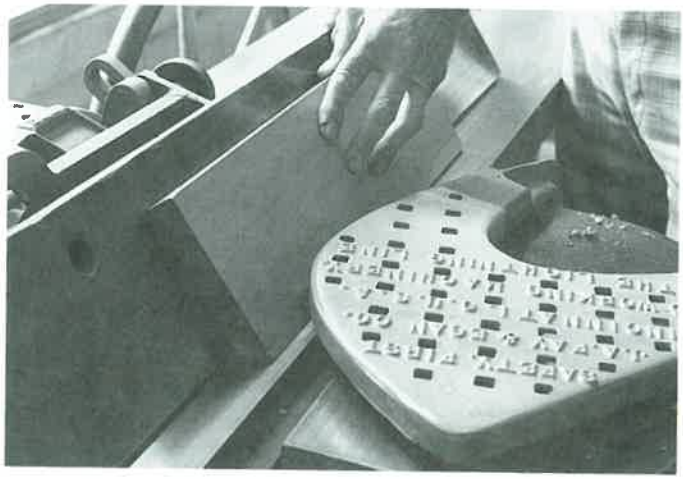


A

B

Figure 23-8. Jointing an end. A—Joint about 1″ (25 mm) of an end. B—Turn the workpiece around and finish surfacing. *(Chuck Davis Cabinets)*

A



B

Figure 23-9. A—Jointing a bevel. B—Use a feather board when jointing narrow materials. *(Chuck Davis Cabinets)*

Other jointer operations

Several other operations can be performed on the jointer. Cutting rabbet joints is one example. These are more specialized and are discussed in *Chapter 29.*

Planer

Surface the second face of a board so it is made parallel to the first side using a **planer**. See **Figure 23-10.** The planer may have a wider cutting head than does the jointer. Like the jointer, the cutting head determines the maximum workpiece width and the size of the machine. Planer sizes range from 10" to 48" (254 mm to 1219 mm).

A planer should *not* be used to surface both faces of stock without having removed any warp, because the planer table rollers press material against the table as it cuts. If there is a cup, bow, or twist in the lumber, it will be pressed down while surfacing. The warp will then spring back when material leaves the planer. This is why both jointer and planer are needed for proper squaring operations.

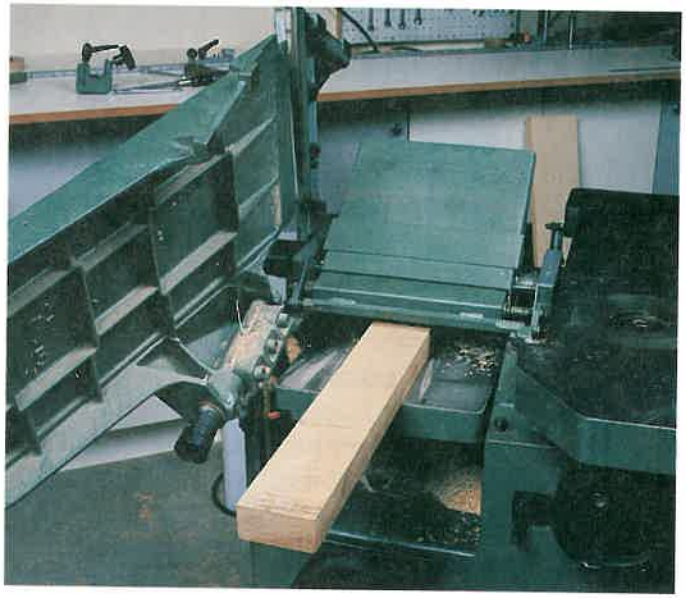


Figure 23-10. Planers surface material to thickness after jointing the first face. *(Chuck Davis Cabinets)*

Planer components

A planer is one of the larger, more automated woodworking machines. The interior components are shown in **Figure 23-11.** Lumber is fed into the planer between the ***infeed roller*** and a ***table roller.*** The infeed roller is corrugated to grab onto the wood and pull it into the cutterhead. The lumber then passes under the rotating cutterhead. The cutterhead knives remove wood from the upper surface. The ***chip breaker*** holds the workpiece down and reduces splintering. The ***pressure bar*** holds the workpiece against the table after the cut is made. The ***outfeed roller*** and ***second table roller*** grab stock to pull it out from under the cutterhead.

Some infeed rollers and chip breakers are in sections. This feature allows workpieces of different thicknesses to be surfaced side-by-side on the first pass. Without section rollers, stock must be fed one piece at a time until all pieces reach a uniform thickness. Then they can be fed side-by-side.

The exterior components of the planer are shown in **Figure 23-12.** The ***table adjusting handwheel*** raises and lowers the table. The approximate planed thickness of stock is shown on the ***thickness scale.*** A ***feed rate handwheel*** may be present on variable feed speed machines. An indicator tells the feed rate (feet per minute) of material being planed. There may be one or two switches. With two-switch planers, one controls the cutterhead motor, the other controls the motor for the feed rollers. The last adjustment is the ***table roller adjusting lever.*** It raises and lowers the table rollers. Not all planes have this feature.

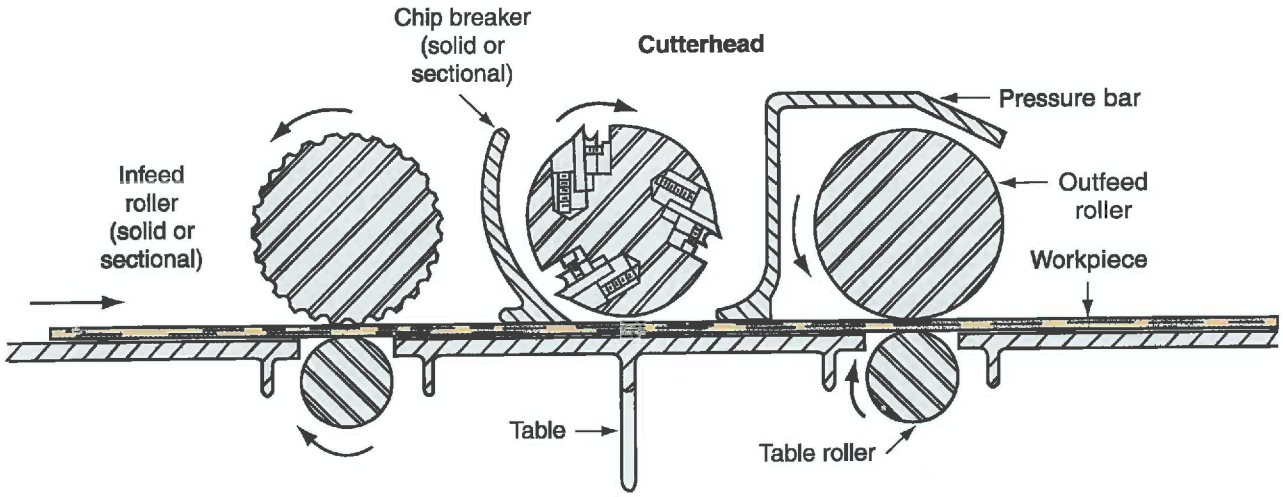


Figure 23-11. Internal components of a planer. *(Powermatic)*

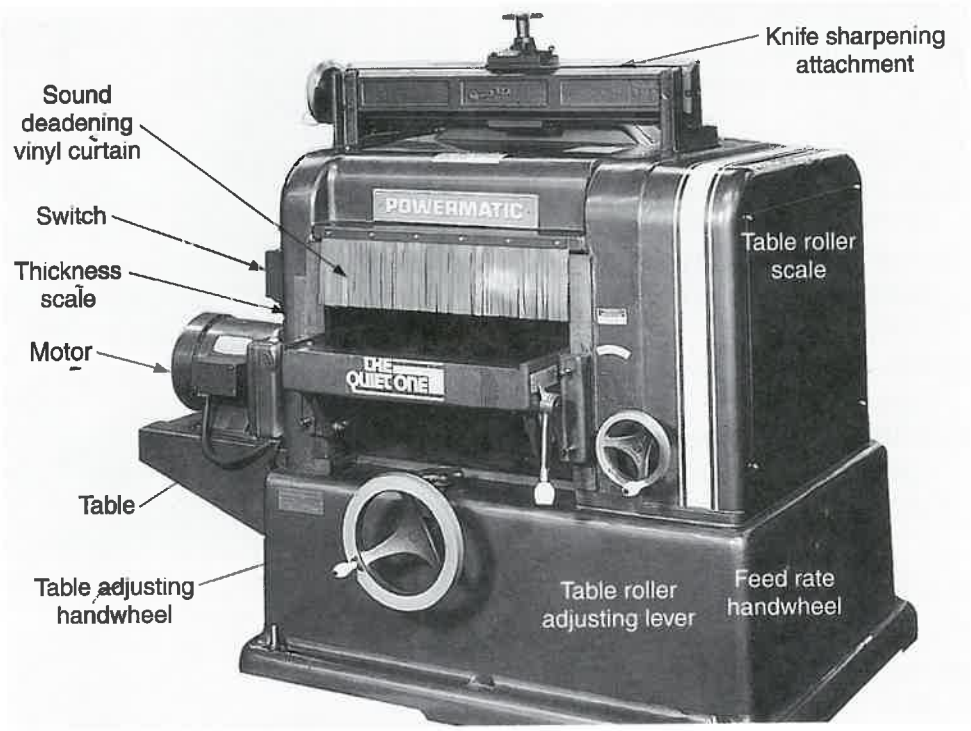


Figure 23-12. External features of a planer. *(Powermatic)*

Planer setup

Follow these steps to prepare the planer for surfacing:

1. Measure the lumber where it is thickest. One face should have already been jointed.
2. Turn the table adjusting handwheel to raise or lower the table. Watch the index mark on the scale. Set the table-to-cutter thickness 1/16" to 1/8" (2 mm to 3 mm) less than the lumber thickness.
3. Adjust the feed rate. If the feed rate is changed by a shift mechanism, the planer must be off. If it is changed by a variable speed handwheel, the planer must be turned on first.

The feed rate is chosen according to the width and density of the material. Slow the feed rate for hardwoods, such as oak. Increase the feed for soft woods, such as pine.

Planer operation

Planer operation is relatively simple. Follow these steps:

1. Inspect the surface to be planed. Loose knots or bark should first be removed.

2. Read the grain to determine which end of the stock will be fed first.
3. Start the machine and allow it to reach operating speed. Turn on the feed rollers if there is a separate switch.
4. Feed the lumber straight into the planer. The infeed roller will take hold and control the feed. If it does not, remove the stock and raise the table.
5. Support the lumber as it exits the planer.
6. Raise the table and repeat the above steps until the lumber reaches the final thickness. Do not use the planer's thickness gauge if the dimension must be accurate. For the final pass, measure each piece with a ruler or Vernier caliper for a more exact thickness.

If the stock binds during the pass, try pushing on the infeed end of the lumber. If this fails to feed the stock, move the table roller lever to a higher setting. Otherwise, turn off the planer, wait until the cutter stops, lower the table, and remove the workpiece.

Workpieces must be at least as long as the distance between the table rollers. Table rollers are generally 12" to 15" (305 mm to 381 mm) apart. Shorter workpieces can become wedged under the chip breaker or pressure bar. If wedging occurs for any reason, you should:

1. Step to the switch side of the infeed opening.
2. Turn off the planer.
3. Lower the table after the cutterhead stops.
4. Push the workpiece out with a push stick or other excess material. Never use your hand.

Planing glued stock

A wide board composed of several narrow workpieces glued together generally warps less than solid lumber. Each piece should have one face and both edges jointed. Glue them together with the jointed faces toward the clamps. Remove excess dry glue with a scraper. Then plane the entire panel to thickness. Use a feed rate slower than normal.

Planing thin stock

The minimum thickness for stock should be 3/8" (10 mm). However, you can plane thinner material using a backing board. It should be longer and wider than the workpiece, and at least ¾" (19 mm) thick. Set the planer cutting depth to 1/16" (2 mm) smaller than the combined workpiece and backing board thickness. Feed the workpiece and backing board into the planer together. See **Figure 23-13.**

Jointer/Planer

The planer and jointer are considered companion machines. They often are placed beside each other. To save space and reduce cost, a single tool, the ***jointer/planer*** is available. See **Figure 23-14.** These tools use the same base, cutterhead, and power supply. They convert from one usage to the other easily.

Radial Arm Saw Surfacing

The versatile ***radial arm saw*** has surfacing abilities if you have the proper accessories. They include a surfacing cutterhead and a guard. See **Figure 23-15.** With these attachments, you can surface one face. The other face must have already

Figure 23-13. Surfacing thin material requires a backing board. *(Chuck Davis Cabinets)*

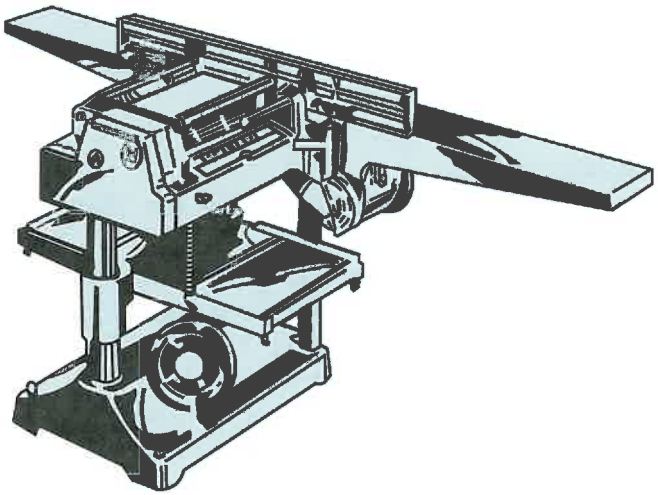


Figure 23-14. For surfacing operations in a small shop, the jointer/planer is a compact alternative.

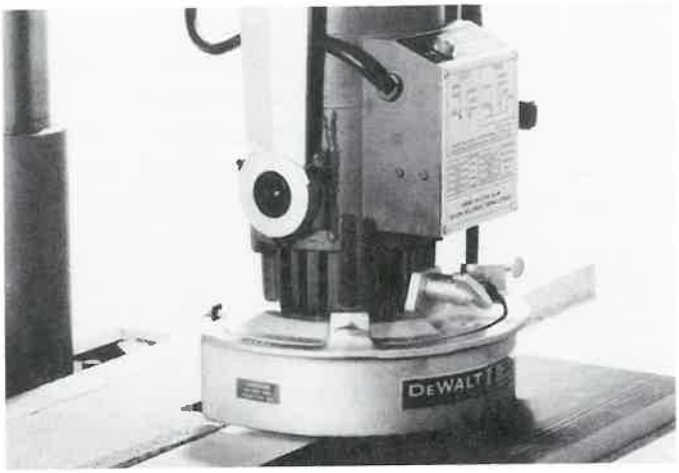


Figure 23-15. The radial arm saw can be converted to a surfacer with a cutter and guard. The arbor is placed down. *(DeWalt)*

been jointed so it can slide along the table easily. One edge must also have been jointed so it can slide along the fence.

Maintaining Surfacing Machines

Surfacing machines must be kept clean, properly adjusted, and lubricated. The cutter should be kept sharp. Machine maintenance and sharpening are critical to producing flat, unblemished surfaces.

Lubrication

Lubrication is necessary preventive maintenance. Moving machine parts have to be protected from excessive wear. The maintenance manual for a surfacing machine should list lubrication procedures. It will show a diagram of lubrication points as well as provide a time schedule. Generally, you should:

- Lubricate rotating shafts and enclosed gear housings. Putting oil on other mechanisms attracts dust, making adjustment difficult.
- Use paste wax, powdered graphite, talcum powder, or spray silicone for lubricating machine slides, adjusting screw threads, and similar mechanisms.

Partial disassembly may be necessary to locate some lubrication points. Look for grease fittings, oil holes, spring-top oil cups, and screw-type grease cups. Fill these, then make sure the tops are closed. Sealed bearings cannot be lubricated and must be replaced if worn.

Rust removal

Unpainted and unplated surfaces may rust over time, even when properly stored. Rust can cause excessive friction between the table and the workpiece. Use fine steel wool to remove the rust. Then apply paste wax or spray silicone to the metal. This will lessen friction without staining the wood. Establish a schedule of regular cleaning and waxing.

Resin buildup prevention

Wood resins can build up on machine surfaces and cause many problems. Known as ***buildup***, the resin that accumulates on threads, slides, and gears can interfere with adjustments. Buildup on the cutterhead, feed rollers, and table rollers can leave dents and grooves in the planed surface.

Remove resin with turpentine, paint thinner, or kerosene. You may have to disassemble parts of the planer to gain access to resin buildup areas. Apply a protective coating of paste wax or silicone to the cleaned parts.

Planer and Jointer Knives

There are many tool steels. The basic types are high-speed steel, high-chrome steel, tungsten carbide, and diamond.

High-speed steel (HSS) is the most frequently used knife for softwoods and hardwoods. Most tooling manufacturers offer more than one grade. HSS is easily ground with aluminum oxide grinding wheels.

High-chrome steel is recommended for hardwoods because it can take shock. It is effective for woods with high-moisture content. It is also easily ground with aluminum oxide wheels.

Tungsten carbide tooling is available brazed on (carbide-tipped), as inserts, and as two-piece knife systems. A two-piece knife consists of a thin piece of carbide and a thicker piece of corrugated tool steel used as a backer. Brazed carbide has a more coarse grain structure and is not capable of as sharp an edge. Carbide is recommended for particleboard, MDF, and hardwoods. Carbide tooling may also be profile ground using conventional grinders with diamond wheels.

Diamond tooling is bought already profiled. You lose versatility that is available with the HSS or tungsten carbide tooling.

Keeping Tools Sharp

Keeping tools sharp is a constant concern. Taking the time to sharpen machine knives and cutters increases surfacing quality and may reduce machining time.

Sharpening includes grinding and honing. *Grinding* is done to remove nicks and excessive wear from knives. *Honing* removes any burrs caused by the grinding and puts a slight bevel on the ground edge to increase tool life.

Sharpening is an involved process. When surfacing, prevent damage to cutting edges by checking for:

- Nails or other metal fasteners in the wood.
- Excess glue. Remove all surface glue.
- Any finishing materials. Some pigments are rock-hard and can dull a cutting edge quickly.
- Be aware that some woods with high silica content, teak for example, will dull cutting edges more rapidly. Plan for it.

Inspecting the machine

You can tell the sharpness of knives by both looking at them, and by listening to the machine. Restrain from touching knives, since even a dull edge can cut you.

Partial disassembly may be needed to look at the cutter knives. Observe the cutting edge in good light. If the tip has a rounded, shiny spot, the knife edge is dull. If the edge is nicked or uneven, it needs grinding. See **Figure 23-16.**

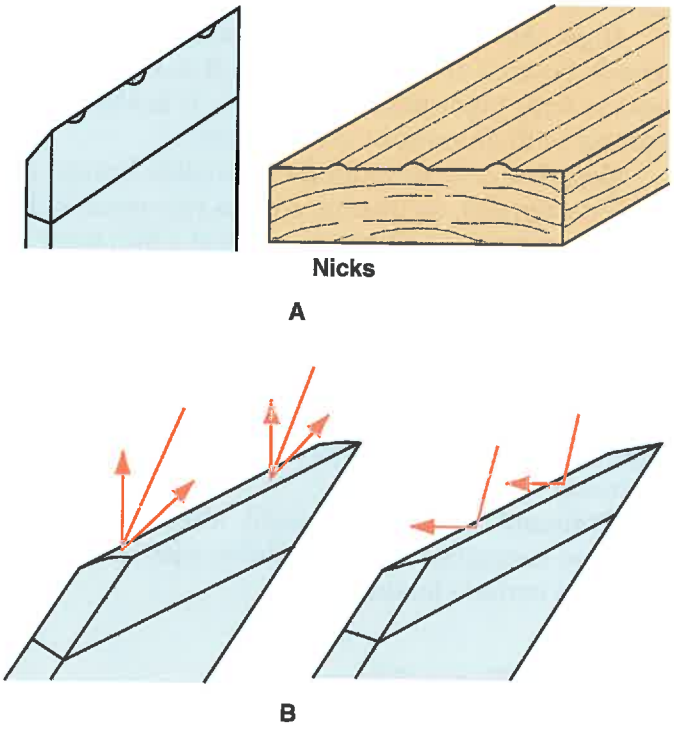


Figure 23-16. A—Nicks in a planer or jointer blade leave ridges on surfaced material. B—A sharp edge and a dull, rounded edge reflect light differently.

Also listen to the machine while it is operating. A low-pitch, low-volume sound usually indicates sharpness because the knives are removing material with ease. A high-pitch, high-volume sound, and vibration, can indicate dullness. The knives are forcing their way into the material.

Grind and/or hone?

After looking at the cutter, you must make a decision. Should you grind and hone or only hone the edge? Grinding is necessary if there are nicks in the edge or if the knife has been honed a number of times. Honing restores the slight bevel edge on the knife tip.

Grinding

Grinding restores a cutting edge that has been nicked or rounded by wear. The tool may be hand-held or secured in a fixture. In some cases the grinder is attached to the machine. Bench grinders may be adapted with special holding fixtures to secure the knife at the proper angle.

Carbide-tipped jointer and planer knives present a special problem because carbide is very hard. Grinding must be done under special conditions with a carbide grinding wheel and coolant. These cutters should be ground by a professional.

Excessive pressure during grinding can cause overheating. This can be seen if the knife begins to turn blue. The temper (hardening) is reduced, the knife becomes soft, and it dulls faster. The knife can still be used, but will need sharpening more frequently. When grinding by hand, dip the knife in water often.

Be very observant while grinding. Sparks that fly around the wheel indicate the edge is dull. The sparks created will fly over the cutting edge when it is sharp. See **Figure 23-17.**

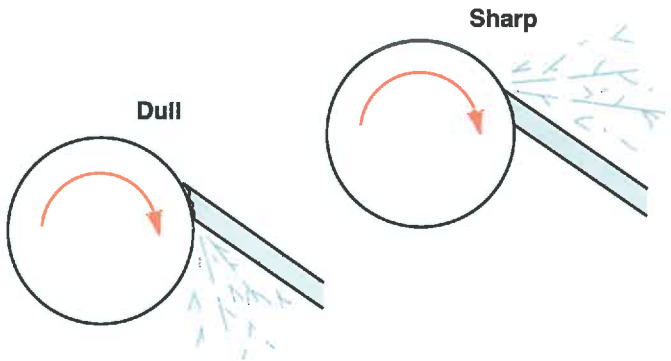


Figure 23-17. Sparks fly over the tool when it is ground sharp.

Honing

Honing restores the sharp bevel edge and removes grinding burrs. The edge is hand-rubbed at a 5° angle over a fine abrasive stone. Some grinders are equipped with very fine circular honing stones. Honing is done on both cutting edge surfaces. This bends any burrs back and forth until they break off. To check the sharpness, slide a piece of paper across the edge. The paper should slice readily. Any resistance indicates a burr remains on the edge. Do not touch the edge to check the sharpness.

Sharpening Jointer Knives

Sharpening jointer knives involves two procedures. First, each knife must be honed, or ground and honed. Then, the outfeed table must be adjusted to the knife height. Always clean off wood chips and resin before inspecting and sharpening the knives.

Knife honing

Hand-honing cutter knives is the easiest of sharpening methods. See **Figure 23-18.** This process is as follows:

1. Turn the switch off and disconnect the electrical power.
2. Move the guard aside or remove it.
3. Remove the fence.
4. Lower the infeed table to its greatest depth of cut.
5. Protect the infeed table with paper and masking tape.
6. Wedge a thin piece of hardboard or plastic laminate between the cutterhead and blade. See **Figure 23-18A.** This holds the cutterhead and further protects the table from damage.
9. Place the stone on the beveled edge of the knife. Rest it on the hardboard or laminate.
10. Slide the stone across each knife the same number of strokes. This should create a very small bevel on the tip of the blade.
11. Move the hardboard behind the knife. See **Figure 23-18B.** Slide the stone across the flat (unground) face of the knives.
12. Raise the table.
13. Replace the guard and fence.
14. Reconnect electrical power to the machine.

Jointer troubleshooting hints

Typical jointer operation problems are snipe, unwanted taper, washboarding, and knife burns on the surface. Clues to these problems come from workpiece inspection after making a cut. See **Figure 23-19.**

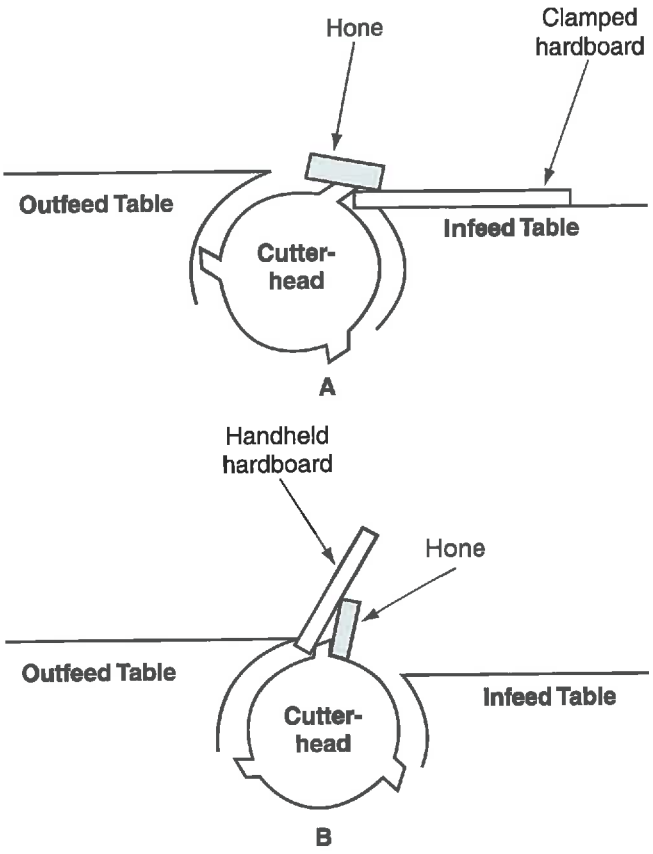


Figure 23-18. A—Honing the backs of the jointer knives. B—Honing the fronts of the jointer knives.

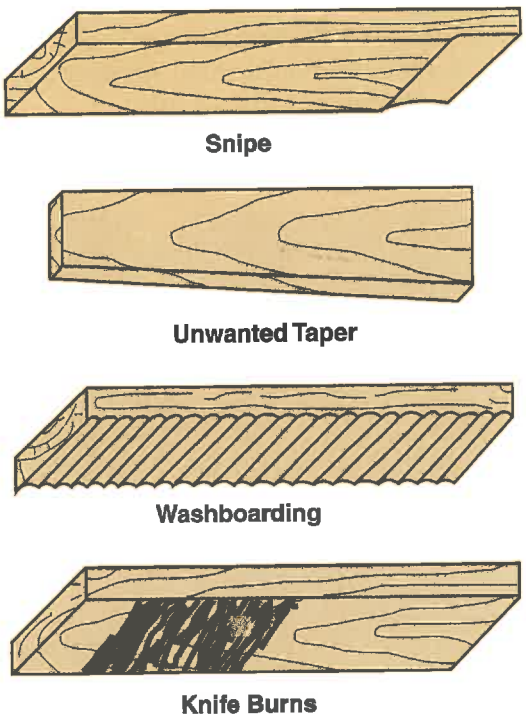


Figure 23-19. The typical jointer operation problems are snipe, unwanted taper, washboarding, and knife burns on the surface.

Causes of these problems and their solutions are as follows:

- ***Snipe.*** Outfeed table is lower than the arc of the knives. Raise the table until snipe disappears.
- ***Unwanted taper.*** Outfeed table is too high. Lower it until the knife is even with table surface.
- ***Washboarding.*** Workpiece pushes through the jointer too quickly (or jointer knives uneven).
- ***Knife burns on surface.*** Knives are dull or feed is too slow.

Knife grinding

Jointer knives may be ground while installed in or removed from the machine. An accessory is needed when grinding is done on the machine. It mounts on the outfeed table.

The attachment to grind knives on the machine is shown in **Figure 23-20.** The procedure is as follows:

1. Turn the switch off and disconnect power to the jointer.
2. Remove the guard and fence.
3. Mount the knife grinder.
4. Lock the cutterhead in the proper position using the indexer.
5. Hold a piece of paper between the knife edge and the grinding wheel.
6. Lower the grinding wheel to contact the paper, then remove the paper.
7. Move the grinder to one end of the slide.
8. Start the grinder.
9. Move the grinder from side to side. Lower it slightly each time until small sparks are created.
10. Grind each knife at this setting.
11. Lower the grinder and repeat Step 9.

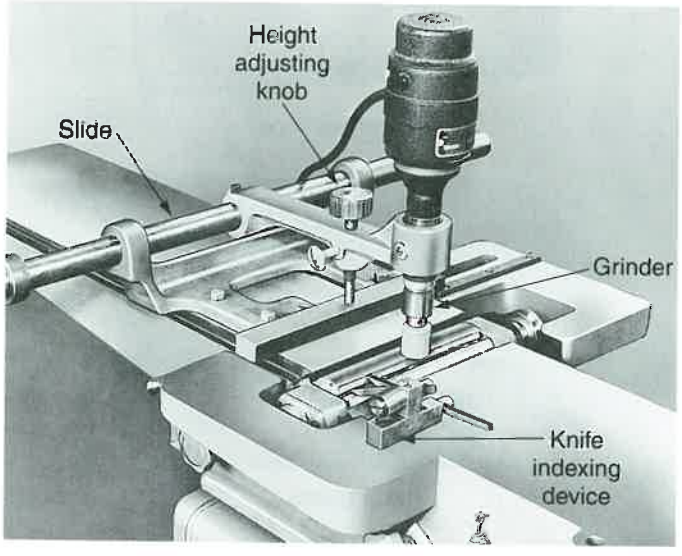


Figure 23-20. Attachment for grinding knives on the jointer. *(Delta International Machinery Corp.)*

12. Remove the grinding accessory and indexer.
13. Hone the knives if a thin, wiry edge remains.
14. Replace the fence and guard.
15. Reconnect electrical power to the jointer.

Removing jointer knives

If jointer knives need to be removed, there are special alignment problems when the knives are replaced. They must each extend an equal distance from the cutterhead. Otherwise, all edges will not contact the workpiece. This can cause ripple in the jointed surface.

The procedure to remove jointer knives is as follows:

1. Turn the switch off and disconnect electrical power to the jointer.
2. Remove the guard and fence.
3. Loosen all gib retainer screws 1/8 to ¼ turn. Consider using a fixture to hold the cutterhead and knife steady. See **Figure 23-21A.** Otherwise, place hardboard over the knife. Pull up and away from the cutting edge to loosen the screws. See **Figure 23-21B.** Use the proper wrench, start from one end, and proceed across the knife. Apply a penetrating solvent if the screws will not turn.
4. Loosen the screws until the gib can be lifted out.
5. Remove the jointer knife.

After removing knives, clean the gibs, gib screws, and cutterhead with mineral spirits or other solvent.

Knives should be ground on proper equipment by experienced technicians. A standard bench grinder and fixture should not be used. It is not accurate enough for the precision required of the jointer.

Professionals will also hone the knives for you after grinding them.

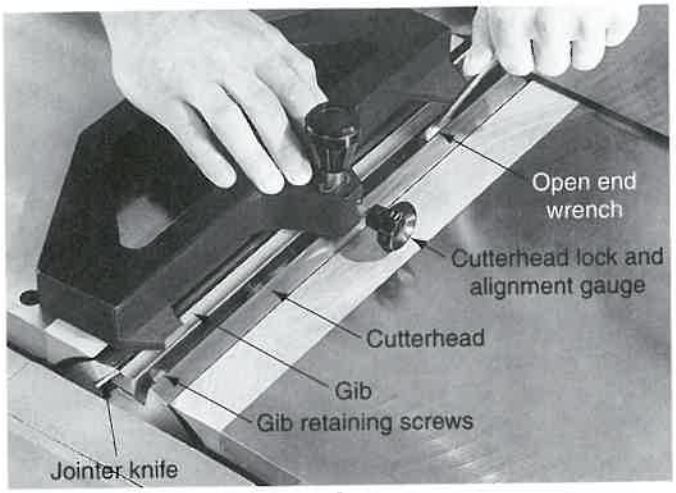
Installing jointer knives

Installing the sharpened knives requires accurate setting so all knives extend the same amount from the cutterhead. You may use:

- A gauge especially designed for setting knives. See **Figure 23-22A.**
- A magnet. The magnet should be perfectly flat. A horseshoe magnet is best. See **Figure 23-22B.**
- A straight edge. See **Figure 23-22C.**

The procedure for installing knives is as follows:

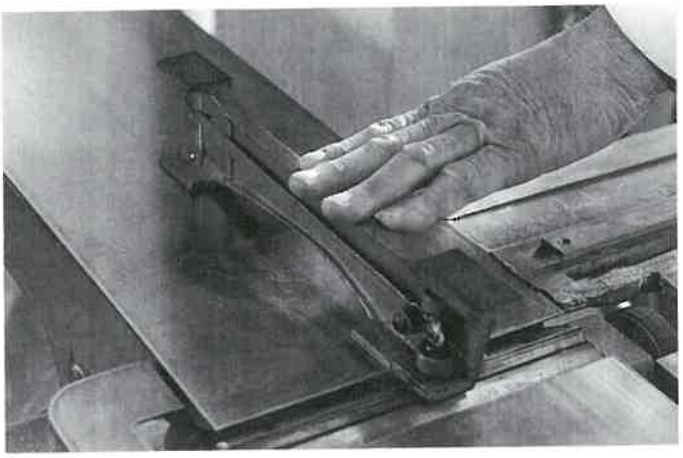
1. Check to see that the lifter adjusting screws turn easily. There are two or three lifters in the bottom of each knife slot. Both the gib and knife sit on the lifters.
2. Place the knife in the slot properly with the gib against it.
3. Align the ends of the knives.



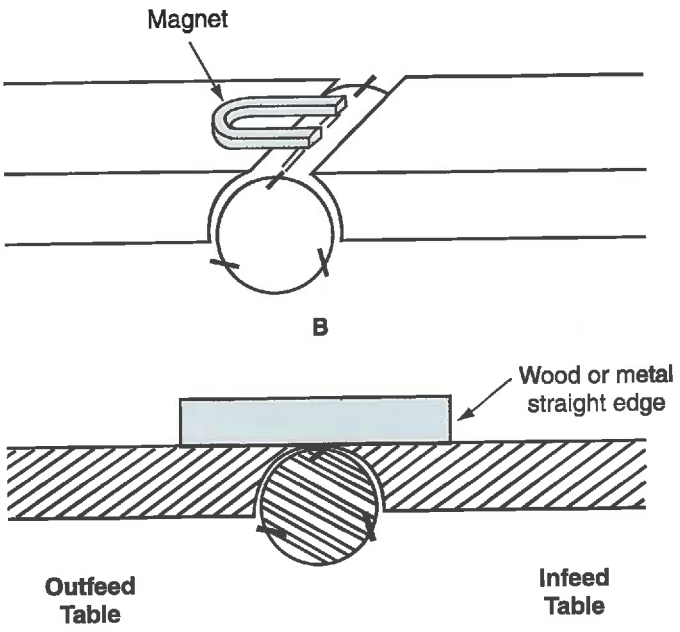
A

B

Figure 23-21. A—Loosen the gib retaining screws to remove knives. A fixture holds the cutterhead in place. *(Delta International Machinery Corp.)* B—Without a fixture, use hardboard to protect your hands.



A



B C

Figure 23-22. Setting the height of jointer knives. A—Gauge. B—Magnet. C—Straight edge.

Note

Some jointers have a rabbeting arm for making rabbet joints. If your jointer is so equipped, you must align the knife ends precisely. They should each extend about .005" (0.13 mm) beyond the table's edge.

4. Tighten each gib screw for all knives with one to two pounds of torque.
5. Set the alignment device (gauge, magnet, or straight edge) near the ends of each knife.
6. Adjust the height of every knife by turning the lifter screws. Manufacturers provide specifications for the amount the knife protrudes from the cutterhead. Many recommend a maximum .125" (3 mm) from the knife edge to the cutterhead.
7. Recheck the knife height using the gauge, magnet, or straight edge.
8. Torque each retainer screw to about 40 ***foot-pounds (ft-lb)*** to 50 ft-lb or 54 ***Newton·meters (N·m)*** to 67 N·m.
9. Replace the fence and guard.
10. Reconnect electrical power to the jointer.
11. Stand aside and turn the machine on and off once. Listen for any unusual sounds.

After the jointer is reassembled, check the outfeed table adjustment. It should be perfectly even with the edge of the knives. If not, there will be a snipe (gouge) in the surface. Loosen the outfeed table lock. Change the outfeed table setting. Place a straight edge from the outfeed table over the knives. See **Figure 23-23.** When the table and knives align, tighten the table lock.

Checking for nonparallel infeed and outfeed tables

The last periodic adjustment concerns whether the infeed and outfeed table are parallel. Suppose you have made several passes with the jointer. When you check the workpiece, you find the jointer is cutting a taper. More material is being removed at one end than the other. To correct this problem, you should:

1. Set the infeed table to zero cut.
2. Place a long straight edge across both tables.
3. Look between the straight edge and the tables. See **Figure 23-24.** There should be no light passing between them.
4. If the tables are not parallel, adjust the outfeed table as instructed in the manufacturer's maintenance manual. For example, there may be an adjustable cam for this purpose. When there are no adjustments provided, place metal shims where the outfeed table and machine base castings join.

Figure 23-23. The outfeed table should be the same height as the tip of the jointer knives. *(Rockwell International)*

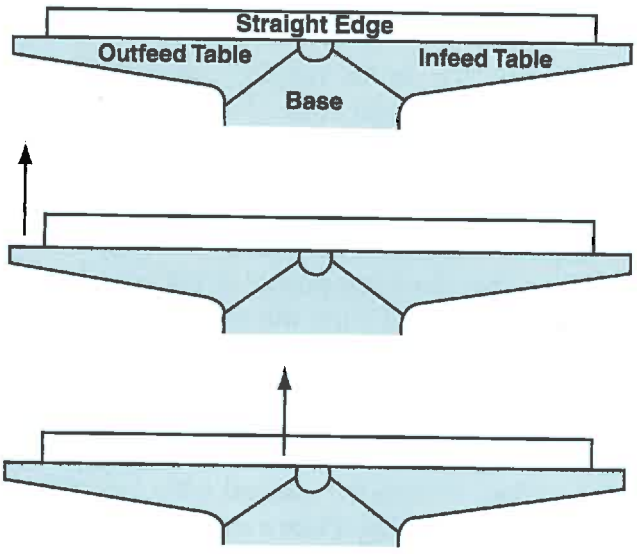


Figure 23-24. Inspect whether infeed and outfeed tables are parallel. Adjust the outfeed table as necessary.

Maintaining the Planer

Planer maintenance includes sharpening the planer knives and adjusting the tables, rollers, and other components of the machine. If the planer is not properly adjusted, serious defects in surfaced lumber will result. See **Figure 23-25.**

Sharpening planer knives

Planer knives can be jointed or ground. These processes can be done with the knives in the machine using special attachments.

Jointing planer knives

Jointing restores the cutting edge to planer knives. The jointing procedure may vary slightly among planers. Each machine manufacturer may have different sharpening attachment setup procedures. However, the procedure is basically the same. This procedure is as follows:

1. Turn the switch off and disconnect electrical power to the machine.
2. Remove the top cover.
3. Position the jointing attachment on the machine. See **Figure 23-26.** On some machines, this attachment is permanently mounted in the machine.

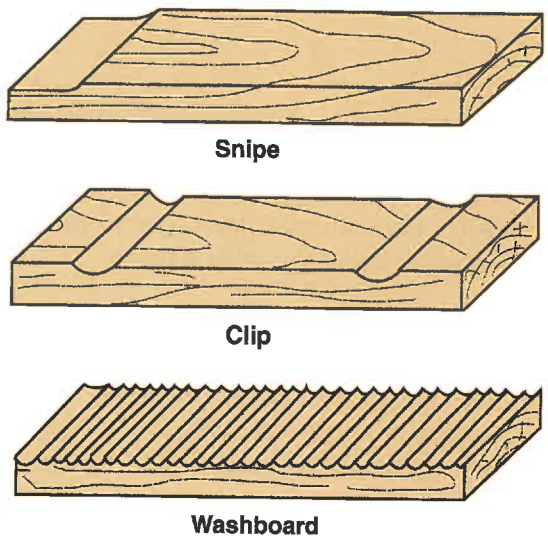


Figure 23-25. Snipe, clip, and washboard result from inaccurate planer settings.

4. Secure the jointing bracket in the attachment. The bracket holds the jointing stone.
5. Lower the stone. It should touch a high spot on the knife very lightly. This is likely to be at one end of the knife. This is where the cutting edges have been used the least.
6. Move the jointing assembly to the left or right on each knife. Raise the stone if it drags on any of the knives.
7. Position the jointing bracket to the side of the machine next to the handwheel.
8. Reconnect electrical power.
9. Stand to the side of the machine on the side of the jointing attachment handwheel. Be out of line with the table. Turn on the machine.
10. Turn the handwheel so the jointing stone traverses the full length of the knives. Light sparks will fly as the stone makes its pass. Sparks will not be seen where the knives are worn.
11. Lower the stone very slightly. *Stop when you see the first sparks.*
12. Turn the handwheel and move the stone back across the knives. Watch the sparks. If you see light sparks throughout the travel, then stop the machine.
13. Inspect the knives. You should see a secondary surface on the knife edge. This is called the ***land*** and it should be .01" (0.254 mm) or less in width.
14. Remove the jointing attachment and replace the top cover.

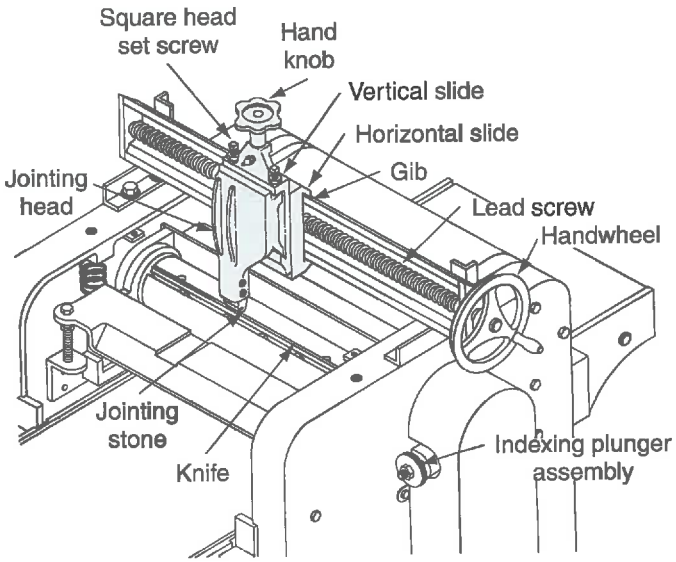


Figure 23-26. Jointing restores sharpness to dull planer knives. This attachment is bolted to the machine. *(Powermatic)*

Grinding planer knives

You may joint the knives several times before the bevel, or land, on the edge of the knife exceeds .016" (0.4 mm). Then grinding is necessary. Grinding may be done while knives are installed or after they are removed.

The method for grinding knives while they are installed in the machine is:

1. Turn the switch off and disconnect electrical power to the machine.
2. Remove the top cover.
3. Install the grinding assembly. See **Figure 23-27.**
4. Lock the cutterhead in position with the indexing plunger assembly. A knife must be directly under the grinding wheel.
5. Lower the grinding wheel until it touches the knife. Do this at the highest point on the knife's length. *Under no condition should the grinding wheel touch the cutterhead.*

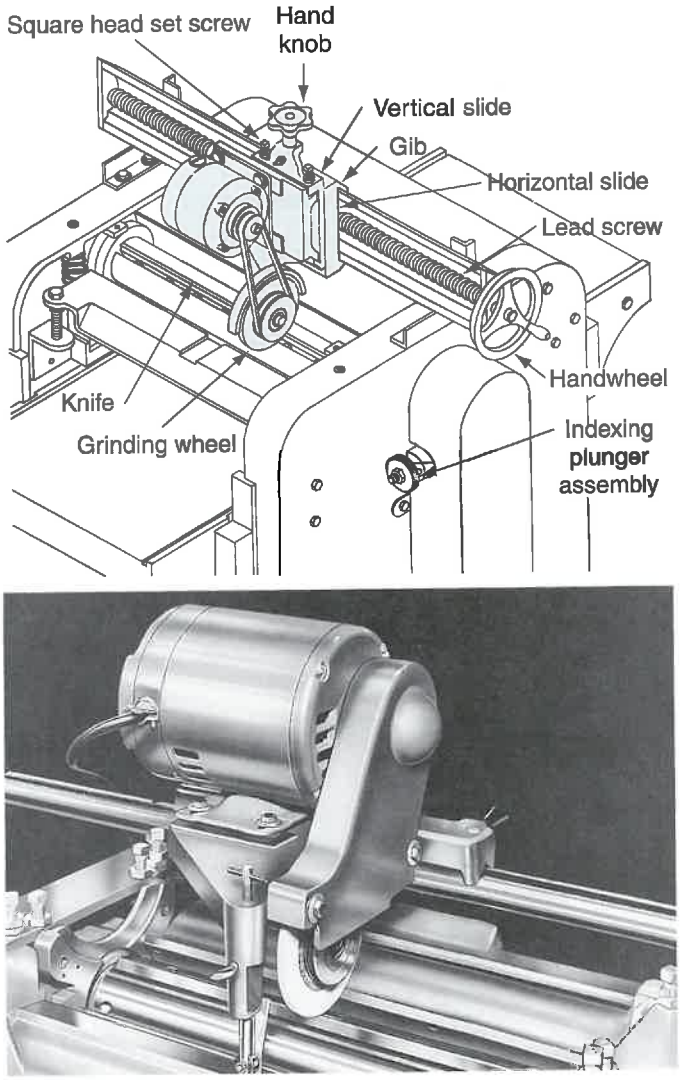


Figure 23-27. Grinding attachments. *(Powermatic, Rockwell International)*

7. Turn the grinding wheel by hand. It should produce a few very light scratches on the knife. These will show if the wheel is touching the knife properly.
8. Move the grinding wheel off the end of the knife by turning the handwheel.
9. Connect the grinder to electrical power.
10. Turn the handwheel while the grinder is operating. Traverse the entire length of the cutterhead. Do not let the grinding wheel sit at one spot on a knife.
11. Lower the grinding wheel slightly. Again, move the wheel the entire length of the knife. Do this until the knife edge is about .003" (0.08 mm) wide. This is approximately the thickness of a piece of paper. There is no need to remove all the surface. This results in a thin, wiry edge, which can easily break off.
12. Note the setting on the grinding wheel. Then raise it just more than the total distance you lowered it. (This is done so the wheel clears the next knife.) Unlock the indexing plunger and rotate the cutterhead so another knife is facing up. Relock it.
13. Continue to grind knives and rotate the cutterhead. Grind until you reach the depth noted on the first knife.
14. Remove the grinding attachment.
15. Secure the top cover.
16. Reconnect electrical power.

If you do not have a grinding attachment, remove the knives and have them ground by a technician. To remove the knives, you must:

1. Turn the switch off and disconnect electrical power and remove the planer's top cover.
2. Loosen the gib retaining screws. See **Figure 23-28.** They hold the gibs against the knives. Pull up and away from the cutting edge to prevent cutting yourself. Accumulated resins might make the screws difficult to loosen. Use mineral spirits or paint thinner to dissolve resin.
3. Lift the knives out by the ends.
4. Remove the gibs.

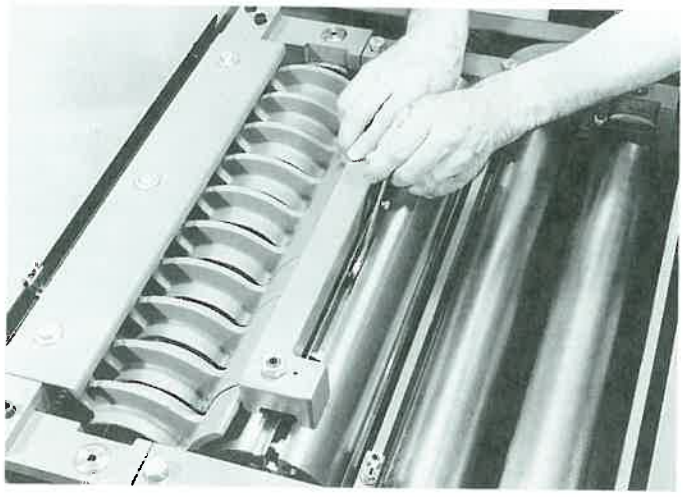


Figure 23-28. Loosen gib retaining screws to remove planer knives. *(Delta International Machinery Corp.)*

Once removed, the knives should be ground by a technician. Then the knives must be reinstalled and precisely adjusted. This process is:

1. Turn the lifter screws so the knife lifter sits at the bottom of the knife slot.
2. Place the knives and gibs in the cutterhead slots.
3. Tighten the end screws on each gib with about 1 ft-lb to 2 ft-lb (1.35 N·m to 2.70 N·m) of torque. This is snug enough so they will stay in place. Always tighten screws by pulling the wrench. Do not push it toward the cutting edge.
4. Adjust each knife with a template or dial indicator. See **Figure 23-29.** Place the template or indicator over the sharp edge. Turn the adjusting screws as necessary. Raise the knife by turning the adjusting screws clockwise. When lowering the knife, turn adjusting screws counterclockwise. Then tap on the knife with a piece of wood to lower it.
5. Tighten each gib screw with 30 ft-lb to 50 ft-lb (40 N·m to 67 N·m) of torque. This is about as tight as you can turn.
6. Inspect each knife setting when the gibs are secure. Use the template or dial indicator.

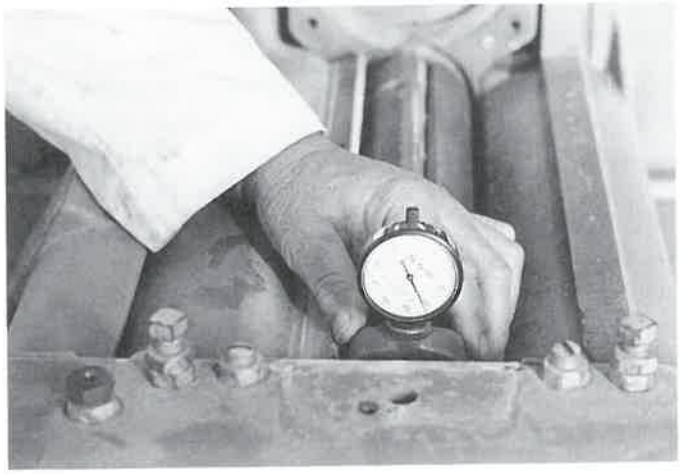
Some machines have very long knives that tend to warp. The center of the installed knife may be low or high. Check both ends and the center when the gib screws are lightly torqued. If the center is high, set the center lifter first. Moderately torque one or two of the center gib screws. Then turn the lifter adjusting screws on each end. This will raise the knife ends to the same setting as the center.

If the center is low, set both end adjusters first. Next torque several end gib screws. Then turn the center knife lifter screws to raise the center. Finally, fully torque all of the gibs.

Aligning the planer

Adjustments should be checked after the knives are sharpened. You need a dial indicator on a flat base. See **Figure 23-30.** Settings to be checked include:

- Planer table
- Infeed roller
- Chip breaker
- Outfeed roller
- Pressure bar
- Table rollers



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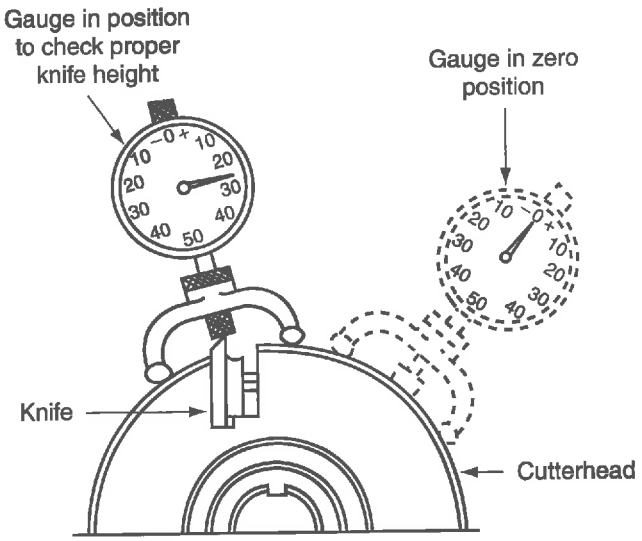

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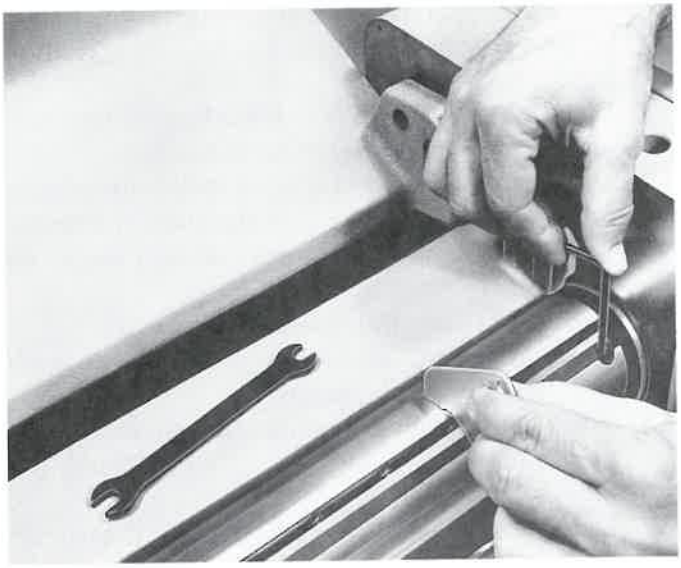


C

Figure 23-29. Setting planer knife height. A—A dial indicator is very accurate. B—The indicator should read zero over the cutterhead. *(Powermatic)* C—A template can also be used to set knife height. *(Rockwell International)*

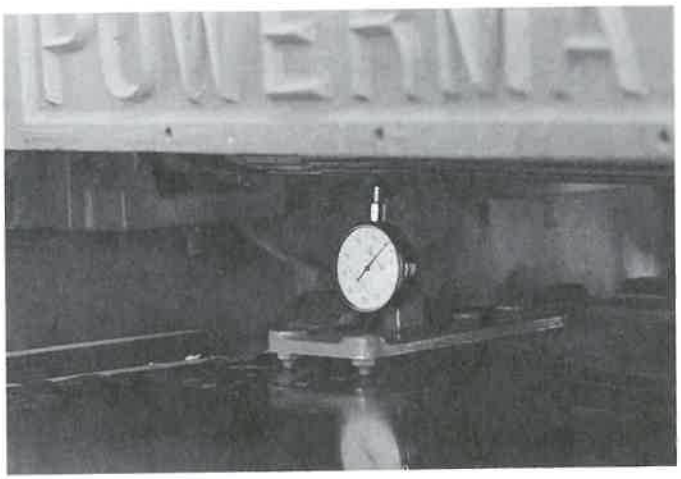


Figure 23-30. Table and all roller adjustments are made using a dial indicator on a flat base.

Table setting

The planer table is generally set first. The table-to-knife distance must be the same on the left and right sides. Rarely do you need to adjust the table. However, periodically check it as follows:

1. Place the dial indicator directly under the cutterhead. Set it to the left or right side of the table. The knife edge must be at its lowest point.
2. Raise the table until you get a reading.
3. Move the indicator to the other side. Compare the dial readings. They should be within .001" (0.025 mm) of each other.
4. If adjustments are necessary, look for an adjusting nut and set screw where the table raising screw and table meet. Loosen the set screw. Turn the adjusting nut to correct the difference. Retighten the set screw.

Infeed roller adjustment

The infeed roller may be solid or in sections. It is mounted on a spring that allows the roller to rise when lumber is fed into the machine. The roller must be set lower than the table-to-knife setting. On a solid roller, it should be 1/32" (0.8 mm) lower. On a sectional roller, it should be 1/16" (1.6 mm) lower.

Compare dial readings under the knife and under the roller. They should differ by .06" (1.6 mm) for solid rollers or .03" (0.76 mm) for sectional rollers.

Chip breaker adjustment

The chip breaker is also spring loaded like the infeed roller. You will find a set screw and locknut at each end of the breaker. Using a dial indicator, adjust these so the breaker is 1/32" (0.8 mm) below the knife edge. A chip breaker set too low will prevent

the workpiece from feeding. A high setting may allow wood to tear and split. The same setting is used for solid and sectional breakers. If you adjust the infeed roller, you must adjust the chip breaker.

Pressure bar adjustment

Many planer-caused defects are the result of an improperly set pressure bar. Its function is to hold material down after passing under the cutterhead. The bar should be in line with the arc of the cutterhead knives. If it is too high, a shallow clip will occur about 6" (152 mm) from each end of the board. Refer to *Figure 23-25.* If it is set too low, stock will not feed through.

To set the pressure bar, place a dial indicator on the table bed under the cutterhead. Adjust the table so the bottom arc of the cutter just touches the indicator. Then move the block under the pressure bar. Adjust the bar so it is .000" to .001" (0.025 mm) above the arc of the cutterhead. Fine adjustments may still have to be made after a test cut.

Outfeed roller adjustment

Behind the pressure bar is the outfeed roller. It is also spring loaded . Its setting is identical to the chip breaker adjustment. Set screws and lock nuts at the ends control the setting.

Table roller adjustment

Table rollers raise the workpiece off the planer table as it passes through the machine. This reduces friction so the infeed and outfeed rollers can move the stock easier. On most planers, table rollers are set .008" (0.2 mm) above the table with the table roller adjustment lever set at zero. (Some smaller planers do not have table roller adjustments.) Some dial indicators can be set up to check the roller adjustment. Preset the dial at "0" against the table. Then move the indicator over the roller. Set screws and locknuts hold the rollers at the proper setting.

Testing the planer

After all adjustments have been made, plane a length of scrap lumber. There may be some visible planer defects. The most common are clip, snipe, and washboard. Refer to *Figure 23-25.* These and other problems can be troubleshot and eliminated. See **Figure 23-31.** This may require resetting some of the planer adjustments.

Summary

Surfacing is a fundamental process in cabinetmaking. Creating flat and square cabinet parts is essential for producing high quality products. The jointer and planer are part of this process. One surface and both edges are jointed. The second surface is planed. The radial arm saw can also be used for surfacing.

Machines will work best when properly maintained. You should periodically inspect, clean, lubricate, and adjust machine parts. Knowing the function of machine parts will help you when maintaining and adjusting them for proper function.

All processing must be done safely. Many operations, in both processing and maintenance, expose you to sharp, rotating cutters. Keep a safe distance between you and any cutter, moving or stationary. You can replace push blocks and push sticks, but you cannot replace fingers.

Test Your Knowledge

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

1. Surfacing produces _____ and _____ workpieces.
2. List the four major components of a jointer.
3. For a jointer, set the depth of cut by raising or lowering the _____.
4. The depth of cut for most jointing should be _____.
5. List the steps taken when squaring a board.
6. When jointing a face or planing, should the concave side of a cupped board be placed up or down?
7. A bevel is best jointed by first _____, then jointing.
8. Describe why the planer infeed roller is corrugated, but the outfeed roller is not.
9. During planer setup, raise or lower the planer table so it is _____ less than the stock thickness.
10. Stock less than 3/8" (10 mm), should be fed on top of a(n) _____.
11. Lubricate slides and screw threads with _____.
12. You can tell the sharpness of knives by both _____ and _____ the machine.
13. When removing both jointer and planer knives, you must loosen the _____, which hold the knives in the slots.
14. List the tools used to set knife height for both jointers and planers.
15. List the acceptable tolerances when checking the planer table, infeed roller, chip breaker, outfeed roller, pressure bar, and table roller.

Troubleshooting Hints		
Problem	**Cause**	**Solution**
Board will not feed through.	1. Pressure bar too low. (most common cause) 2. Table rollers too low. 3. Insufficient pressure on infeed roller or outfeed roller. 4. Cut too deep.	1. Readjust pressure bar. 2. Raise roller with quick-set handle. 3. Increase pressure equally on both sides. 4. Reduce cut to capacity of machine.
Snipe appears at beginning of board only.	1. Front table roller set too high.	1. Readjust front table roller.
Snipe appears at end of board only.	1. Rear table roller set too high.	1. Readjust rear table roller.
Clip appears 3-6" (7.6-15.2 cm) from both ends of the board.	1. Pressure bar set too high. 2. Table roller set too high.	1. Readjust pressure bar. 2. Check position of quick-set handle and if at zero, readjust table rollers.
Board appears to splinter out.	1. Excessive feed. 2. Cutting against grain. 3. Chipbreaker too high. 4. Green lumber.	1. Reduce feed. 2. Reverse starting end of workpiece. 3. Lower chipbreaker. 4. Accept surface as is or change stock.
Knives raise grain.	1. Dull knives. 2. Green lumber.	1. Sharpen knives. 2. Accept surface as is or change stock.
Chip marks appear on stock.	1. Exhaust system not working properly. 2. Loose connection in exhaust system. 3. Chips stuck on outfeed roller.	1. Repair or replace. Check for proper duct sizing. 2. Repair. 3. Clean roller.
Taper across width.	1. Table not parallel with cutterhead.	1. True table to cutterhead.
Glossy or glazed surface appearance on stock.	1. Dull knives. 2. Too slow a feed.	1. Resharpen knives. 2. Increase feed.
Washboard surface finish.	1. Knives not set at the same height. 2. Too fast a feed rate. 3. Table gibs loose.	1. Reset knives. 2. Reduce feed rate. 3. Readjust gibs.
Chatter marks across width of board. (Small washboard.)	1. Table rollers too high (particularly) noticeable on thin material.	1. Use backing board.
Line on workpiece parallel to feed direction.	1. Nick in knifes. 2. Scratch in pressure bar.	1. (a) Resharpen knives, to remove nick. (b) Offset nick mark if possible. (c) Replace knives if nick too wide or deep. 2. Hone pressure bar smooth.
Excessive noise.	1. Dull knifes. 2. Joint on knives too wide. 3. Table roller too high for workpiece thickness.	1. Resharpen knives. 2. Regrind knives. 3. Lower table rollers.
Excessive vibration.	1. Knives not sharpened evenly such that they are different heights.	1. (a) Measure knives, set for even overall height and resharpen. (b) Replace knives.
Workpiece twists while feeding.	1. Pressure bar not parallel. 2. Table rollers not parallel with table. 3. Uneven pressure on infeed or outfeed roller. 4. Chipbreaker not parallel. 5. Resin build-up on table.	1. Readjust pressure bar. 2. Reset table rollers. 3. Readjust for even pressure. 4. Readjust chipbreaker. 5. Clean table.
Main drive motor kicks out.	1. Excessive cut. 2. Bad motor. 3. Dull knives.	1. (a) Reduce depth of cut. (b) Reduce feed rate. 2. Replace motor. 3. Resharpen knives.
Feed motor stalls.	1. Bad motor. 2. Lack of lubrication on idlers.	1. Replace motor. 2. Lubricate idlers.

Figure 23-31. Learn to troubleshoot and correct planer problems. *(Powermatic)*

The wood for this furniture was surfaced before processing, assembly, and finishing. (*Thomasville*)

Surfacing with Planes and Scrapers

Objectives

After studying this chapter, you will be able to:

- List the various hand planes for surfacing face, edge, and end grain.
- Describe the use of hand and cabinet scrapers.
- Explain the operation of a portable power plane.
- Follow procedures to sharpen plane irons and scraper blades.
- Remove the cutterhead from a power plane for sharpening.

Important Terms

bench planes
block plane
cabinet scraper
fore plane
hand scraper
helical cutterhead
jack plane
jointer plane
portable power plane
smooth plane

Though most surfacing is done with jointers and planers, hand and portable power planes remain valuable to the cabinetmaker. Hand planes are needed for very small cabinet parts that cannot be machine surfaced. Portable power planes are used for on-site architectural woodwork. Scrapers are used for removing dried glue from joints and smoothing surfaces. These tools, used properly, will reduce the time you spend sanding. The planing characteristics for various wood species are covered in *Chapter 12*. Refer to *Figure 12-45*.

You must read the wood grain before planing, just as you did before using the planer or jointer. Hand and portable power planes also chip and tear the surface when the cutter moves against the grain.

Hand Plane Surfacing

Various hand planes will surface lumber faces as well as plywood edges. You can also plane composition materials, such as fiberboard and particleboard. However, the adhesives that bond these materials can dull cutting edges rapidly. With low-density composites, planing may make the surface even rougher.

Always scrape away excess adhesive from joints before planing. The cutting edge on a scraper can be restored quicker than the edge on a plane iron.

Face and edge grain are surfaced with bench planes. Use a block plane to surface end grain. There are additional hand planes, such as the router plane and rabbet plane. These are used when making joints to smooth the bottoms of grooves and rabbet edges. They are covered in *Chapter 29*.

Bench Planes

Bench planes include the jack, fore, jointer, and smooth planes. The standard parts of bench planes are shown in **Figure 24-1.**

The most universally used bench plane is the ***jack plane***. It is 12" to 15" (305 mm to 381 mm) long with a 2" to 2 3/8" (51 mm to 60 mm) wide plane iron.

The ***fore plane***, 18" (457 mm) long, is slightly larger and heavier than the jack plane. See **Figure 24-2.** The fore plane provides for rapid stock removal. The longer sole helps the plane true up edges of longer workpieces and helps leveling wide boards. It has less tendency to follow contours of warped lumber.

The largest plane is the ***jointer plane***. It has a 20" to 24" (508 mm to 610 mm) sole with a 2 3/8" (60 mm) iron width. This plane, as the name implies, is used to accurately true long edges that are to be jointed together.

The ***smooth plane*** is the shortest of the bench planes. See **Figure 24-3.** It is 6" to 10" (152 mm to 254 mm) long. Generally, the cutting edge is 2" (51 mm) wide or less. Some of these planes have a series of grooves in the sole. The smallest may have blades with a radius for extremely fast removal of stock. These are sometimes referred to as ***scrub planes.***

Adjusting the bench plane

Bench plane adjustments control the ***plane iron***, which is the cutter. The iron moves in and out through the ***mouth***, which is a slot in the ***sole***. This movement controls the depth of cut. See *Figure 24-4A*. The ***frog*** holds the iron at a 45° angle. The ***adjusting***

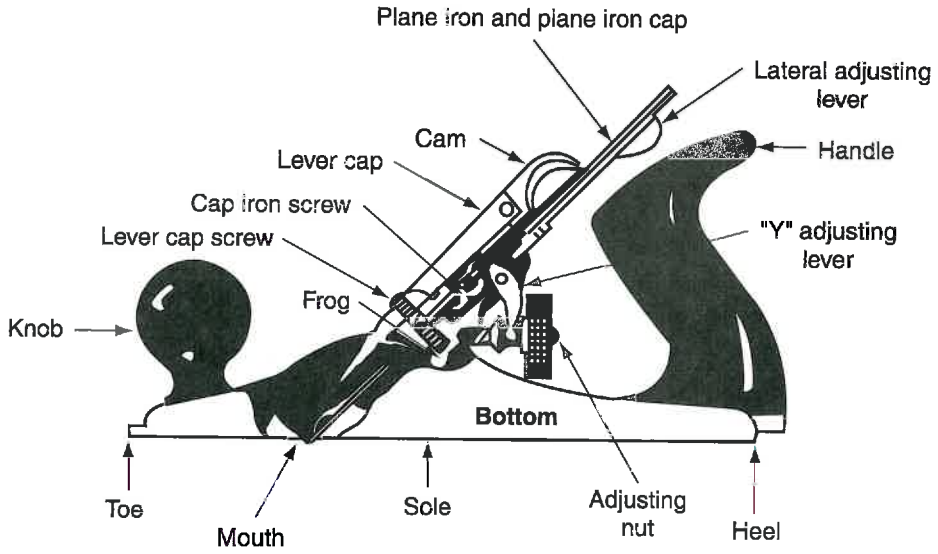


Figure 24-1. Knowing the parts of the plane helps you adjust and use the tool. *(Stanley Tools)*

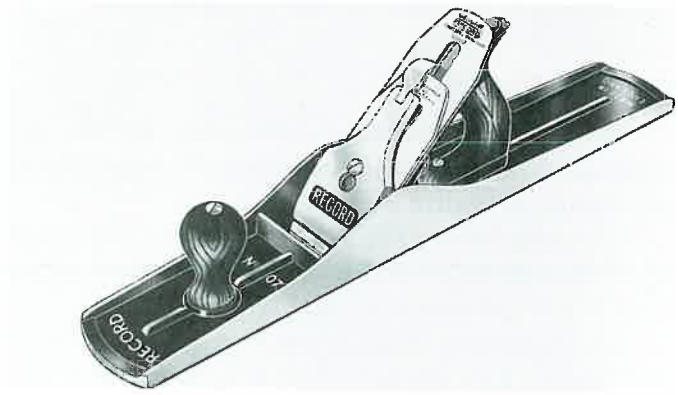


Figure 24-2. Fore plane. *(Record Ridgeway)*

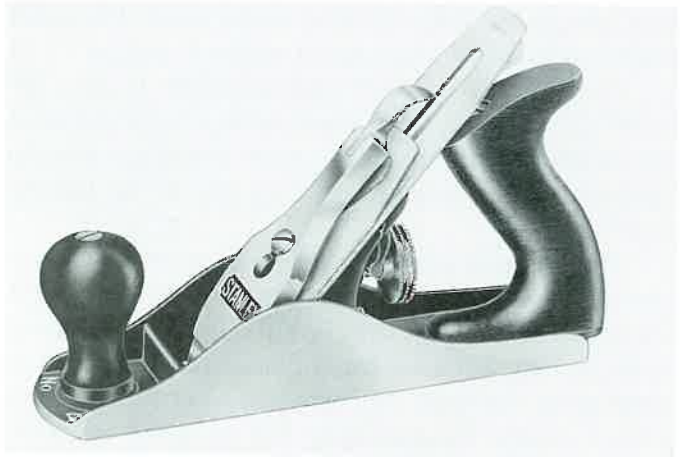


Figure 24-3. Smooth plane. *(Stanley Tools)*

nut moves the ***Y lever.*** As a result, the plane iron slides across the frog to adjust the depth of cut. The ***lateral adjusting lever*** moves the plane iron left and right. See **Figure 24-4B.** It keeps an even amount of cutting edge extended through the mouth. The ***plane iron cap*** is placed on top of the plane iron. The cap has a slot for the Y lever and a threaded hole for the cap screw. The ***cap screw*** secures the plane cap to the plane iron. They must be held tightly enough to prevent slippage. Tension to hold the entire assembly in place is provided by the ***lever cap.***

Before planing, check the plane iron sharpness and the plane cap to iron spacing. To do so, lift up the lever cap and remove the plane iron and cap assembly. Adjust the plane iron cap to within 1/32" to 1/16" (1 mm to 2 mm) of the plane iron edge. See **Figure 24-4.** Place the iron and cap assembly on the frog and resecure it with the lever cap. Turn the plane upside down and *sight down* the sole. See **Figure 24-5.** The iron should protrude from the mouth an even amount on each end. If it is uneven, move the lateral adjusting lever.

Surface planing

When planing a surface, you should get thin and feathery shavings. Taking deep cuts will result in grooves. Use long strokes with the grain. Short strokes cause small ridges to appear across the grain. Turning the plane 10° to 20° makes it easier to push. See **Figure 24-6.**

To plane a surface, proceed as follows:

1. Clamp the workpiece in a vise or between a vise and bench stop.
2. Have a firm footing.
3. Start with the toe of the plane at one end. Push downward on the knob as you start.
4. Push downward on both the knob and handle for most of the distance.
5. At the end of the pass, push downward only on the handle.

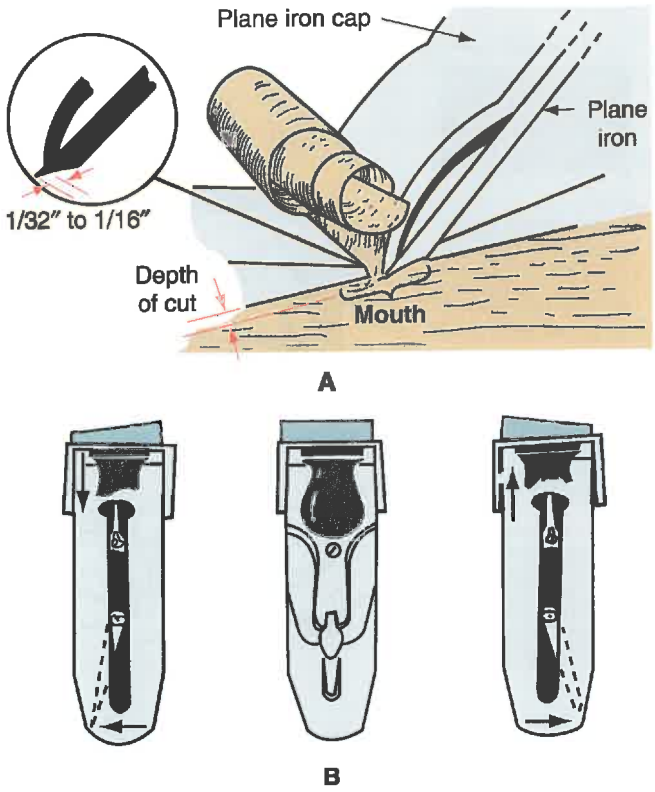


Figure 24-4. A—The plane iron extends 1/32" to 1/16" (1 mm to 2 mm) beyond the cap for smooth cutting action. B—Moving the lateral adjusting lever changes the lateral angle of the plane iron. *(Stanley Tools)*

Figure 24-5. Sight down the sole to check whether the plane iron extends equally through the mouth.

6. Continue passes along the surface until it is flat.
7. When finished, place the plane on its side to prevent damage to the cutting edge.

Fore planes work well for removing a cup. Push the plane diagonally across the surface to remove the warp. Then plane with the grain to remove any diagonal marks or rough grain.

Figure 24-6. Turn the plane at an angle for easier cutting. The shavings should be thin.

Planing an edge

The procedure for planing an edge is much the same as for planing a surface. However, there are some special cautions.

- Mark a line to which you will cut. This shows if you are removing even amounts at the center and ends.
- Crossgrain lines angle down and toward you.
- Be especially careful to hold the plane square. On narrow material, the plane tends to rock. It is sometimes helpful to hold your fingers under the toe of the plane and against the stock to keep the tool square.

Block Plane Surfacing

The ***block plane*** is designed to surface end grain. See **Figure 24-7A.** Compared to bench planes, the block plane is smaller, lighter, and has fewer movable parts. The plane iron is set at a different angle. See **Figure 24-7B.** The block plane is held in the palm of your hand. See **Figure 24-8.** An adjusting screw changes the depth of cut. The lever cap screw secures the iron once it is set. The plane iron is set at a lower angle than bench planes. The bevel on the iron faces up instead of down.

To prepare a block plane, first unlock the lever cap and remove the iron. Check the sharpness of the cutting edge. Reposition the iron in the plane with the bevel up. Align the notches on the iron with the adjusting screw nut. Replace the lever cap and tighten the screw. Sight down the sole of the plane bottom and adjust the depth of cut. Also check lateral adjustment so the iron protrudes an even amount from the mouth. Tighten the lever cap screw once the iron is set.

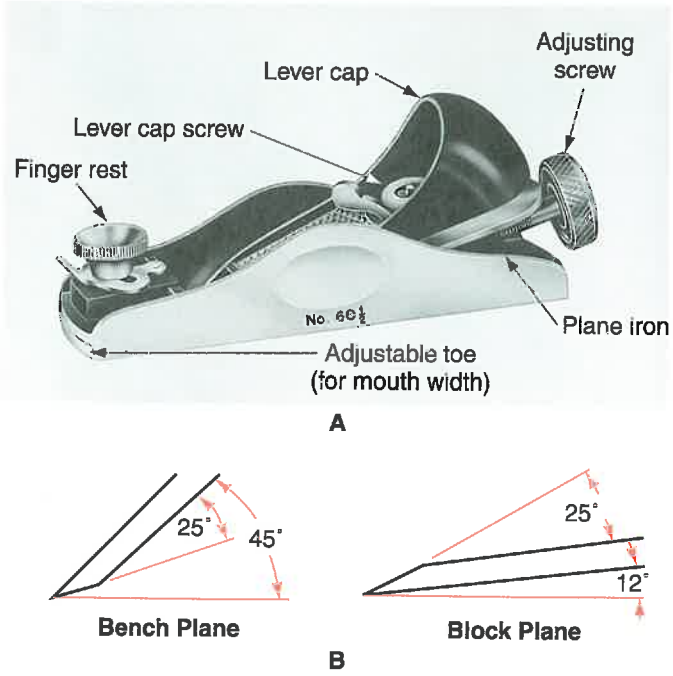


Figure 24-7. A—The block plane is effective on end grain. *(Stanley Tools)* B—Bench and block plane irons are installed differently.

Figure 24-8. Hold a block plane in the palm of your hand.

There are several ways to plane end grain properly. You can work both ways from the edges to the center. See **Figure 24-9A.** If you wish to plane in one direction, you should:

- Plane a 45° bevel on one corner. Then plane from the opposite corner. See **Figure 24-9B.**
- Clamp a piece of scrap material to the workpiece. Then plane across both the workpiece and scrap. See **Figure 24-9C.**

Figure 24-9D shows how a workpiece can splinter if you plane over the opposite edge.

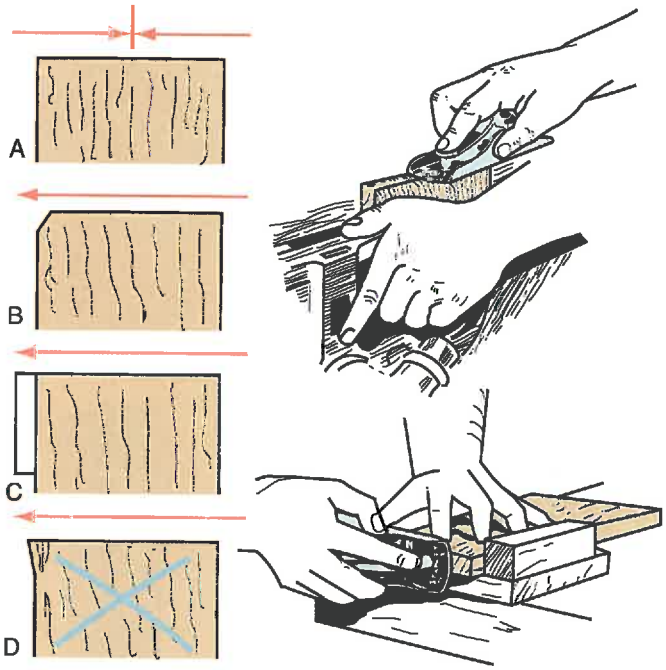


Figure 24-9. A—Plane from both sides. B—Plane to a bevel. C—Plane over a piece of scrap. D—Planing off the end will damage the edge.

Scrapers

Scrapers are another type of hand surfacing tool. They are effective on edge and face grain, not end grain. Use them when another cutting tool, such as a stationary power planer, has left minor defects in the surface. The scraper rapidly removes this roughness prior to smoothing by abrading. Scrapers are also useful for removing dried adhesive from surfaces.

When you work with a plane, the cutting edge leads into the material. This is why reading the grain is important. With a scraper, the blade is the front of the cutting edge. Therefore you can scrape in either direction along the grain, but not across the grain.

Hand scraper

A ***hand scraper*** may be rectangular or contoured. See **Figure 24-10.** A rectangular scraper is best for flat surfaces. It is 2½" to 3" (64 mm to 76 mm) wide and 5" to 6" (127 mm to 152 mm) long. The scraper's cutting edge appears to be square, but actually has a small, sharp burr. It is held in both hands at about a 75° angle. See **Figure 24-11.**

As you push or pull the scraper, a thin shaving should be cut from the surface. A well prepared scraper works like a bench plane. You can use it to do about any thing that you would otherwise do with 60 grit to 220 grit abrasive paper. Use it to clean

up excess glue, remove layout marks, smooth over and around knots, or take a board from a thickness planer to fine finish in a matter of minutes. Be careful because scraping generates heat concentrated under your thumbs. If you are removing only dust or chips, the tool is dull. You may choose not to abrade the exceptionally smooth surface created by a well-sharpened scraper.

Burnish new hand scrapers before use. New scrapers are sharp, but not burnished. Sharpening and burnishing are discussed later in the chapter.

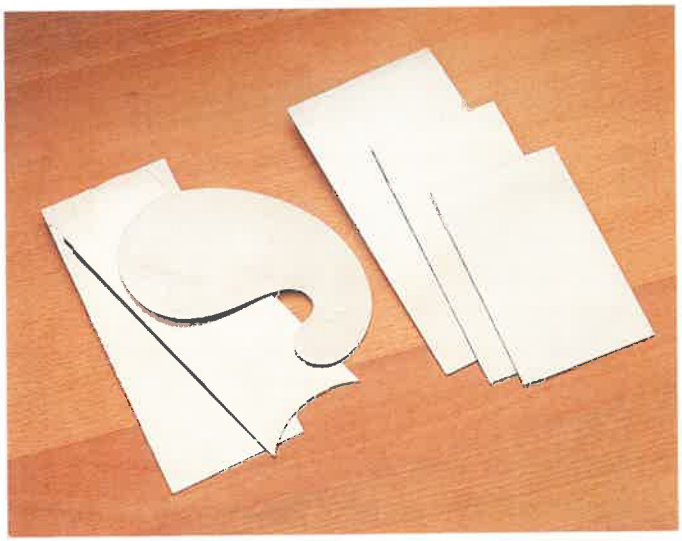


Figure 24-10. Hand scrapers may be rectangular or contoured. *(The Fine Tool Shop)*

Cabinet scraper

A ***cabinet scraper*** or ***handled scraper*** looks like a hand scraper blade mounted rigidly in a handled body. See **Figure 24-12.** Other models look like a smooth plane, about 9" (229 mm) long. The clamp screws secure the blade at a 75° angle. The adjusting thumb screw changes the depth of cut. The edge itself is at a 45° angle. See **Figure 24-13.**

Scraping the surface is the final step before using abrasives. The cabinet scraper will remove chips, especially around knots. It also removes ridges made by a plane iron or surfacer knives.

To install the blade, turn the thumb screw back even with the body casting. Be sure the clamp screws are loose. Hold the blade near the sharpened end. Slide the unsharpened end through the mouth from the bottom. The bevel on the cutting edge must face the adjusting thumb screw. Place the cabinet scraper on a flat wooden surface. See **Figure 24-14.** Press lightly against the top edge of the blade. Tighten the clamping thumb screws. Pick up the scraper and turn it over to inspect that neither blade corner extends out of the body. If one does, loosen the screws and correct the problem. While looking at the bottom of the body, turn the adjusting screw clockwise. The blade will bend slightly at the 75° mounting angle. This forces a center portion of the blade out of the body to set the depth of cut.

When using the cabinet scraper, place your thumbs on each side of the adjusting screw. Turn the

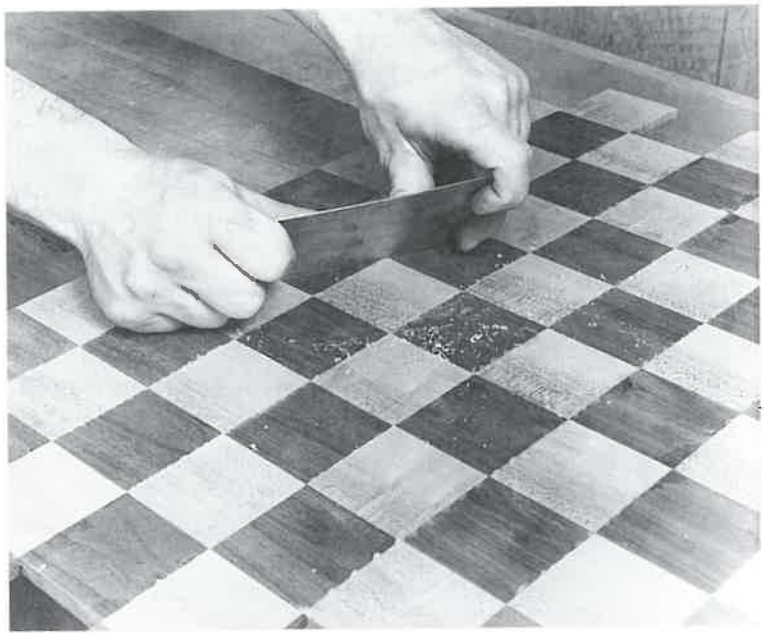


Figure 24-11. A—Cabinet scrapers are an excellent tool for smoothing the surface of parquet surfaces. *(Butler Specialty Co.)* B—Scrape with blade leaning toward the direction of cut. *(Chuck Davis Cabinets)*

Figure 24-12. Cabinet scrapers have a handle, clamp, blade, and adjusting screw. *(The Fine Tool Shop)*

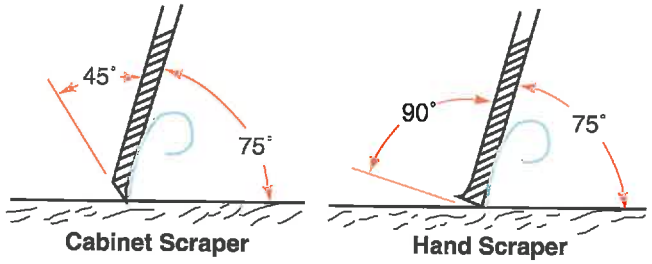


Figure 24-13. Cabinet and hand scraper edges are shaped differently.

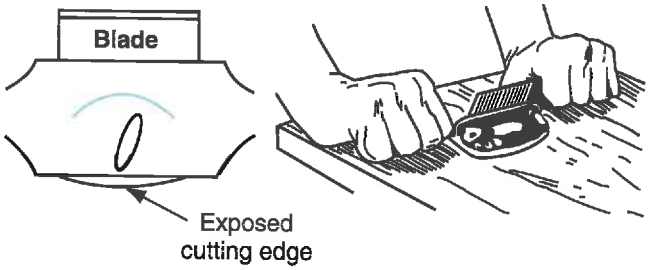


Figure 24-14. Change depth of cut with the adjusting screw. *(Stanley Tools)*

tool slightly to one side or the other. Then the blade will be at an angle, making the scraper easier to push. See **Figure 24-15.**

Think Safety—Act Safely when Surfacing with Hand Tools

Surfacing with hand tools is a relatively safe operation. However, to reduce the chance of accidental injury, you should:

- Wear eye protection.
- Remove jewelry and secure loose clothing.
- Have a safe, solid footing.

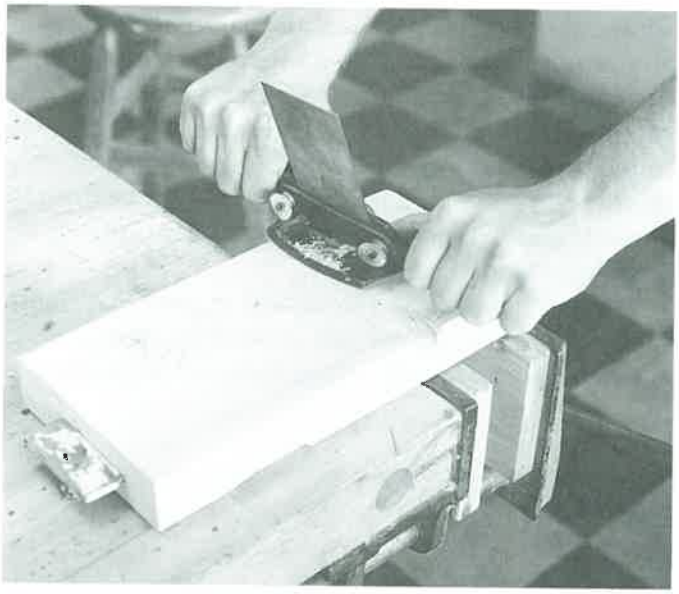


Figure 24-15. Cabinet scrapers are easier to hold than hand scrapers.

- Clamp the material securely.
- Keep both hands behind the cutting edge.
- Remove shavings and chips that accumulate on the floor.

Portable Power Plane Surfacing

Surfacing with portable power tools is quicker and easier than using hand tools. They can be moved from one workstation to another.

The ***portable power plane*** serves the same purpose as the bench plane. See **Figure 24-16.** You hold it by a knob at front and handle at the rear. The handle contains a trigger switch. The bottom of the plane is in two parts. The ***front shoe*** is adjustable up to a 3/32" (2 mm) depth of cut, much like the infeed table on a jointer. A ***chip deflector*** directs the chips away from the operator. A fence controls squaring and beveling. Use a T-bevel or square to position the fence.

Two styles of cutterheads are available. One is straight and one is helical. See **Figure 24-17.** The straight cutterhead works like the knives on a jointer or planer. The ***helical cutterhead*** cuts at a slight angle that reduces waviness and other planer marks.

Plane setup

Plane setup includes setting the depth of cut and positioning the fence. The procedure for plane setup is as follows:

1. Turn the switch off and disconnect power.
2. Move the depth adjusting lever to 0.
3. Turn the plane upside down.

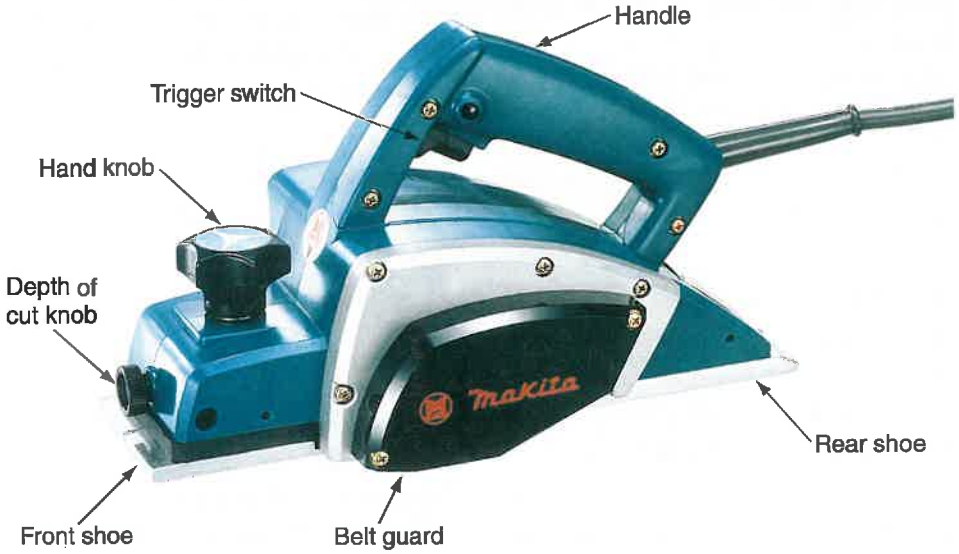


Figure 24-16. Portable power plane. This model features double-edged tungsten-carbide blades. *(Makita U.S.A., Inc.)*

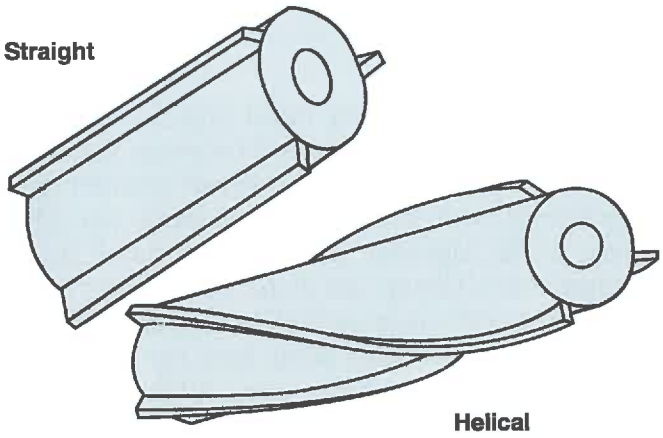


Figure 24-17. Cutterheads for power planes are straight or helical.

4. Inspect the alignment of the front and rear shoes. A straightedge should remain flat across both. Check the service manual for proper adjustment procedures.
5. With the cutter depth at zero, the cutter should just touch the straightedge.
6. Adjust the fence, if it is to be used. Use a T-bevel or try square. Wing nuts usually hold the fence in place.

Plane operation

The procedure for using the portable power plane is as follows:

1. Adjust the depth of cut. The last cut made on a surface should be 1/32" (1 mm) or less. This will provide the smoothest surface.
2. Remove the fence if you will be planing a surface. Install and set the fence before planing an edge.
3. Place the front shoe of the plane on the workpiece. Make sure the cord is out of the way.
4. Start the motor and let it reach full speed.
5. Slowly slide the plane onto the surface. For edge planing and beveling, keep the fence snug against the face. See **Figure 24-18.**
6. Reduce pressure on the toe of the planer as you reach the end of the cut.
7. When finished, let the planer come to a stop. Then set the planer on its side to prevent damage to the blade.

Think Safety—Act Safely when Surfacing with Portable Planes

Operating a power plane requires planning and concentration. You must determine your direction of cut. Also choose a safe place to put the machine when you are finished. Follow these safety precautions.

- Wear eye protection.
- Remove jewelry and secure loose clothing.
- Have a safe, clean, and solid footing.
- Adjust fences and secure them properly.
- Keep the cord away from the point of operation.
- Be sure the cord is long enough for the length of cut.
- Connect power to the machine only after the adjustments are made. Be sure the switch is in the off position when reconnecting power.

- Operate the tool with your right hand on the handle. The chip chute will throw chips away from you.
- Let the motor reach full speed before cutting.
- Move the tool with constant pressure against the workpiece.
- Set the machine out of your way when you are finished.

Sharpening Surfacing Tools

The quality of any surfacing operation relies on the cabinetmaker's skill. It also depends on how the tools are maintained. Scrapers and planer blades must be sharpened regularly to cut properly.

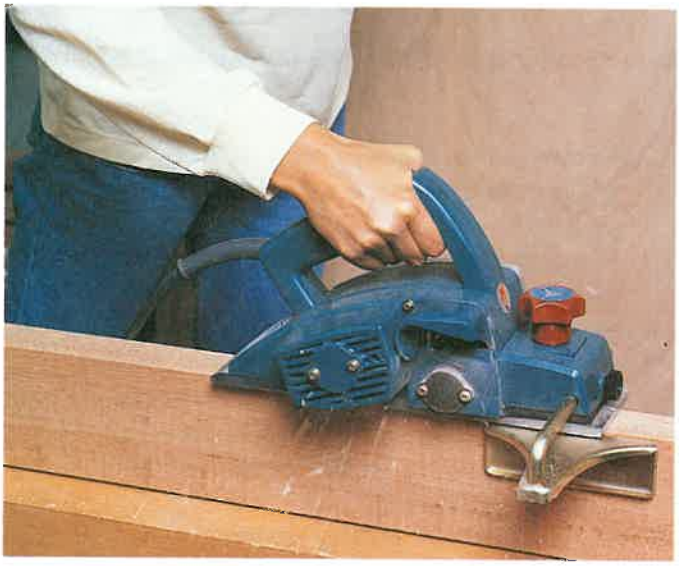


Figure 24-18. Portable power planes are useful for on-site architectural woodwork. *(Makita U.S.A., Inc.)*

Sharpening plane irons

Plane irons can be honed or ground and honed. Honing restores the edge. Grinding puts a new bevel on the plane iron.

Honing

Plane irons can be honed several times before grinding is needed. Soak waterstones in clear water. Reapply water to keep the surface wet. Place the bevel of the plane iron on the stone, then raise the back end up about 5° so the cutting edge rests on the stone. See **Figure 24-19A.** (The plane iron will be about 30° to 35° from horizontal.) Move it back and forth until you achieve a fine, wiry cutting edge. Start with 800 grit, move to 1200, and complete with 6000. See **Figure 24-19B.** Then turn the plane iron over, lay it flat on the 6000 waterstone, and stroke several times. See **Figure 24-19C.** The wiry burr will be removed.

Grinding

After the plane iron bevel has been honed several times, the hollow grind becomes flattened. Grinding is then needed. A bench grinder and sharpening fixture is used to grind plane irons. See **Figure 24-20.** Holding the knife by hand is not recommended. Clamp the plane iron in the fixture so that the bevel you grind will be two and one-half times the thickness of the plane iron. For example, a standard 1/8" (3 mm) plane iron will have a 5/16" (8 mm) bevel. The final bevel angle should be about 25°. See **Figure 24-21.**

A B C

Figure 24-19. Hone a plane iron at an angle just greater than the bevel. A—Start with an 800 grit waterstone, progress to 1200 grit. B—Finish with 6000 grit. C—Then hone several strokes on the flat side of the iron using the 6000 grit waterstone. *(Chuck Davis Cabinets)*

Make a light cut across the grinding wheel and check the angle. If it is correct, continue grinding with light pressure. Move the plane iron back and forth across the wheel. The cutting edge should not turn blue. This indicates overheating. Dip the plane iron frequently in water to cool it.

Grind the outside corners so they will be slightly rounded, or about 1/64" (0.4 mm) less than the center. This prevents gouge marks when using the plane. Continue grinding until the edge is thin and a slight burr is formed.

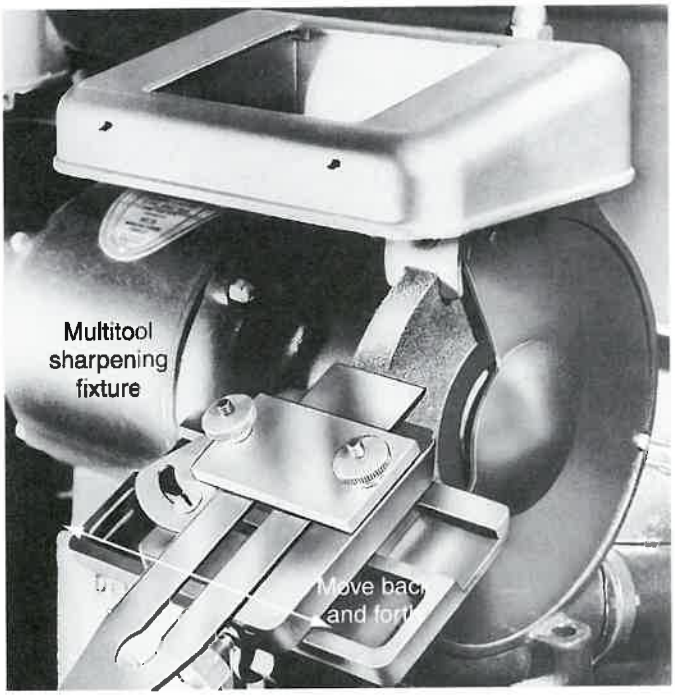


Figure 24-20. Place the iron in the grinding fixture at the proper angle. *(Rockwell International)*

Sharpening hand scrapers

Scrapers are sharpened differently than most hand tools. The scraper is first filed square. Then a burnisher is used to bend the edge into cutting position. There are burnishing tools made for this purpose, but you can use a rounded screwdriver blade or the butt end of a large-diameter, high-speed steel drill bit. The goal is to roll the edge over slightly. It takes very little pressure. Take eight or ten strokes with light pressure. The procedure to sharpen a hand scraper is:

1. Clamp the blade in a vise with the cutting edge up. See **Figure 24-22.**
2. File the edge straight and square.
3. Hone all edges and sides on a flat stone to produce square surfaces for the burnisher.
4. Burnish both edges. Bend the metal with a series of burnisher strokes.
5. Place the burnisher flat on the edge for one or two strokes. Then tilt the handle down about 2° to 3° each way with several strokes to bend the corners.
6. Test the scraper on a surface.

A scraper may be reburnished several times between filings. To reburnish the edge, lay the scraper flat on a bench. Remove the dull burr by lightly drawing the burnisher across the scraper in a diagonal motion. Keep the burnisher flat on the scraper. Do this on both sides and then repeat steps 4 and 5 above.

Sharpening cabinet scraper blades

Cabinet scraper blades differ from hand scrapers. The blade is narrower and the edge is filed

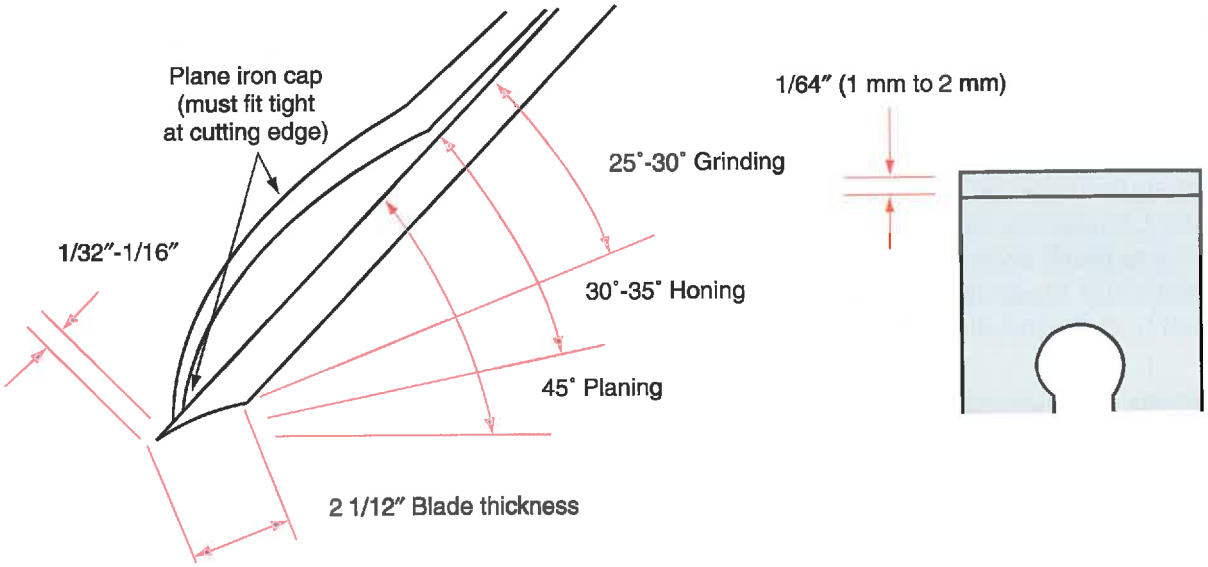


Figure 24-21. Honing, grinding, and planing angles of the plane iron.

A

B

Figure 24-22. A—File a hand scraper blade straight and square. B—Then burnish the edge. *(Chuck Davis Cabinets)*

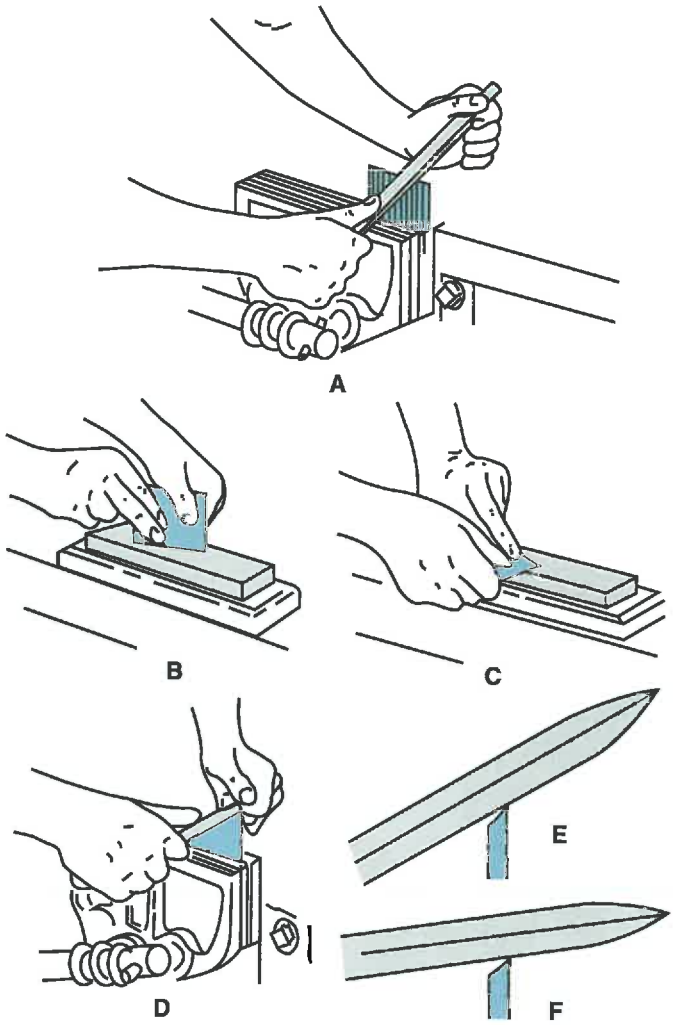


Figure 24-23. Sharpening a cabinet scraper blade. A—File a 45° bevel. B—Hone the bevel. C—Hone the flat side to remove the wiry edge. D—Burnish with a few firm strokes. E—The first stroke should be at a 45° angle. F—The last stroke should be at a 75° angle. *(Stanley Tools)*

to a 45° angle. The procedure to sharpen the cabinet scraper blade is as follows:

1. Clamp the blade in a vise with the cutting edge up.
2. File the edge straight, at a 45° angle. See **Figure 24-23A.**
3. Remove the blade from the vise and hone the 45° bevel and flat face. See **Figure 24-24B.** First use a medium grit stone, then a fine one.
4. Replace the blade in the vise.
5. Burnish the edge several strokes. Start at a 45° angle. Change the angle on successive strokes until you reach about 75°. See **Figure 24-23F.** Remove the blade from the vise, inspect, and install it in the handle.

Maintaining portable power planes

Portable power tools operate much like stationary surfacing machinery. Therefore, you must check lubricants, motor brushes, and belts regularly. Tools with sealed bearings require little, if any, lubrication. Carbon brushes on the motor should be inspected for wear at regular intervals. Check drive belts for wear, cracks, and other damage.

Power plane cutters are helical or straight. Most are hardened steel and can be sharpened. Carbide tipped cutters must be sharpened by a technician.

Some portable power planes with helical cutters have a grinding attachment on one side. See **Figure 24-24.** A small grinding wheel fits in the chuck on the motor shaft. The cutter is placed in the side accessory when the machine is off. Then, with the machine on, rotate the cutter by hand against the grinding wheel.

To remove the cutter for sharpening, you will have to disassemble part of the power plate. Turn off the switch and disconnect power to the tool. Then remove any covers or guards over the cutterhead. To remove the cutter, you must hold the shaft

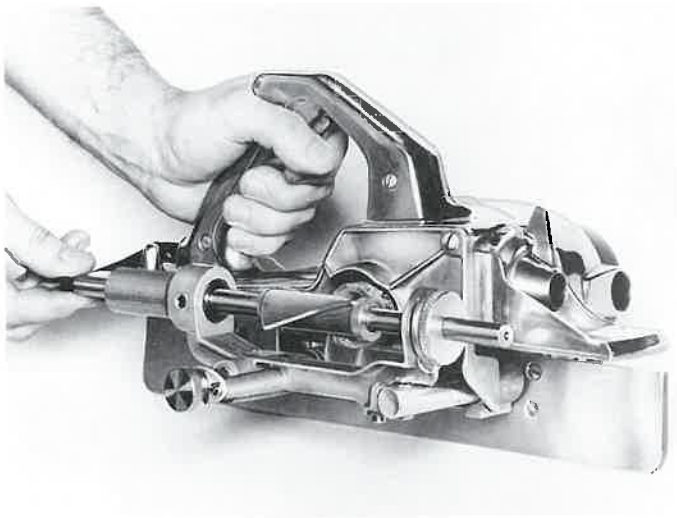


Figure 24-24. Some portable power planes have a grinding attachment. The stone is attached to the motor. The cutter is held in a fixture on the side of the plane. *(Delta International Machinery Corp.)*

stationary and remove the nut holding the cutter. Some planes have a shaft lock. On others, you must use two wrenches.

After reassembling the plane, inspect the angle on the rear shoe. Both front and rear shoes should be parallel when the depth of cut is at zero. If not, follow the manufacturer's procedure for adjusting them.

Summary

Although most surfacing is done with jointers and planers, hand tools are useful for small cabinet parts and on-site architectural woodwork. Jack, fore, jointer, and smooth planes surface edges and faces. Block planes are used to surface end grain. Scrapers will remove excess glue and minor surface defects often caused by surfacing machines. Portable power planes make the work much easier. They can be used for face, edge, and end grain.

Surfacing tools and machines will serve you best when they are properly maintained. Periodically check for blade sharpness, rust, needed lubrication, and other items recommended in the manufacturer's operation and maintenance manuals.

Test Your Knowledge

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

1. Describe two situations in which you would choose a hand plane over a stationary surfacing machine.
2. The _____ plane is the longest bench plane and the _____ plane is the shortest bench plane.
3. The most used bench plane is the _____ plane.
4. Name the adjustment that determines how much of the plane iron protrudes out of the mouth.
5. The plane iron cap should be within _____ of the cutting edge of the plane iron.
6. When surfacing a face, should you stroke with or against the grain?
7. Explain how you can use a plane to remove a cup in the face of a board.
8. List three methods of planing end grain without splintering the edge.
9. File the edge of cabinet scraper blades at a(n) _____ angle before burnishing.
10. The two types of cutterheads available on power planes are _____ and _____.
11. Plane irons are ground at a(n) _____ angle.
12. Plane irons are honed at a(n) _____ angle.
13. What makes the cabinet scraper blades different than the hand scraper blades?
14. List the steps taken to square a board using hand planes.
15. The front and rear shoes of a power plane should be _____ when the depth adjustment is set at zero.

Surfacing and drilling processes were performed as parts of the manufacturing process of this cabinet. *(Thomasville)*

Drilling and Boring

25

Objectives

After studying this chapter, you will be able to:

- Select drills and bits based on the hole to be made.
- Operate hand, portable, and stationary drilling equipment.
- Follow procedures for drilling through and blind holes, holes at an angle, and flat or cylindrical workpieces.
- Sharpen drills, bits, and cutters.
- Maintain hand and power drilling equipment.

Important Terms

adjustable dial saw
auger bit
bell hanger's drill
boring
brace
circle cutter
cutting lips
dowel bit
drill points
expansive bit
Forstner bit
glass drill
hammer drill
hand drill
machine spur bit
masonry drill
multispur bit
plug cutter
Powerbore bit
push drill
right angle drill
screw bit
ship auger bit
spade bit
star drill
twist drill

Drilling and boring are hole making processes as basic to cabinetmaking as sawing and surfacing. Holes are necessary for installing hardware, making joints, and producing various cabinet design features.

As a rule, ***drilling*** refers to making holes smaller than ¼" (6 mm) with twist drills and drill points. ***Boring*** describes making larger holes with different types of boring bits. The type of drill or bit you choose depends on the hole to be made. See **Figure 25-1.** What diameter and how accurate must the hole be? Will it be a flat bottom hole bored partway into the workpiece? How smooth should the hole surface be? In addition, bit type, wood species, or manufactured panel composition will also affect the hole's surface. Refer to *Figure 12-45.* These are all important considerations when you select a drilling tool.

Figure 25-1. Select the correct bit and drilling tool for making precise holes. *(Vermont American Tool Company)*

Drills and Bits

Drills and bits may be made of carbon steel, high-speed steel, or be carbide tipped. Carbon steel bits are the least expensive. They are weaker than other bits, and should be limited to drilling wood, plastic, and aluminum. Bits marked ***high-speed (HS)*** or ***high-speed steel (HSS)*** are more durable than carbon bits and will cut through most materials. (However, the design of some HS bits limits them to boring wood only.) Carbide-tipped bits drill through hard materials, such as ceramic tile and concrete. High-speed drills and bits are the most cost-effective for cabinetmaking.

Drilling is done with hand tools, portable power drills, and stationary machines. The shank of the bit determines whether it can be used in a particular tool. Bits with round shanks are inserted into drilling tools that have three-jaw chucks. Three or six flat surfaces milled into the shank hold a bit more securely in three-jaw chucks. Square, tapered ends of auger bits limit their use to a hand brace.

Certain operating speeds are recommended for drills and bits. See **Figure 25-2.** Drilling at the correct speed, with the proper feed, will produce

A

Tool Name	Drilling† Practice	Max. No-Load Machine Speeds (R.P.M.)	
		Stationary	Portable
Auger bit	H,S,P	1000	1000
Expansive bit	H,S	300 to 150*	
Twist Drill Wood 1/16" to 1/2" HS	H,S,P	6000 to 2000*	2800 to 1000*
Twist Drill Wood 1/16" to 1/2" Carbon	H,S,P	3000 to 1000*	2000 to 600*
Twist Drill Steel 1/16" to 1/2" HS	H,S,P	3000 to 600*	2000 to 600*
Twist Drill Steel 1/16" to 1/2" Carbon	H,S,P	1500 to 300*	1000 to 450*
Spade bit 1/4" to 1 1/2"	S,P	3000	2000
Spur bit	S,P	3000	2000
Multispur bit 1" to 5"	S	600 to 200*	
Forstner bit 1/4" to 4"	H,S	2000 to 150*	
Power bore bit®	S,P	2000	2000
Drill point	H		
Circle cutter	S	250	
Adjustable dial saw	S	250	
Hole saw 1" to 5"	S,P	600 to 150*	600 to 150*
Countersink	H,S,P	3000	2000
Screw mate®	H,S,P	3000	2000
Plug cutter	S	3000	
Countersink	S,P	See twist drill speeds	
Counterbore	S,P	See twist drill speeds	
Masonry and glass drill	S,P	600	600

†H = Hand tool S = Stationary power P= Portable power

B

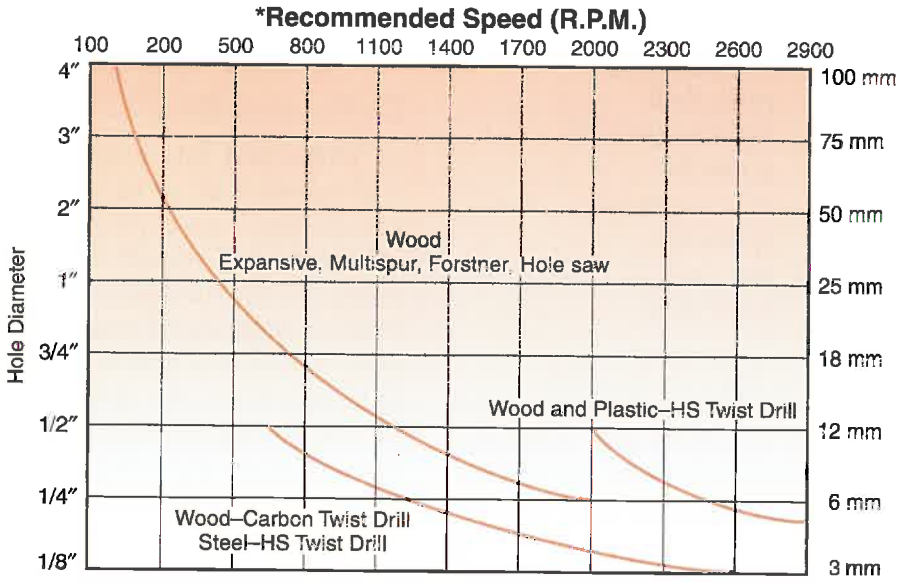


Figure 25-2. A—Use proper speeds when drilling. B—Safe drilling speeds vary by bit size.

the best results. A high speed or an incorrect feed rate will cause the bit to heat up, which can damage the tool permanently.

Auger bit

Auger bits produce holes in face and edge grain, but are not effective in end grain. See **Figure 25-3.** Auger bits have two sharpened ***cutting lips*** and ***spurs***. The spurs score the wood before the cutting lips remove chips. A ***threaded feed screw*** pulls the bit into the workpiece. The ***twist*** carries chips out of the hole. The tapered square ***tang*** is secured in a brace chuck. The combined length of the twist and the ***shank*** determines the maximum hole depth. That may be 7" to 10" (178 mm to 254 mm).

When using an auger bit, you must drill the proper size hole the first time. You cannot enlarge it with another auger bit. To counterbore a hole with an auger bit, drill the larger hole first. Then continue with a smaller bit.

Auger bits are sized by two systems: U.S. customary and SI (System International) Metric. Auger bits come in sets of 13. U.S. customary sizes are numbered 4 to 16. The size is stamped on the tang or shank. Only a single number appears. The number is the increments in 16ths of an inch. For example, a 4 indicates 4/16, or 1/4" bit. A number 16 indicates 16/16, or 1" bit. Metric sets are sized from 6 mm to 25 mm.

The tapered square tang limits the use of auger bits. They can only be held in a brace. However, some auger bits can be modified to work in three jaw chucks found on hand drills as well as portable and stationary power drills. If the shank has three or six flat surfaces, you can saw off the tang. See **Figure 25-4.**

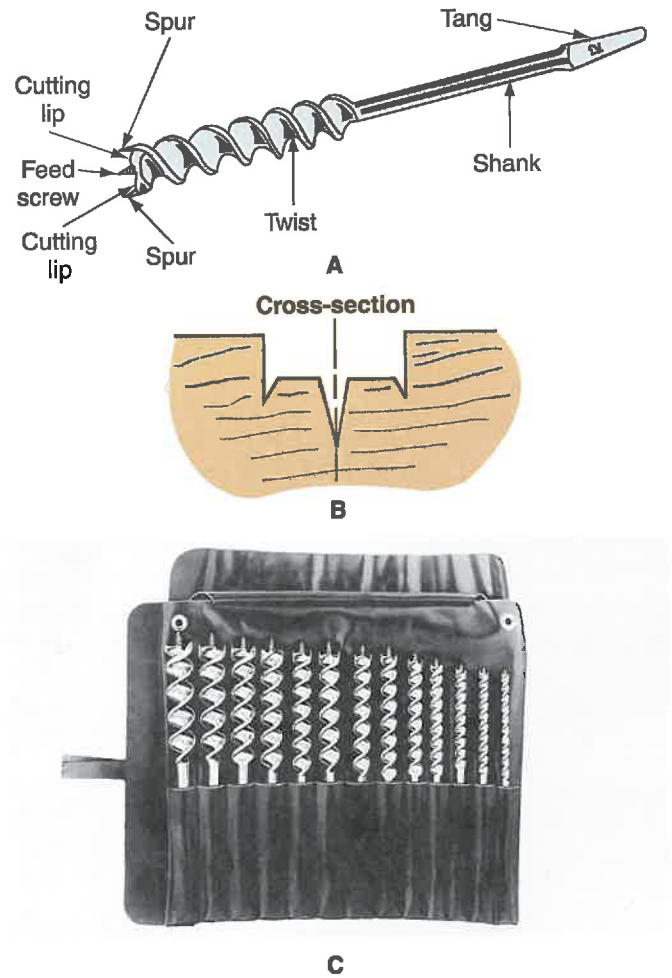


Figure 25-3. A—Parts of an auger bit. B—Section view of hole created by auger bit. C—Bits come in sets of 13. *(Stanley Tools)*

Figure 25-4. Auger bit shanks have a tang fit in a brace. The tang can be sawed off so the bit can be used in power drills. *(Irwin)*

Auger bits are slow speed bits. Most often, they are used in a hand brace. When used in power equipment, drilling speeds must be kept between 300 rpm to 800 rpm.

Ship auger bit

A ***ship auger bit*** has a six sided shank, and is 17" (432 mm) long. They are used for fast, heavy-duty wood boring using ½" portable power drills. The large wide flutes provide fast chip clearance. Bit diameters range from 7/16" to 1½". Metric bits are available in relative millimeter sizes. Similar auger bits that are 8½" (216 mm) long provide the ability to work in places with clearance restrictions as would be faced by electricians.

Dowel bit

A ***dowel bit*** looks much like a short auger bit. It is about 5" (127 mm) long. There are three diameter sizes: ¼", 3/8", and ½". Metric bits are available in relative millimeter sizes. The dowel bit diameter is .003" (.08 mm) over the marked size. Auger bits are about .015" (0.4 mm) oversize. The close tolerance of dowel bits makes them more suitable for drilling holes for dowel joints.

Expansive bit

An ***expansive bit*** is an adjustable auger bit. See **Figure 25-5.** The feed screw helps pull the bit into the workpiece. One cutting lip is located on the body just above the feed screw. The other is on the adjustable cutter. The cutter also has spurs to score the wood before removing material.

Expansive bits adjust from 5/8" to 3" (15 mm to 75 mm). Expansive bits with metric scales are also available. Adjust the hole diameter according to the index mark and scale on the adjustable cutter.

Some expansive bits may have a round shank instead of a tang. These may be used in drill presses at a very slow speed, about 300 rpm.

Twist drill

The ***twist drill,*** also sometimes called a twist drill bit or drill bit, is shown in **Figure 25-6.** It has a round, straight shank. At the end of the bit are two

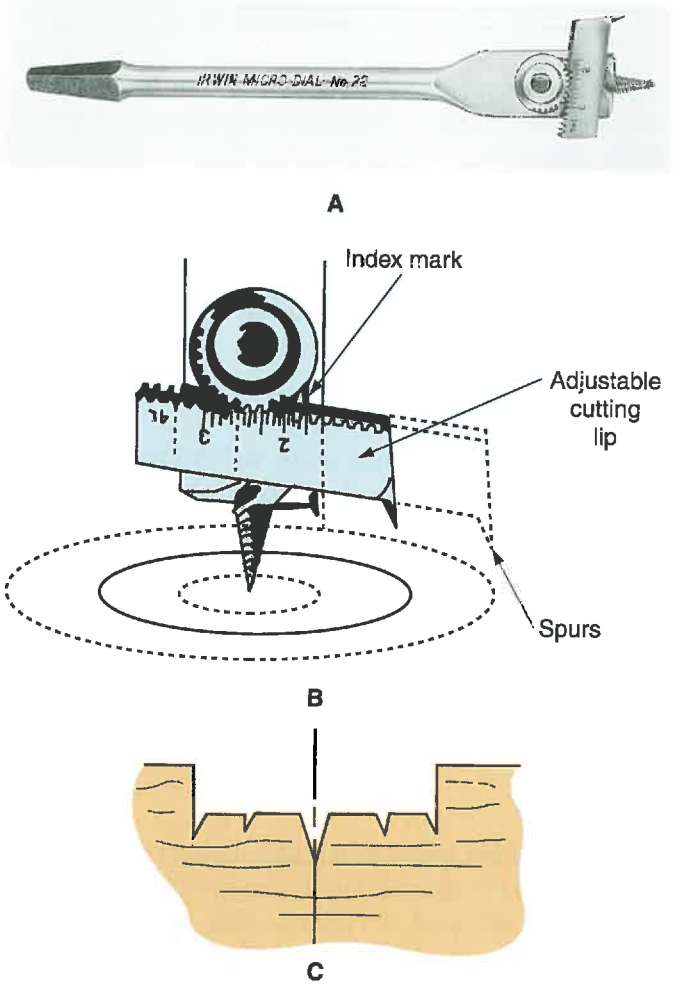


Figure 25-5. A—Expansive bit. B—Adjust the bit's lip and spur to vary hole sizes. *(Irwin)* C—Section view of hole created by an expansive bit.

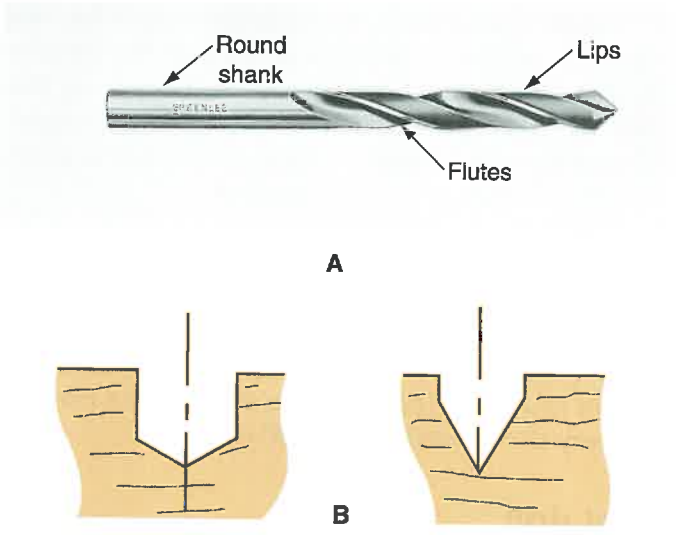


Figure 25-6. A—Twist drills have round shanks, flutes, and two cutting lips. *(Greenlee)* B—Section view of holes created by twist drills.

sharp cutting lips. ***Flutes*** carry wood chips away from the point of operation.

Twist drill sizes may be given in fractions, letters, or numbers. Metric twist drill sizes are noted in millimeters. The shank may or may not be the same size as the flutes. If not, common shank sizes will likely be ¼", 3/8", or ½". Large bits with small shanks can fit into portable power drills.

Twist drills are made of either carbon or high-speed steel. Carbon steel drills are adequate for wood and soft metals. High-speed twist drills remain sharp longer and are less likely to bend. You can turn them at faster speeds when drilling wood, plastic, and steel. Manufacturers may coat twist drills with cobalt or titanium for longer life.

The point angle may differ among twist drills. Most are sharpened at a 118° angle, and are suitable for many materials. Other angles are recommended for drilling wood or plastic.

Machine spur bit

Machine spur bits drill a somewhat flat bottomed hole. See **Figure 25-7.** They have a round shank, two flutes, and two cutting lips. A short brad point prevents wandering as drilling is started. Bit sizes range from 3/16" to 1¼". Metric bits are available in relative millimeter sizes.

Brad point bit

Brad point bits are close to the machine spur bit, except that a flatter hole bottom results. Spurs, at the outside, score the wood to reduce chipping.

Spade bit

A ***spade bit*** is flat with a fairly long brad point to center it. See **Figure 25-8A.** The spade has cutting lips ground into the bottom. The width of the spade determines the hole diameter. The shank usually has three or six flat surfaces that hold better in three jaw chucks. This also facilitates the use of extensions. Refer to *Figure 25-23.*

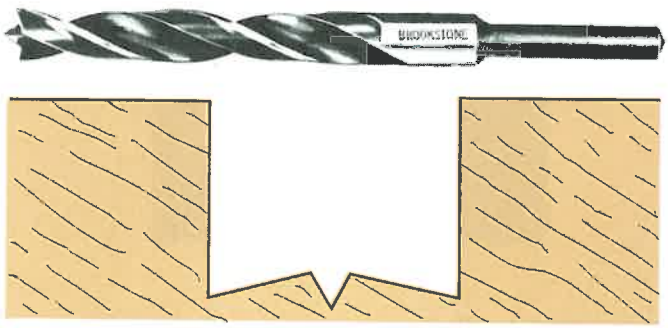


Figure 25-7. Machine spur bit with a reduced shank to fit in smaller portable drill chucks. *(Brookstone)*

Spade bits do not produce the most accurate holes. However, they are inexpensive and adaptable. You may grind the sides or cutting edges for special needs. See **Figure 25-8B.** For example, you could drill a tapered hole by grinding the edges of the spade at an angle. You can also create a round bottom hole by grinding a curved cutting edge. By grinding the spade at two different widths, you can counterbore a hole.

Multispur bit

The outer edge of the ***multispur bit*** looks somewhat like a saw. See **Figure 25-9.** A series of saw tooth spurs surround a brad point. There is one cutting lip between the point and spurs. This serves as a chip breaker. The tool has a standard ½" (13 mm) shank with three milled flats for secure grip in portable electric drills. This style of bit is designed for boring holes in wood for pipe and conduit. Sizes range from 1" to 4 5/8". Metric bits are available in relative millimeter sizes.

Forstner bit

The ***Forstner bit*** is a tool used to drill flat bottomed holes. See **Figure 25-10A.** The circumference of a Forstner bit is smooth, but very sharp. One or two cutting lips are located at the bottom. A small brad point helps center the bit before boring. Once the hole is started, the sharp circumference guides the tool.

A Forstner bit creates a very smooth hole surface. It is especially effective when drilling blind holes. (Blind holes do not go all the way through the workpiece.) Forstner bits are also very sturdy. The brad does not have to be used to center the bit. **Figure 25-10B** shows angled holes and holes in an edge of the workpiece.

Bit sizes range from 3/8" to 3". Metric bits are available in relative millimeter sizes. Shank sizes are usually ½" (13 mm) because the bit is used in a drill press. However, 3/8" (10 mm) shanks are readily available.

Forstner bits are available in both chrome steel alloys and carbide-tipped versions. Blind holes are used in the bottom of wall cabinets to insert low voltage lights. To completely hide the wire, a second hole must be drilled from the back edge of the bottom panel through which to pass the wire.

32 mm System boring bits

Carbide-tipped bits are used in automatic and semiautomatic boring machines to prepare materials to accept mounting screws for functional hardware, dowels, RTA fasteners, and Euro-style hinges. See **Figure 25-11.** The bit includes a centering point, 2 outside scoring teeth and 2 straight cutting teeth. The shank is 10 mm in diameter with a locking flat. The overall length is 57 millimeters. Always *bottom* (insert as far as it will go) the shank when inserting these bits. The boring depth is set for the machine and seldom changes. Some bits have an adjusting screw in the end of the shank to allow for minor adjustments.

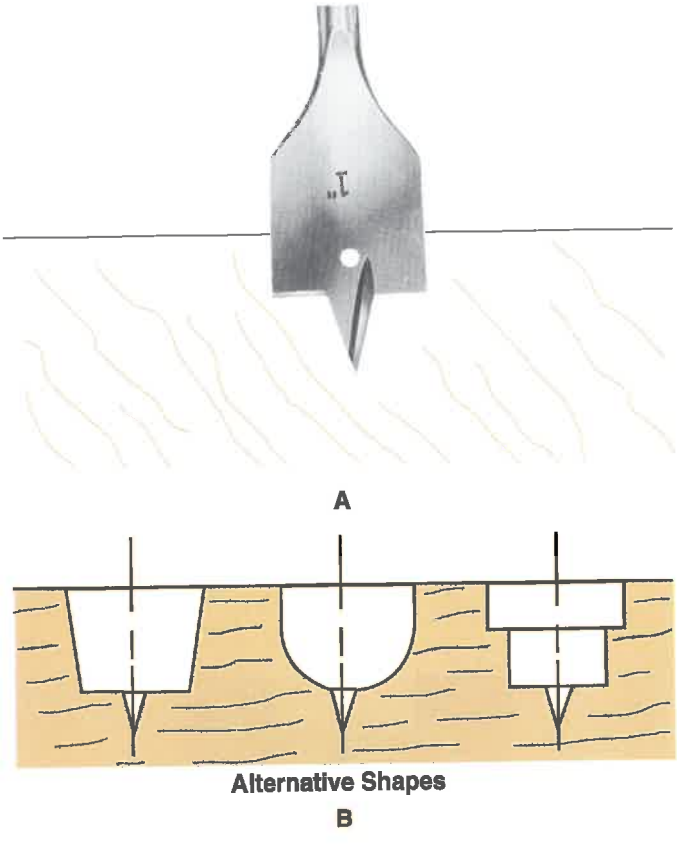


Figure 25-8. A—Spade bit. *(Irwin)* B—The spade can be ground to create different hole shapes.

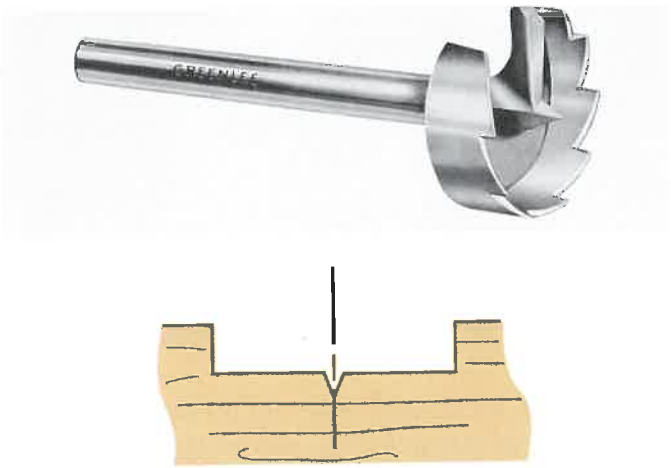


Figure 25-9. Multispur bit. *(Greenlee)*

Bit diameters for hinge cup insertion are available in 15 mm, 20 mm, 25 mm, 26 mm, 30 mm, 35 mm, 38 mm, and 40 mm to fit the wide variety of available hinges. Clockwise and counterclockwise versions are available.

Bit diameters for functional hardware, dowels, and RTA fasteners are available in 5 mm, 6 mm, 8 mm, 10 mm, and 12 mm. Clockwise and counterclockwise versions are available. Adapters are available to hold 2.5 mm bits for pilot holes when using wood screws.

A

B

Figure 25-10. A—Forstner bits drill flat bottomed holes. B—Because its circumference guides the bit, you can bore at any angle. Clamp the workpiece securely. *(Chuck Davis Cabinets)*

Powerbore bit

The ***Powerbore® bit*** functions much like spade and multispur bits. See **Figure 25-12,** It has a ¼" (6 mm) shank, one brad point, one spur, and one cutting lip. Bit diameters range from 3/8" to 1". Metric bits are available in relative millimeter sizes.

The design of the Powerbore® bit lessens friction between the bit and the wood. Forstner and multispur bits have smooth sides that slightly rub the wood. The Powerbore® bit has little surface contact with the wood.

Drill points

Drill points are used with the push drill. See **Figure 25-13.** They have straight flutes with two cutting lips sharpened like a twist drill. Drill points are effective for drilling pilot holes for small screws or nails. Bit diameters are 5/64", 7/64", 9/64", and 11/64". Metric bits are available in relative millimeter sizes.

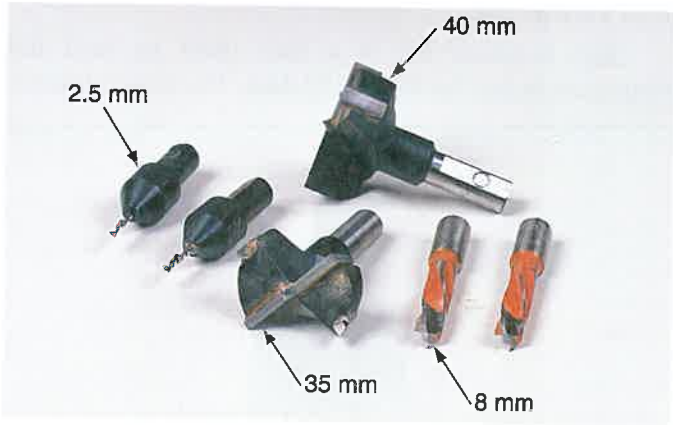


Figure 25-11. Bits used for Euro-style concealed hinges. The larger 35 mm and 40 mm are for the hinge cups. For accurate hinge positioning, use either the 8 mm bits to receive plastic dowels, or the 2.5 mm bits to drill pilot holes for wood screws. *(Chuck Davis Cabinets)*

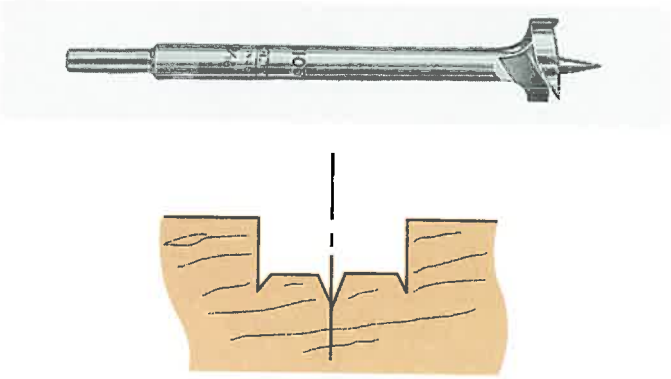


Figure 25-12. A Powerbore® bit is easier to control than a spade bit. *(Stanley Tools)*

Figure 25-13. Drill points fit in a push drill. They make holes for screws, brads, and other purposes. *(Chuck Davis Cabinets)*

Circle cutter

A ***circle cutter*** can create large holes through a workpiece. See **Figure 25-14.** The material removed is wheel-shaped.

To drill, set the desired radius. It is adjustable from 1¾" to 8" (46 mm to 203 mm) diameter. Then tighten the cutter with a screwdriver or Allen wrench. Use this bit only in a drill press at a maximum speed of 250 rpm.

Adjustable dial saw

The ***adjustable dial saw*** is like the circle cutter. See **Figure 25-15.** It has a center guide drill with three surrounding arms. Each arm has two saw teeth. Set the diameter according to the dial index. Then tighten the hex nut on the top. The dial saw is a slow speed tool. Use it in a drill press at 250 rpm.

Hole saw

A sturdier tool than the dial saw is the ***hole saw.*** See **Figure 25-16.** It has a guide drill. The circumference is a series of saw teeth. A different saw tooth insert is necessary for each diameter. These are attached to a common size shank. The shank has 6 milled flats for a secure grip in portable power drills.

Countersink bit

The countersink bit angles hole tops that allows flat head screws to set flush. One end is an 82° V-shaped point with several cutting lips. The

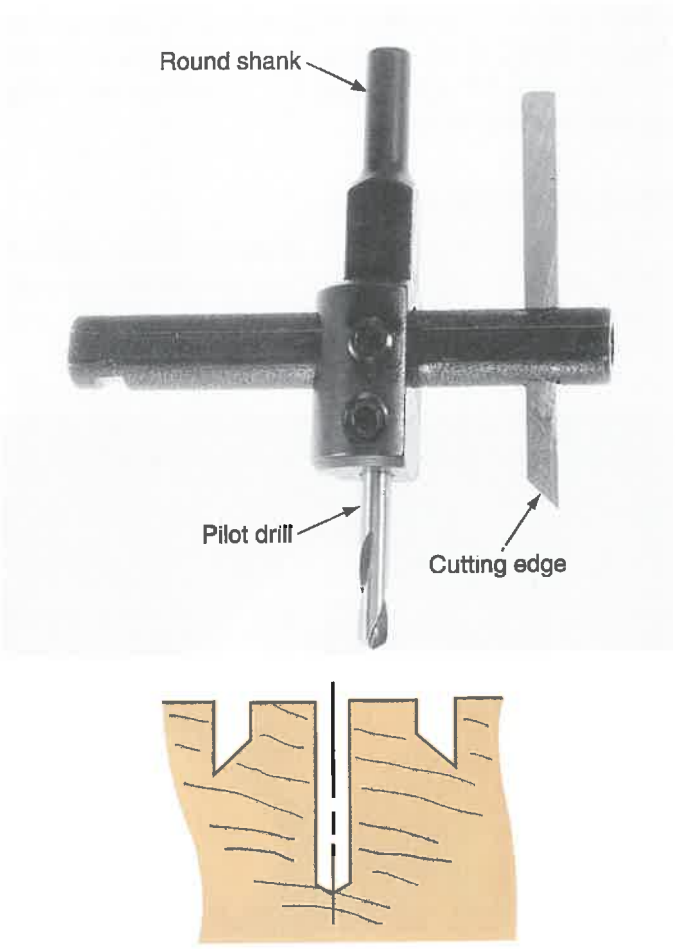


Figure 25-14. Circle cutters produce holes up to 8" (203 mm) in diameter. Use them in a drill press. *(General Manufacturing)*

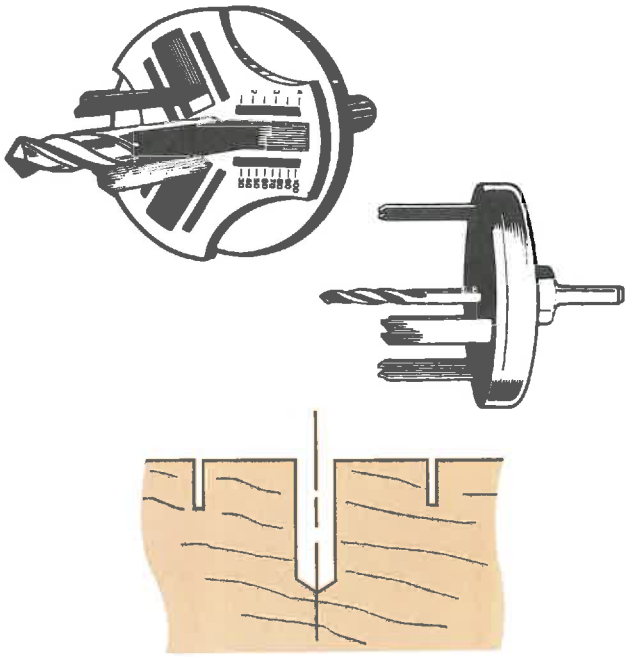


Figure 25-15. The adjustable dial saw has a center drill and three cutter arms. Use them in a drill press. *(Brodhead-Garrett)*

other end is a square tang or round shank. See **Figure 25-17.** Even though metric screw heads are formed at a 90° angle, the 82° countersink works equally well in wood.

Multioperational bits

Multioperational bits include ***Screw-Mate® drills*** (Refer to *Figure 16-30*) and ***countersink/counterbore cutters***. See **Figure 25-18.** Screw-Mates drill pilot holes and clearance holes for wood screws. Countersink/counterbore cutters drill, countersink, and/or counterbore at the same time. Countersinks leave the bottom of the hole at 82°. Counterbore cutters leave a square (90°) shoulder. Use this if you want a nut and washer or round head screw below the surface.

Plug cutter

Plug cutters make plugs to cover mechanical fasteners in counterbored holes. See **Figure 25-19.** Sizes are 3/8", ½", and 5/8". Metric bits are available in relative millimeter sizes. Counterbore holes with one of these sizes. Use the same wood species as your cabinet for the plug and match wood grain both in color and direction. Contrasting wood may be used for highlighting where the plugs are artfully arranged.

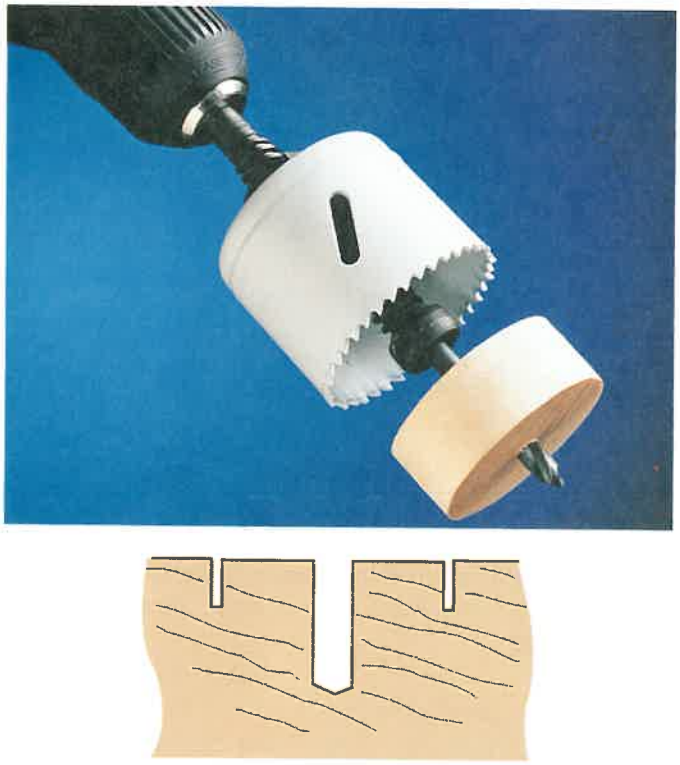


Figure 25-16. Hole saws. *(The L.S. Starrett Co.)*

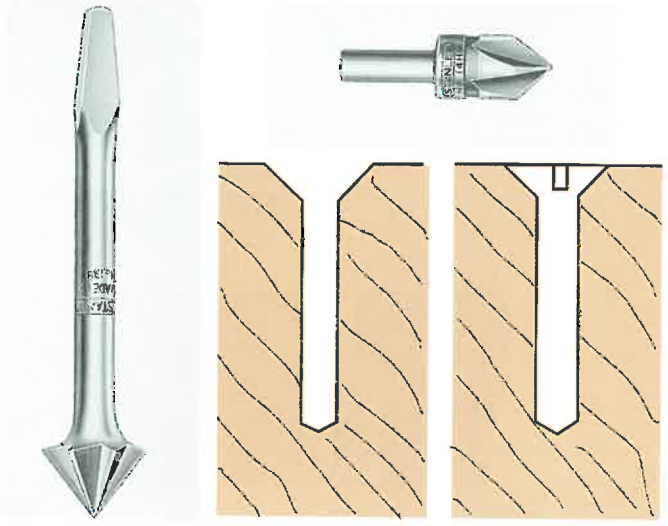
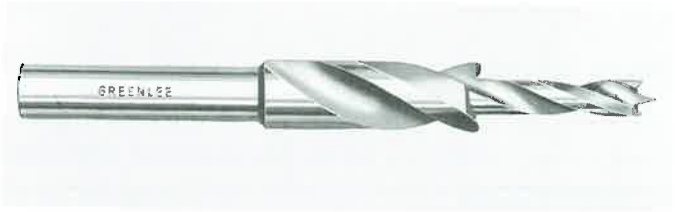
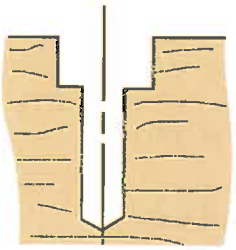
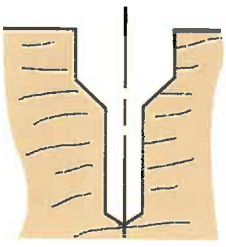


Figure 25-17. Countersinks angle the end of a hole to accept flat head screws. *(Stanley Tools)*





Counterbore



Countersink

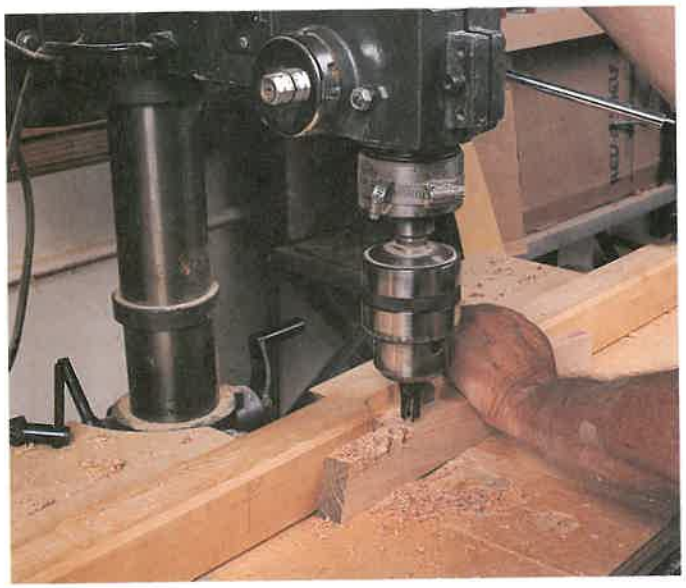
Figure 25-18. Counterbore bits drill two size holes at one time. Multioperation countersinks drill clearance, countersink, and possibly counterbore holes. *(Greenlee)*

Star drill

A ***star drill*** makes holes in concrete for cabinet installations. See **Figure 25-20A.** Typical diameters are ¼" to 1". Metric bits are available in relative millimeter sizes. Tool lengths vary. Power star drills fit in portable power hammer drills.

Masonry drill

Masonry drills have carbide tips. They drill holes in concrete and ceramic materials. See **Figure 25-20B.** Use a masonry drill to make holes for screw anchors to install cabinetry to concrete walls. Also drill ceramic tile surfaces with masonry drills. Diameters range from ¼" to ¾". Metric bits are available in relative millimeter sizes.



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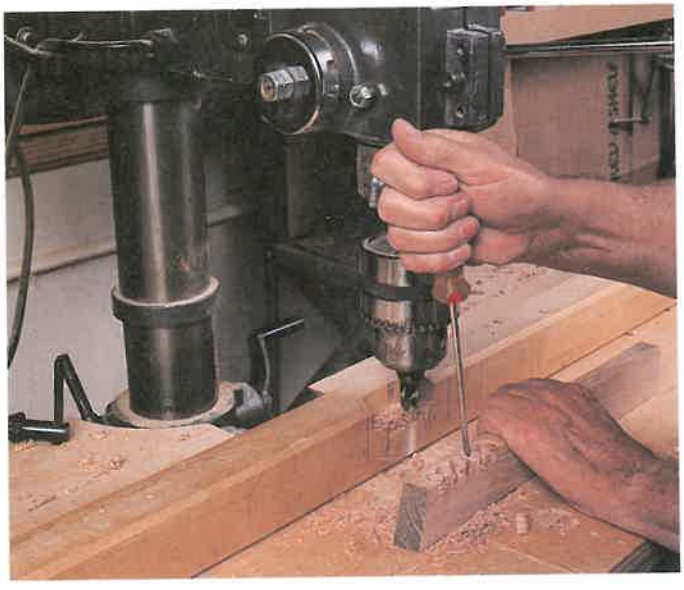


B

Figure 25-19. A—Make tapered plugs to cover counterbores. Make sure to match workpiece grain and color. B—Snap plugs from workpiece with a narrow blade screwdriver. *(Chuck Davis Cabinets)*

Glass drill

Glass can be drilled with a spear-shaped, carbide-tipped ***glass drill.*** See **Figure 25-21.** Various sizes are available for drilling holes to mount hardware. Tempered glass cannot be drilled.

Bell hanger's drill

Drill extra long holes with a ***bell hanger's drill.*** See **Figure 25-22.** There are two types. One has a tang and is used in a brace. The other has a round shank for a drill press or portable drill.

Bell hanger's drills are sized from ¼" to ¾" in diameter. Shank sizes vary from ¼" to 3/8". Lengths are 12", 18", 24", and 30". Metric bits are available in relative millimeter sizes. Some are available with carbide tips to drill in concrete.

Drill extensions

Drill extensions allow you to make long holes with standard drills and bits. See **Figure 25-23.**

A

B

Figure 25-20. A—Star drill. B—Masonry drill. *(Vermont American Tool Co.)*

Figure 25-21. Glass drill.

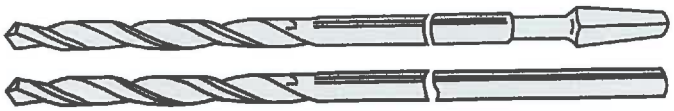


Figure 25-22. Bell hanger's drills are 18" (457 mm) long. Some have a straight shank and others have a tang.

These extensions are 18″ or 450 mm long. The shank may be round or six-sided for a portable power drill. Do not use drill extensions in a drill press.

Hand Tools for Drilling

Drilling by hand is done with three tools. These tools are braces, hand drills, and push drills.

Brace

A *brace* holds only square tang bits. See **Figure 25-24.** Turning the chuck tightens two angled jaws that grasp the tang. The sweep of the brace's bow determines the size of the brace. Sweep is the diameter of the circle made as you rotate the handle. A box ratchet on the chuck allows you to drill next to a wall or corner without a full circle swing.

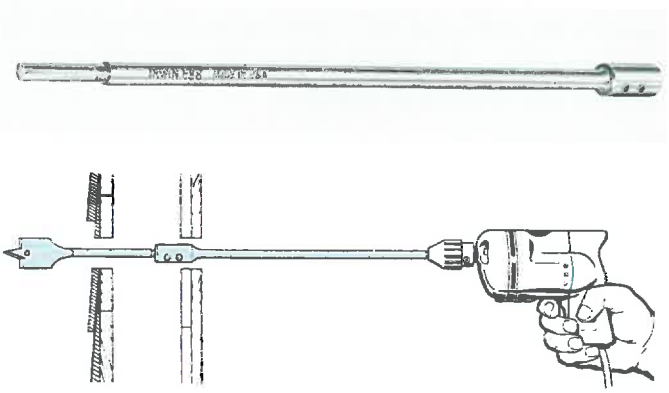


Figure 25-23. Portable power drill extensions lengthen the drill bit's reach. *(Irwin)*

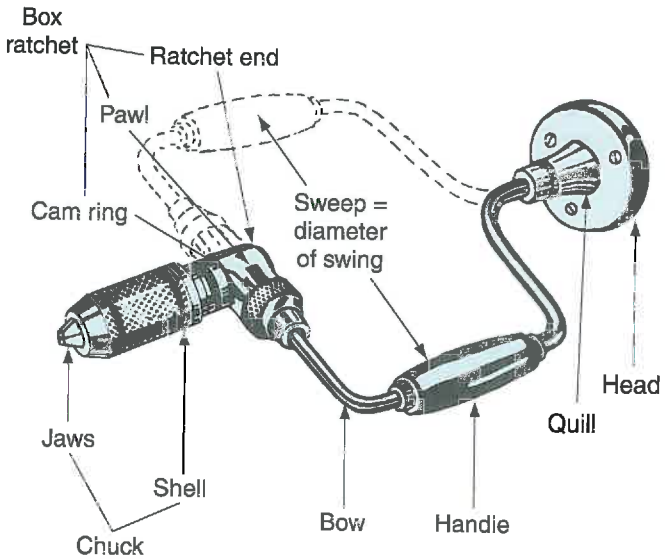


Figure 25-24. Parts of a brace. *(Stanley Tools)*

Hand drill

A *hand drill* holds round shank twist drills in a three-jaw chuck. See **Figure 25-25.** A crank and handle rotate the chuck while the top handle is held securely to steady the tool. Some have storage for drill bits inside the handle.

Push drill

A *push drill* is operated with one hand. See **Figure 25-26.** A spring mechanism turns the chuck as you push on the drill. Drill points are used with the push drill for making small holes, such as pilot holes for screws. To change points, press the locking ring so the knurled chuck slides down. The point can then be inserted. Some models store points in the handle.

Stationary Power Machines for Drilling

Nearly all production and custom cabinetmaking shops use stationary power drills. Even the home woodworker is likely to have a floor or bench model drill press. It is more accurate than hand and portable drills. It is much easier to control depth, drilling angle, and positioning.

Drill press

The *drill press* is the most common vertical stationary power drill used by cabinetmakers. See **Figure 25-27.** The table clamps to the column and slides up or down as needed. It can also tilt for drilling at an angle. The motor drives the spindle

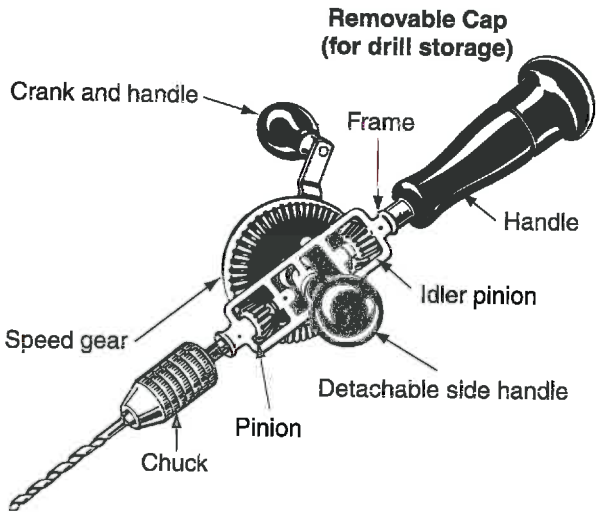


Figure 25-25. A hand drill is satisfactory for making holes up to 3/8″ (10 mm). *(Stanley Tools)*

A

B

Figure 25-26. A—Push drills are very efficient for drilling small holes. B—Insert bits in the push drill by pushing the knurled chuck forward. *(Chuck Davis Cabinets)*

and chuck. Change drilling speed by moving belts on motor and spindle step pulleys or turn a variable rate handwheel.

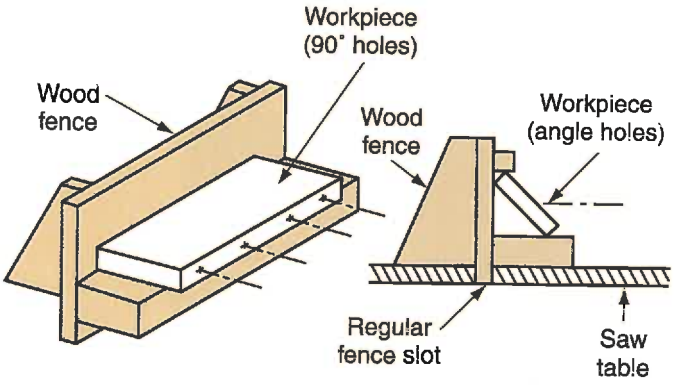
Drill presses are specified by the distance between the chuck and the column, multiplied by two. For example, a 20″ (508 mm) drill press has a distance of 10″ (254 mm) between the chuck and column. It can drill a hole in the center of a 20″ (508 mm) diameter circular workpiece.

Bits are clamped in the chuck and fed into the workpiece with the feed control lever. Most drill presses have a ½″ (13 mm) shank capacity chuck. The spindle's depth of travel can be limited using the depth stop.

Figure 25-27. Vertical drill press. *(Ryobi America Corp., Black & Decker Corp.)*

Radial arm saw

The versatility of the ***radial arm saw*** makes it a drilling machine. See **Figure 25-28.** Thread a chuck on the motor arbor and place the workpiece against the fence. The yoke clamping levers and scales align the drill. Push the motor assembly toward the column when drilling. You may want to clamp the



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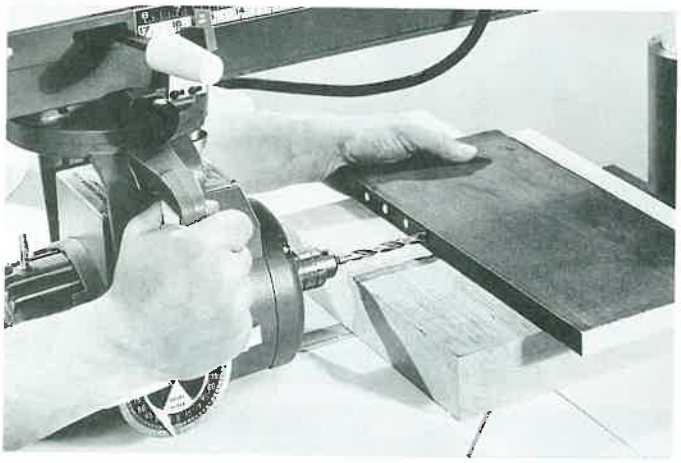


B

Figure 25-28. The versatile radial arm saw can be used as a horizontal boring machine. Make attachments that clamp to the table. These hold the workpiece at the proper angle. *(DeWalt Industrial Tool Co.)*

workpiece to the fence when drilling at angles other than 90° to the fence. Use only bits that are designed for high speed use.

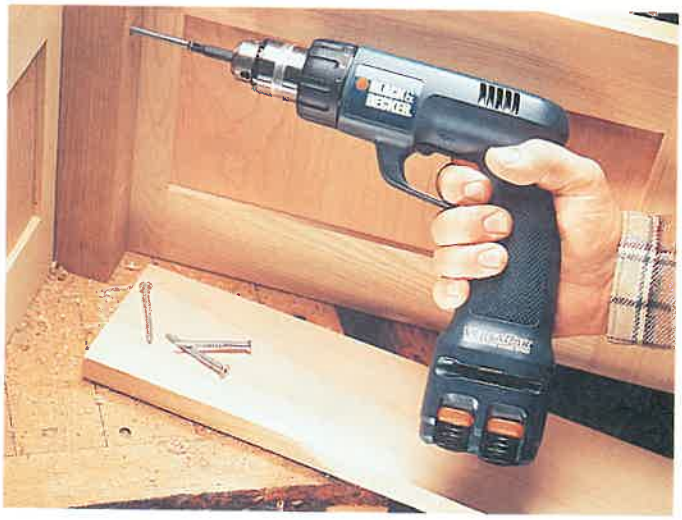
Portable Power Tools for Drilling

Portable power tools are a quick way to make holes. Although not as accurate as stationary drills, they take little setup time. A portable drill can often fit in enclosed spaces and tight corners.

Portable power drill

The ***portable power drill*** is the most used portable drilling tool. There are many types and shapes. See **Figure 25-29.** Some are light and require only one hand for operation. Others require two hands to control the drill. A cordless, battery operated drill offers added flexibility. Have a second battery charging just in case. Smaller, hand-held drills are available for power screwdrivers and light

A



B

C

Figure 25-29. A—Portable power drill. B—Cordless drill and power screwdriver. C—This battery operated drill has an adjustable, five position clutch for matching drill torque to workpiece. This prevents it from stripping screws when using a screw bit. *(Black & Decker Corp.)*

duty drilling. Refer to *Figure 16-23*. For tight corners, use a right angle drill or a right angle accessory mounted on a standard drill. See **Figure 25-30.** Motor sizes range from 1/7 ***horsepower (hp)*** to 2/5 hp. Using a light duty drill for heavy work may burn out the motor. The drill housing may be double insulated to prevent shock. Those which are not double insulated should have a three wire cord and grounded plug.

Drills are one, dual, or variable speed. Variable speeds allow you to start holes at a slow speed and then drill through at a high speed. Some are reversible so you can back out the bit or unscrew fasteners. A trigger switch lock maintains the speed when you remove your finger. However, this can be dangerous if the bit binds. The bit stops, but the drill will still try to turn.

A

B

Figure 25-30. A—Right angle drill. *(Makita U.S.A., Inc.)* B—Right angle drive for power drill. *(General Manufacturing)*

Chuck sizes range from ¼" to ½" (6 mm to 13 mm). You may need to use a large diameter bit with a power drill having a small chuck. Then choose a bit with a reduced shank size.

Portable power drills can be mounted vertically in a stand. See **Figure 25-31.** This setup is not as accurate as a drill press. However, it is convenient. Use a portable drill with a trigger lock. Lock the drill *on*. Hold the workpiece with one hand and operate the feed lever with the other. After drilling, a return spring will help raise the drill.

Hammer drill

The ***hammer drill*** turns and hammers on masonry bits to make holes in concrete. See **Figure 25-32.** Cabinetmakers use this tool when setting screw anchors for hanging cabinets on concrete walls. Masonry bits will also work with standard portable drills, but using the hammer drill is quicker.

Drilling and Boring Holes with Hand Tools

Select the proper drilling tool for the bit you wish to use. For inserting bits in a brace, unscrew the

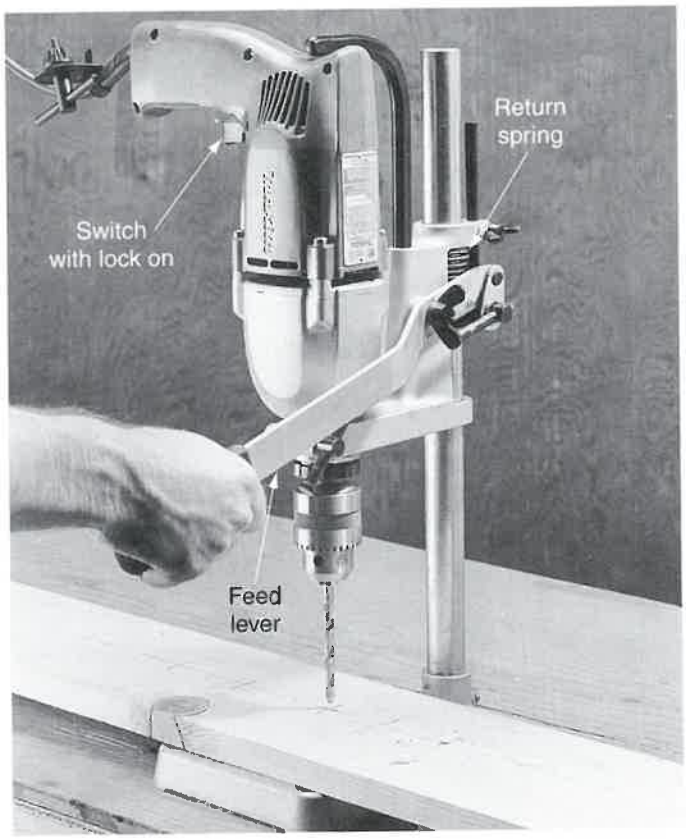


Figure 25-31. A drill press stand converts a portable drill into a drill press. *(Makita U.S.A., Inc.)*

chuck shell and insert a bit with a tang. Turn the shell clockwise until the bit is snug. See **Figure 25-33.** For drilling small diameter holes, use a hand drill and select a straight shank drill bit.

Secure workpieces in a vise or with clamps when drilling large holes or holes at angles. Vise jaws covered with wood blocks are recommended. See **Figure 25-34A.** This reduces damage to the workpiece when tightening the vise. Flat workpieces can be held between the vise and a bench stop. Hold or clamp cylindrical workpieces in a V-block or V-shaped grooves in the vise. See **Figure 25-34B.**

Keep the tool at the proper angle when boring. Use both hands. See **Figure 25-35.**

Before boring, use a scratch awl to make a small dent at the hole layout mark. This helps center the bit point. A try square or T-bevel can help keep the bit aligned.

Figure 25-32. Hammer drills create holes in concrete for basement cabinet installations. *(Black & Decker Corp.)*

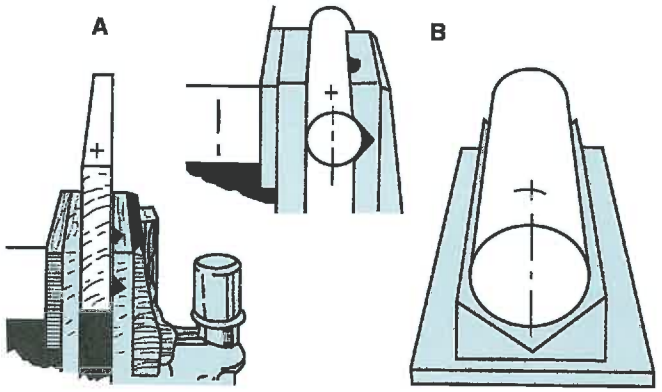


Figure 25-34. Clamp or hold the workpiece securely when preparing to drill. *(The Stanley Works)*

Figure 25-33. For both a brace and hand drill, install the bit and tighten the chuck by hand.

Figure 25-35. Hold the drill at the proper angle. *(The Stanley Works)*

If the hole will be drilled through the material, clamp a backing board under the workpiece. This prevents splintering when the bit cuts through the opposite face. See **Figure 25-36.**

Sometimes it is not convenient to place waste stock behind the workpiece when boring a through hole. In this situation, you must bore from both sides. Bore from one face until the feed screw or point of the bit breaks through the opposite face. See **Figure 25-37A.** Complete the hole, boring from the other side. See **Figure 25-37B.**

A blind hole does not go through the workpiece. Use a depth gauge, drill stop, or tape to limit how far the bit enters the workpiece. See **Figure 25-38.** A ***depth gauge*** clamps onto the bit. A ***drill stop*** slips over the bit and is secured with a set screw. For less precise depth, wrap a few turns of masking or electrical tape around the bit.

To bore holes at an angle, start the bit vertical. Once it penetrates the surface, tilt it to the required angle. Check your angle using a T-bevel. When multiple holes need to be drilled at an angle, make a boring jig. A simple jig is a block of wood with an angled hole. Clamp the jig to the workpiece and drill through the jig. See **Figure 25-39.**

Drilling and Boring with the Drill Press

The general procedure for drilling and boring with the ***drill press*** is as follows:

1. Set the drill press speed. A chart on the machine shows you how to move the belt on the pulleys to change speed. Drill speeds for certain bits and sizes are shown in *Figure 25-2A* and *Figure 25-2B.*
2. Insert the bit in the chuck. A chuck key is used to tighten the chuck. Remember to remove the chuck key before using the drill.
3. Clamp your workpiece to the table when drilling large holes, holes at an angle, or when using saw tooth and adjustable bits. See **Figure 25-40.** Lower the bit with the feed lever and align the tip with hole layout marks. Back the workpieces if the hole is to be bored through.
4. Adjust the table. Move the table so the bit is ½" (12.7 mm) above your work. Support the table as you loosen the column clamp. The table is heavy and can injure you if it falls. When the table is positioned, retighten the clamp.

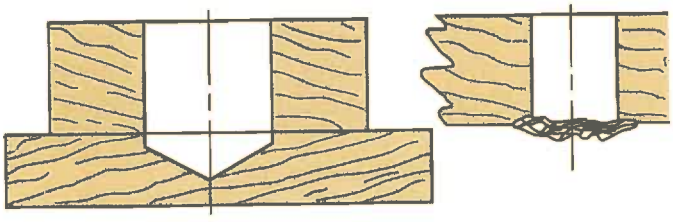
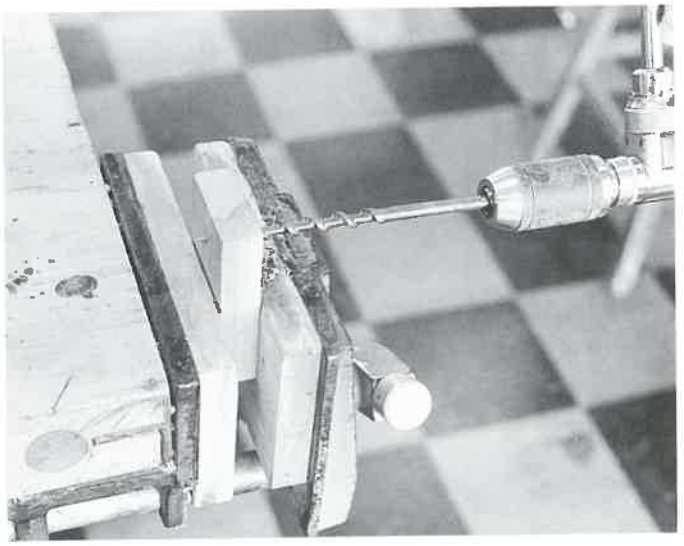


Figure 25-36. Back up your workpiece when drilling a through hole. Failure to do so may tear the wood.



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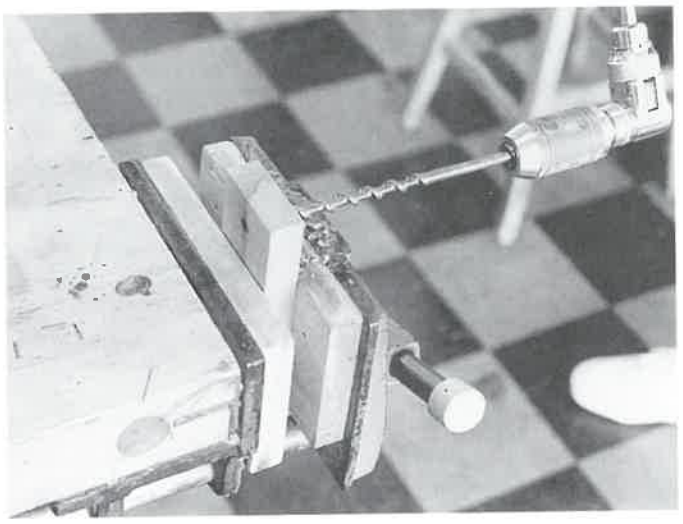

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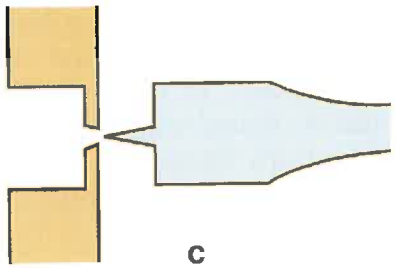
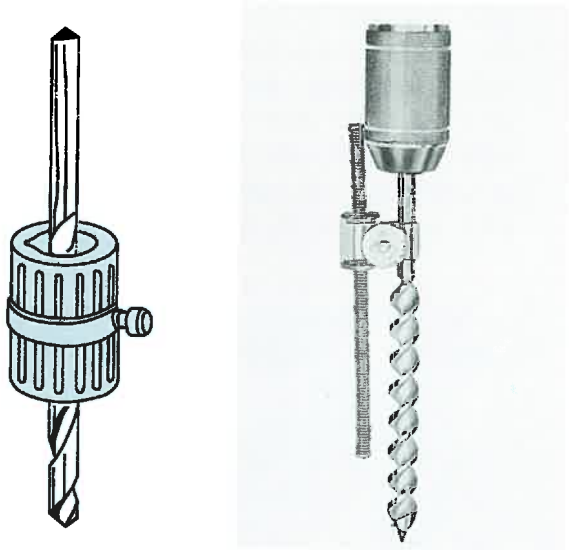


C

Figure 25-37. Boring a through hole by drilling from both sides. A—Bore until the feed screw breaks through the other side. B—Turn the workpiece around and bore the hole through.



A B

Figure 25-38. Two attachments for determining depth. A—Depth gauge. *(Stanley Tools)* B—Drill stop. *(General Hardware)*

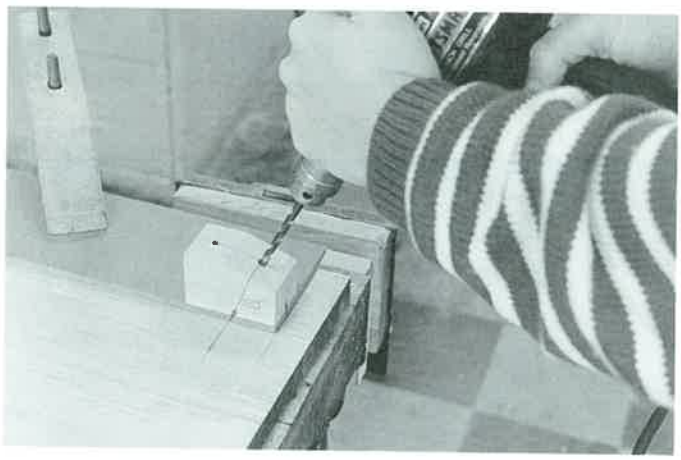
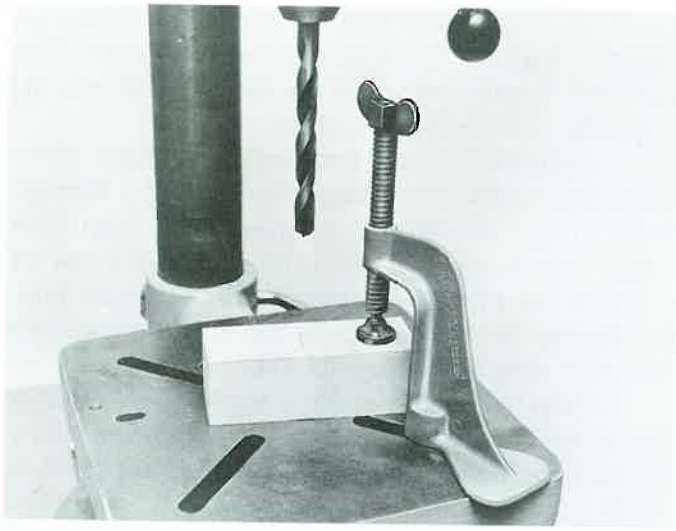


Figure 25-39. Angled holes can be accurately drilled with a jig.

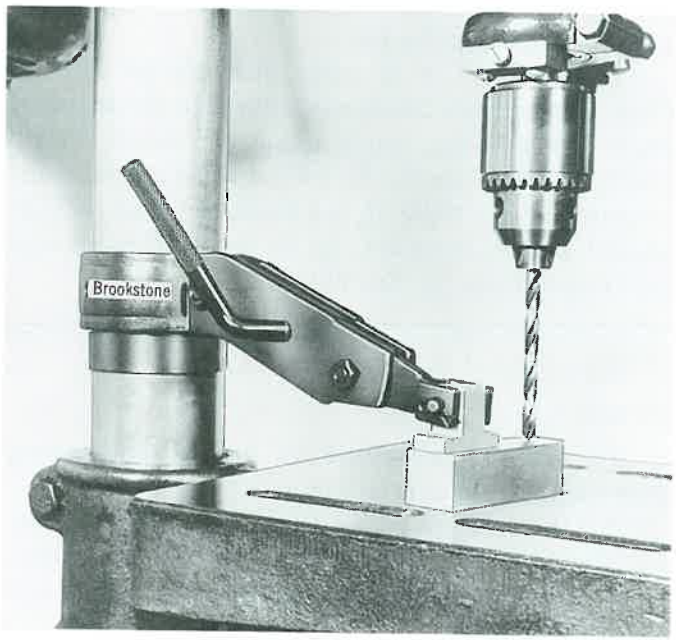
5. Turn on the motor.
6. Hold the workpiece tightly, if it has not been clamped.
7. Turn the feed lever to lower the bit into the workpiece. Feed the bit in at a moderate rate. If you see dust instead of wood chips, you are feeding too slow, or the bit is dull. In either case, heat is created which can further dull the bit and/or burn the wood.
8. When the hole is complete, raise the bit.

Drilling deep holes

Often, deep holes are required. Bore first with a standard twist drill. Then use a bell hanger's drill of the same size. The length of spindle travel on the drill press is only about 6". You will need to raise the table after each feed.



A



B

Figure 25-40. Clamp the workpiece securely. A—Hold down clamp. *(Adjustable Clamp Company)* B—Quick clamp. *(Brookstone Co.)*

Another method to bore deep through holes is to bore from both ends. This can present problems when aligning the second hole. The first hole bored must be directly under the drill. To do this, you make a jig. The following procedure illustrates drilling a 3/8" (9.5 mm) hole through a lamp stand:

1. Cut a board the size of the drill press table. Drill a ¼" (6.3 mm) hole in the center.
2. Insert a 3/8" (9.5 mm) dowel in the drill press chuck. It should be a few inches longer than the workpiece.

3. Put a 3/8" (9.5 mm) plug cutter with a ¼" (6.3 mm) shank in the ¼" (6.3 mm) jig hole.
4. Place the jig on the table just beneath the dowel.
5. Lower the dowel onto the plug cutter. Align the jig with the drill press chuck. See **Figure 25-41A.**
6. Remove the dowel and replace with a 3/8" (9.5 mm) twist drill.
7. Replace the plug cutter with a countersink.
8. Layout the centers of the workpiece ends and mark them with a scratch awl.
9. Position the lower end of the workpiece on the countersink. See **Figure 25-41B.**
10. Hold the workpiece firmly and turn on the machine. Lower the drill to align with the center of the upper end of the workpiece. Then drill as deep as possible.
11. Raise the bit, turn the workpiece over, and drill from the other end. See **Figure 25-41C.**
12. For very long parts, insert a bell hanger's drill in the chuck after drilling from both ends to complete the hole.

Drilling at an angle

Drill holes at an angle by tilting the machine table or using a fixture. To tilt the table, loosen the tilt control and set the table using a T-bevel or protractor with a level. See **Figure 25-42.** Then tighten the tilt control. Clamp the workpiece with the hole mark centered under the bit. Then turn on the machine and make the hole. See **Figure 25-43.**

A tilt fixture has two boards, hinged at one side, with slides clamped to hold the top boards at an angle. See **Figure 25-44.** Clamp the bottom board to the table. Set angles for both the fixtures using a protractor with level.

Installing the secondary table fixture on a tilted table is an added convenience. You are able to drill compound angles. See **Figure 25-45.**

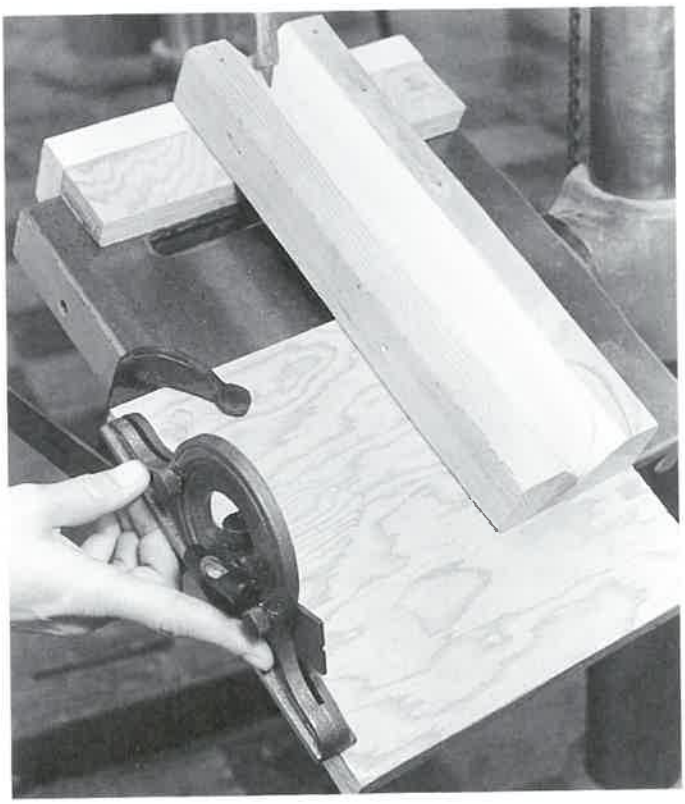


Figure 25-42. Use a protractor with level to set the table angle.

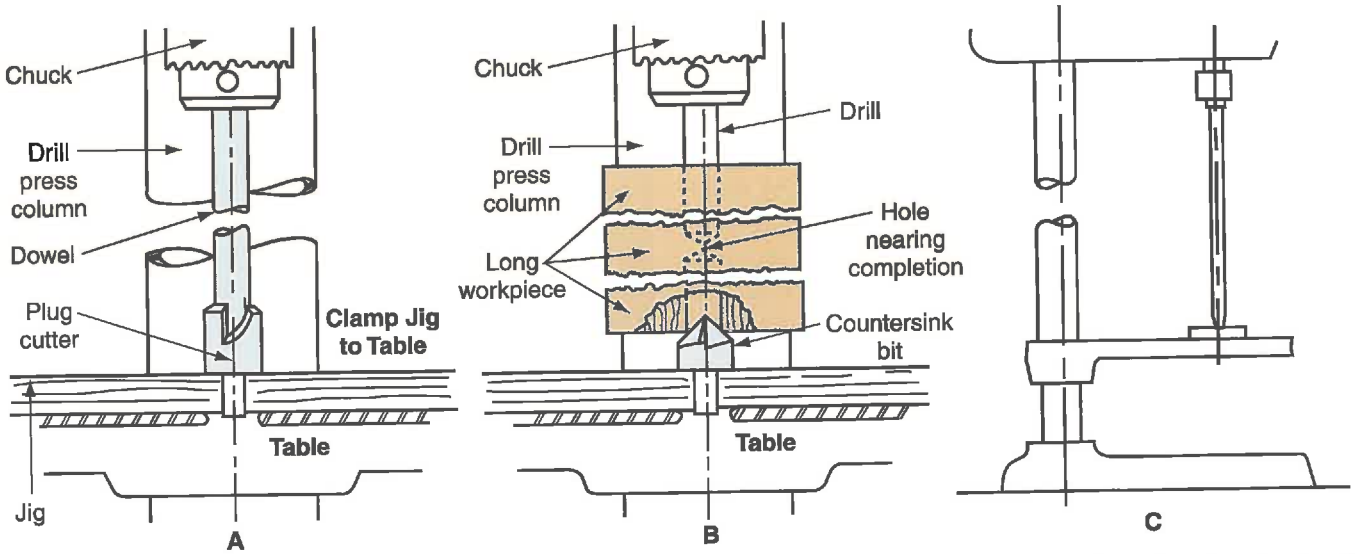


Figure 25-41. Dowel and drill alignment are critical when drilling from both ends. A—Align a dowel in the chuck with a plug cutter in the jig. B—Insert the workpiece between the bit and a countersink bit inserted in the jig. C—As the hole nears completion, it should align precisely.

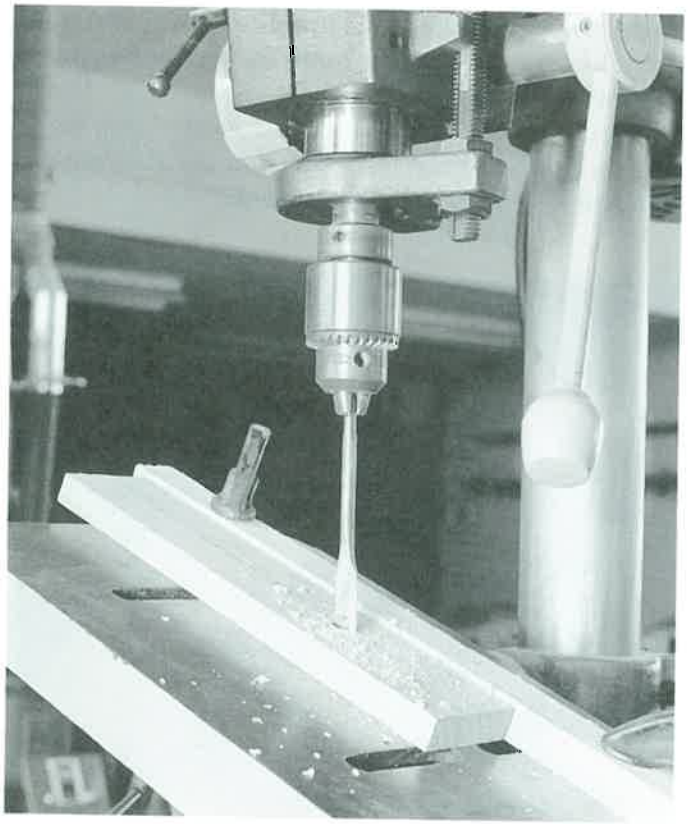


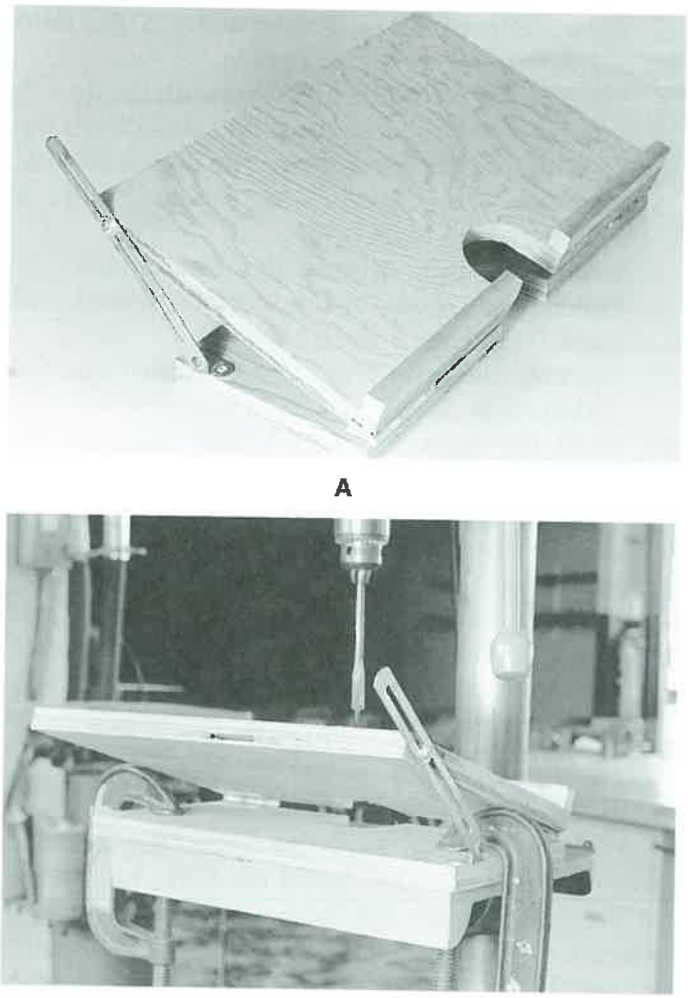
Figure 25-43. Drilling at an angle with a spade bit.

Bits with long centerpoints and Forstner bits will enter the workpiece at an angle rather easily. Simply mark the hole using a scratch awl and bore the hole. Twist drills lack a long centerpoint. Therefore, they may tend to bend out of position when you start to drill. Small diameter drills can be damaged or broken. Feed carefully, or use another type of bit if you have a choice.

Drilling blind holes

A blind hole does not go through the workpiece. Drill presses have an ***adjustable scale*** and *stop* to limit bit travel. See **Figure 25-46.** A depth scale shows how far you lower the spindle. However, it is best not to use the scale because of different bit lengths and table heights. The scale reading can be inaccurate. Instead, mark the depth on the edge of the workpiece. Then lower the bit beside the workpiece until the cutting lips are in line with the mark. See **Figure 25-47.** Turn the two threaded depth collars until they stop. While drilling, the feed lever will not move past the preset depth.

You can also use a depth gauge, bit stop, or tape to mark how far the bit should enter the workpiece. A depth gauge clamps onto the bit. A bit stop slips over the bit and is secured with a set screw. Refer to Figure 25-38.



A

B

Figure 25-44. A—Fixture for drilling at an angle. B—Raise the jig and tighten the slides.

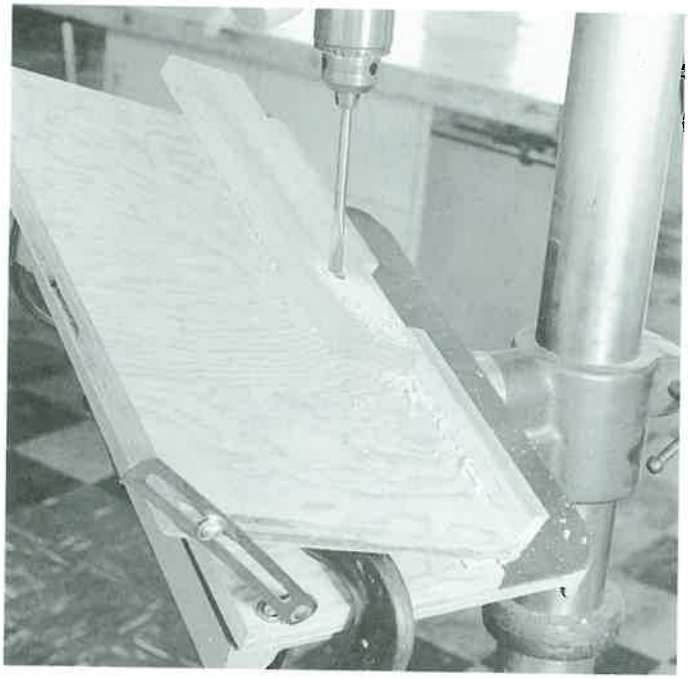


Figure 25-45. Both the jig and table are tilted for compound angles.

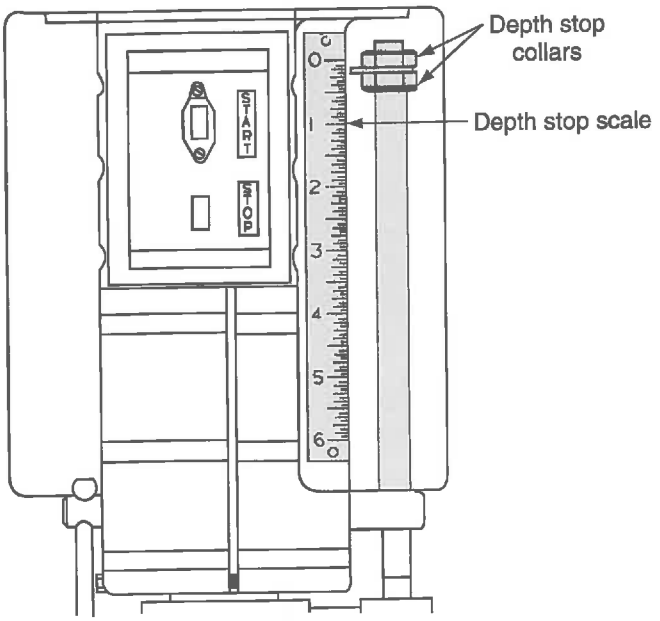


Figure 25-46. Depth stop on drill press stops the feed lever from turning at preset depth. *(Powermatic)*

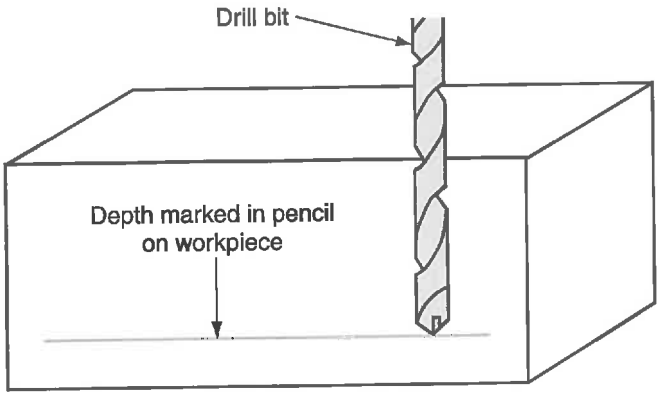


Figure 25-47. Set depth by lowering the bit next to the workpiece, then adjust depth collars.

Many cabinet designers have made good use of low-voltage halogen lights. With blind holes you can add lighting under kitchen cabinets and inside moveable or built-in display cases. When adding light to a display case, plan to install glass shelves. When the light fixture is under the cabinet, a blind hole must be bored to a specified depth. See **Figure 25-48A.** Bore the hole approximately 4" (102 mm) from the front edge of the bottom panel. A typical depth for a 12-volt, 20-watt halogen light is 5/8" (15 mm). Bore a second blind hole from the back edge of the panel to provide for passage of the wire from the light to the remote transformer. You may need additional holes for electrical wiring. See **Figure 25-48B.**

Blind holes are used for Euro-style hinges. Multiple spindle boring and insertion machines make precise location of the hinge cup hole and two screw holes. When you bore finished doors, hinges to be secured with plastic dowels may be mounted on the boring and insertion machine's ram. After the holes for one hinge are bored, swing the ram under the boring bits and again lower the machine to the door. Press the hinge and plastic dowels into the door. The machine has a precise depth stop that is factory set. See **Figure 25-49.**

Drilling round workpieces

Round workpieces should be held in a V-block. The *V* must be centered under the drill. If drilling at an angle, clamp the workpiece to the block. See **Figure 25-50.**

Drilling equally spaced holes

Drilling equally spaced holes can be done either of two ways. You could lay out all the hole locations. However, this is time-consuming. A more efficient method is to make a jig.

One useful jig for equally spaced through holes has a stop block. See **Figure 25-51.** After drilling the first hole in the workpiece, insert a dowel rod in the hole. Then move the workpiece until the dowel hits the stop block. This works for both blind holes and through holes. The distance between the drill bit and the top block determines the distance between holes.

For small holes, replace the dowel with a nail or bolt the same size as the drill bit. For example, when drilling evenly spaced ¼" (6.3 mm) holes for shelf clips, use a ¼" (6.3 mm) diameter bolt. This procedure is not recommended for *32 mm System* holes due to the accuracy required in hole spacing. Many manufacturers provide jigs with steel guide bushings that can be used with portable power drills for mounting hinges and drawer slides. A multiple spindle line boring machine speeds work with the degree of accuracy required. See **Figure 25-52.**

Wood chips can interfere with accuracy when positioning the workpiece against a solid fence. Consider using three or more dowels as a fence. See **Figure 25-53.** Accumulated chips are pushed aside easily.

When counterboring, you only enlarge one end of a hole. This is done so the screw or bolt head sits below the wood's surface. You can hide the hole with a plug or button. The best method for counterboring is to drill the large-diameter counterbore hole first. Then drill the smaller clearance hole.

A

B

C

D

Figure 25-48. Installing low voltage halogen light. A—Boring 58 mm diameter blind hole to receive the light fixture. B—Boring hole for installation of wire. C—Assembled cabinet ready for finishing. Install light and wire before installation of cabinet. D—A completed low voltage light installation. *(Chuck Davis Cabinets)*

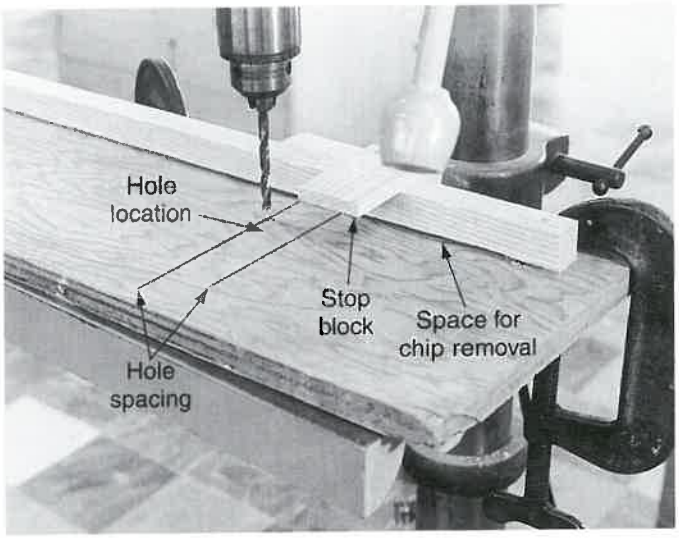
Drilling glass

Glass is a difficult material to drill. However, you may need holes for mounting glass door hinges and pulls. One method of drilling glass is shown in **Figure 25-54.** Mark the hole location with crayon or a glass marker. You could also attach masking tape and mark on it. Next, clamp the glass panel on the drill press table with the mark directly under the drill. You must have a special carbide glass drill. The glass needs to remain cool while drilling to prevent cracking. Do so by putting kerosene within a putty dam. The backing board keeps you from losing kerosene until the hole is finished. Drill at a slow speed (500 rpm to 800 rpm).

Drilling with Portable Drills

Portable drills are popular for cabinetmaking. Many of the procedures for hand and stationary drilling machines hold true for portable tools. With portable drills, disconnect power before installing bits. As a reminder, attach the chuck key to the cord near the plug. Mark the holes using a scratch awl to center the bit. Use a vise or clamp to secure the workpiece. Use a V-block for cylindrical work. When drilling angles, use an angle jig, like the one for hand drills, to guide the bit. Drill larger holes at a slower speed and use two hands to hold the drill.

Figure 25-49. Boring blind holes for insertion of Euro-style concealed hinges. *(Chuck Davis Cabinets)*



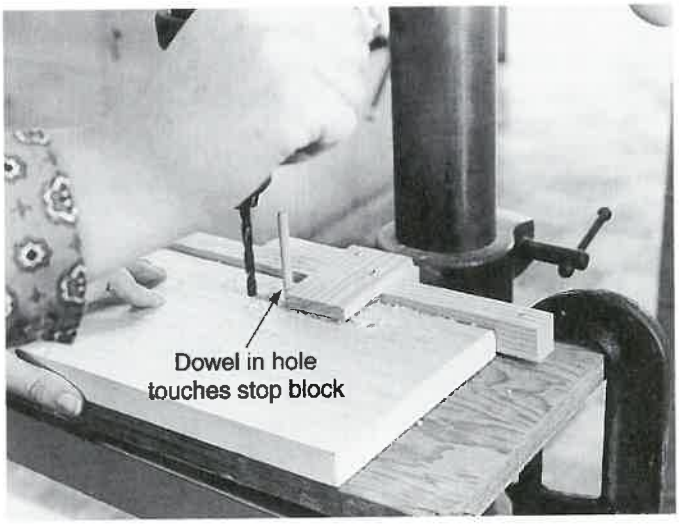


Figure 25-51. Use a jig for drilling equally spaced holes. Insert a dowel in the previously drilled hole. Move workpiece until dowel hits stop block to measure off distance between holes.

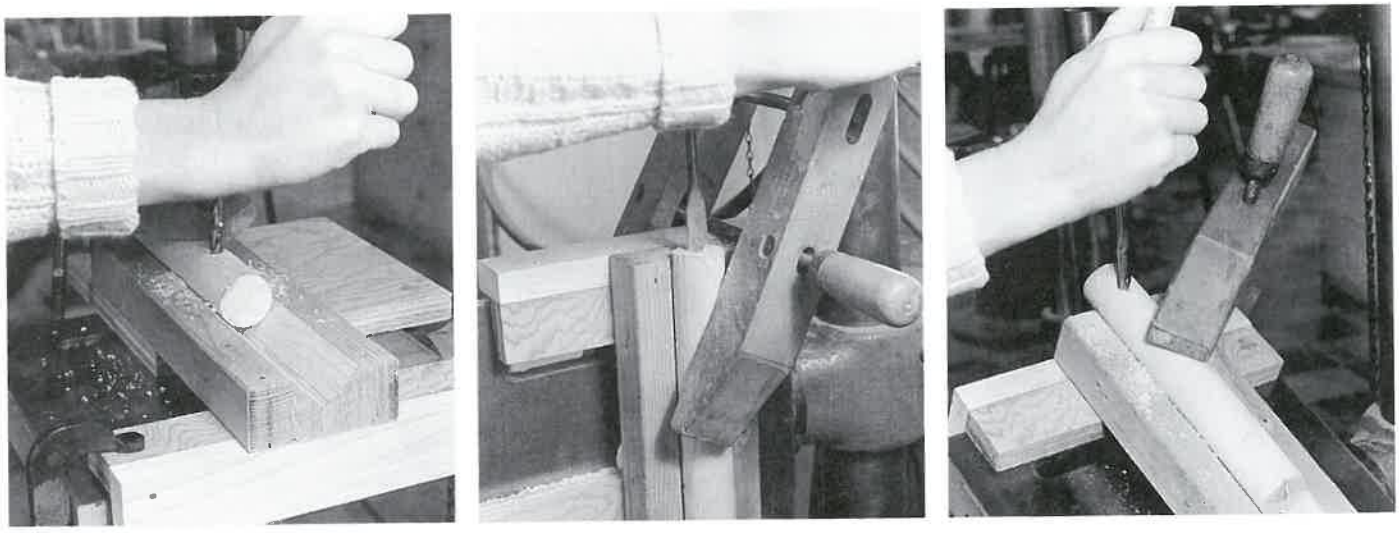


Figure 25-50. Drilling cylindrical workpieces. A—Horizontal. B—Vertical. C—Angled.

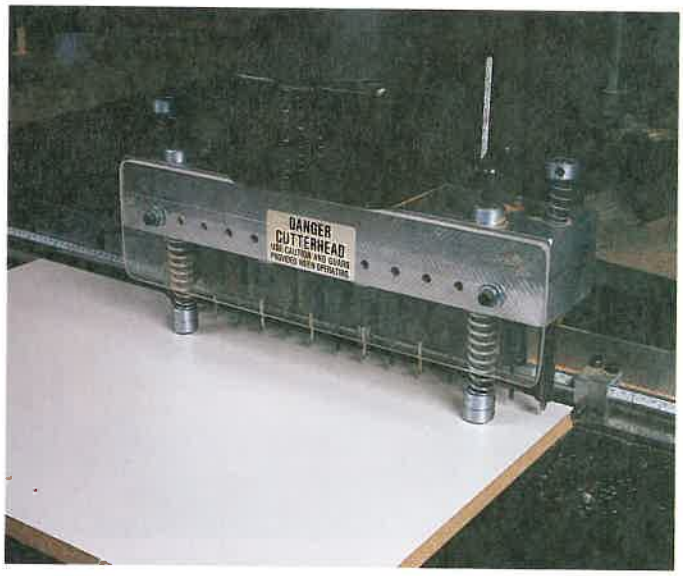


Figure 25-52. Equally space holes for 32 mm System holes are accurately and rapidly made with a multiple spindle line boring machine. *(Chuck Davis Cabinets)*

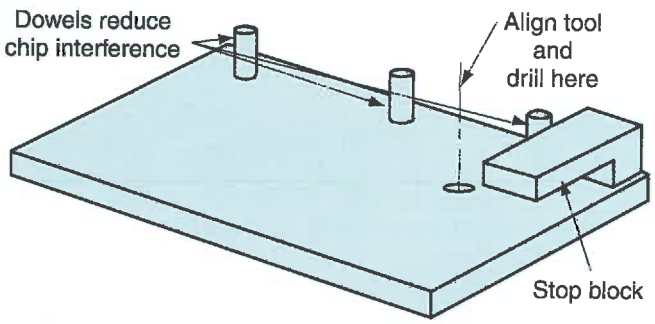


Figure 25-53. A dowel fence on a jig lessens the interference caused by accumulated wood chips.

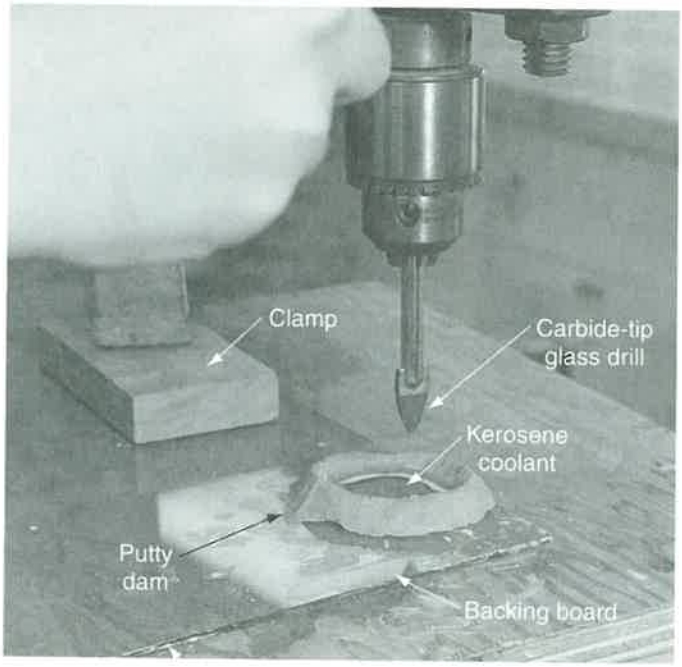


Figure 25-54. Setup for drilling glass.

Drilling holes in line is more difficult with portable tools. With a drill press, you can set up a fence. With a portable drill, use a jig. Mark lines on the jig which help center it on the workpiece. Hold the workpiece and jig securely when drilling.

Maintenance

Maintenance involves keeping drill bits sharp, plus keeping hand and power tools lubricated and clean. Most drilling tools can be sharpened by the cabinetmaker using the proper file, stone, or grinding wheel. The cabinetmaker must compare the cost of shop labor and lost production to the cost of bit replacement. For lubrication requirements, refer to the equipment instruction manual.

Sharpening bits, drills, and cutters

Bits, drills, and cutters are sharpened with files or abrasives. Those made of high-speed steel marked (HS or HSS) cannot be sharpened with a file. They would ruin the file teeth. If the bit is not marked, perform a simple test. Push the corner of the file lightly across the shank. If an obvious nick is made, the bit can be file-sharpened. If no mark is made, or a high pitch screeching is heard, the bit is hardened. It cannot be sharpened with a file.

High-speed steel bits are sharpened on the grinder. However, carbide-tipped bits cannot be sharpened on a standard wheel. In many cases, it may be less expensive to discard and replace the bit than to have it sharpened.

Before sharpening, check to see that the bit is straight. Sometimes drills and bits can be straightened. Support the ends and hold it firmly with the curve up. Then strike it with a mallet or hammer. See **Figure 25-55.** Tools marked HS or HSS may be straightened a few thousandths of an inch. Carbon steel drills and bits bend easier. However, if you cannot correctly shape the drill or bit, discard it. A bent bit will wobble, creating oversized holes.

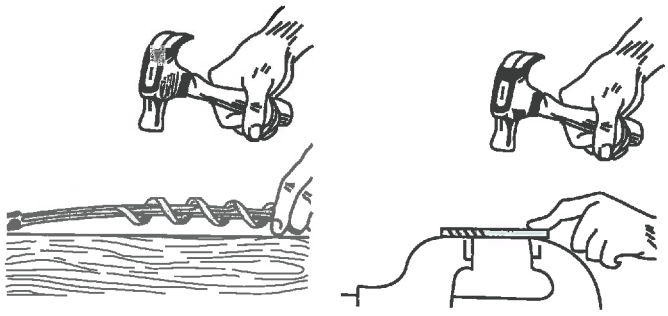


Figure 25-55. Often you are able to straighten drills with light mallet or hammer blows.

Sharpening an auger bit

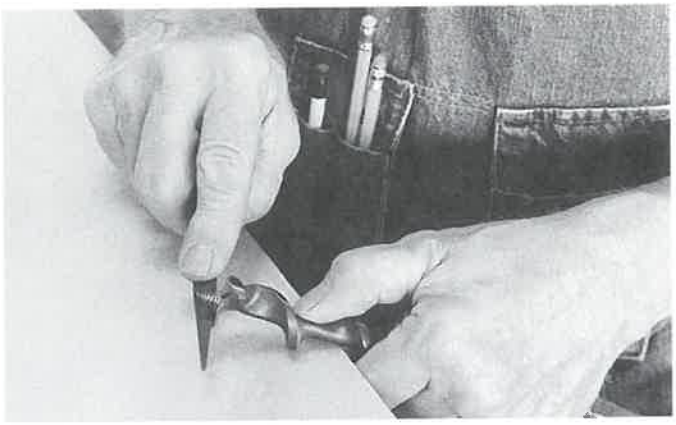
An auger bit can be sharpened with a file or small stone. An auger bit file is preferred. See **Figure 25-56A.** Only two surfaces at the end of the file have teeth. This prevents damage to adjacent surfaces.

File only four surfaces on the bit: both inside spur surfaces and the two cutting lips. See **Figures 25-56B and 25-56C.** Keep the spurs and cutting lips even. Use the same number of strokes on both lips and spurs.

Sharpening expansive and power bore bits

Use the auger bit procedure on expansive bits. File the adjustable cutting lip and spur while in a vise. A power bore bit is sharpened like the auger or expansive bit. Only the front edge of the cutting lip and spur is filed.

A



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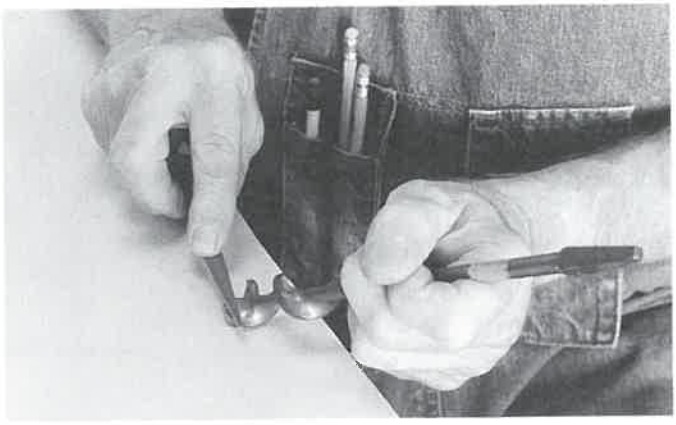


C

Figure 25-56. A—Auger bit file. *(The Cooper Group).* B—Sharpen only the insides of the spurs. C—Sharpen cutting lips from the top.

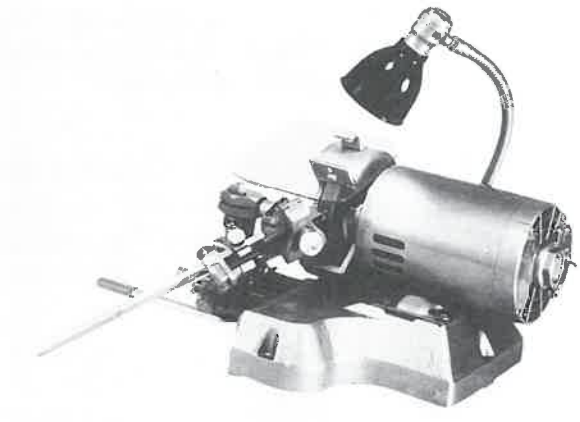
Sharpening twist drills

Twist drills are probably the most difficult bit to sharpen by hand. Therefore, jigs and machines are provided for this purpose. See **Figure 25-57.**

You can sharpen twist drills by hand with practice. Note the proper terms and angles shown in **Figure 25-58.** First, practice the following procedure with the grinder off. Hold the drill between the thumb and first finger of your left hand. Have the drill shank in your right hand. Place your hand on the bench grinder's tool rest. Point the drill toward the wheel arbor, not above or below it. Have the cutting lip horizontal. See **Figure 25-59A.**

Touch the drill against the wheel at the desired lip angle. As you grind, turn your right wrist about 30° clockwise. Also lower it to the left about 20°. See

A



B

Figure 25-57. A—Jig for sharpening twist drills. *(General Hardware)* B—Jig installed on bench grinder. *(Brodhead-Garrett)*

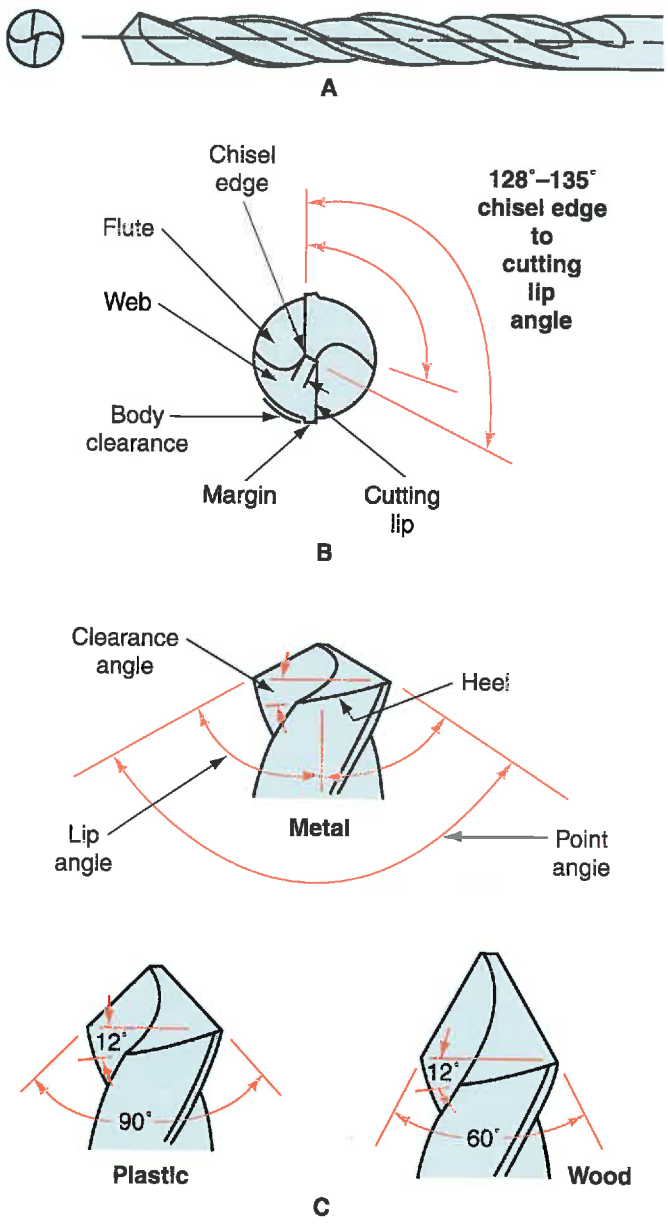


Figure 25-58. A—Side and end views of a twist drill. B—Critical twist drill angles from the end view. C—The point angle differs for metal, plastic, and wood.

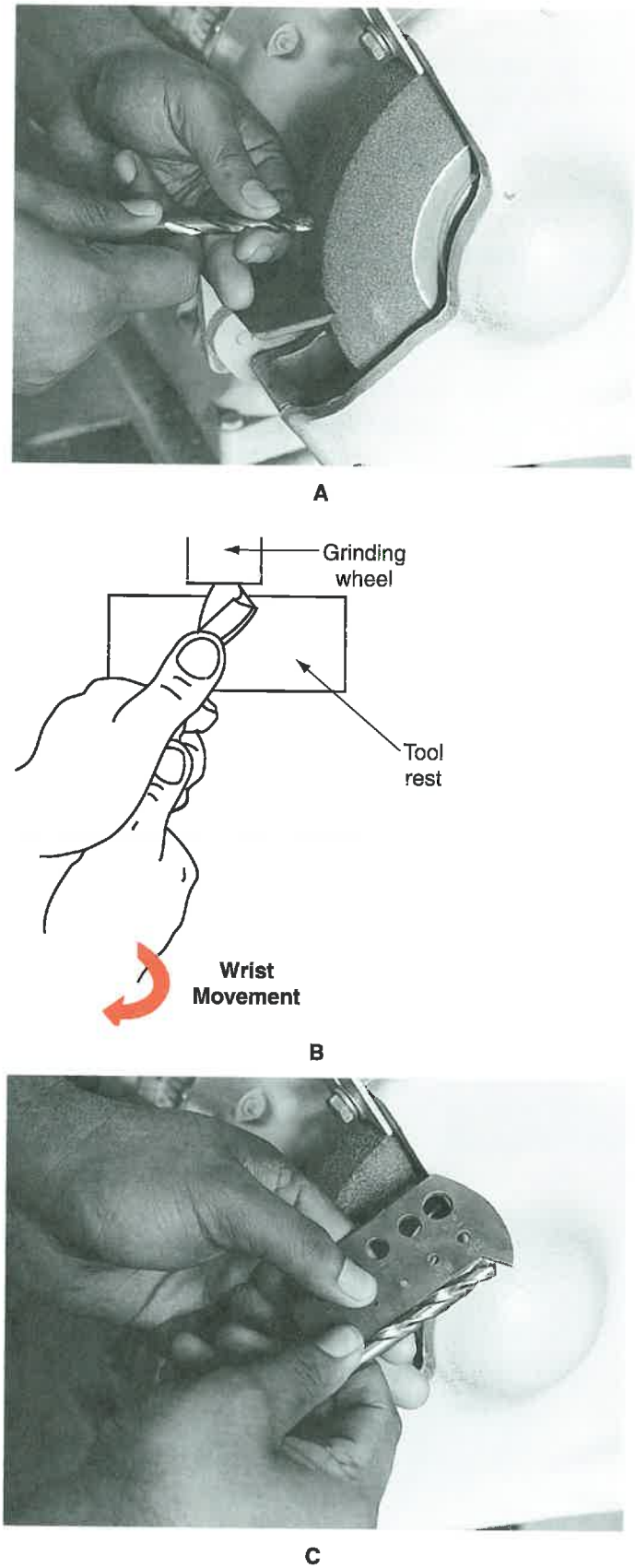


Figure 25-59. Grinding a twist drill. A—Align bit with center of wheel. Have the cutting lip horizontal. B—Place hand on rest and turn your wrist while grinding the clearance angle. C—Check the sharpened cutting lip angle with a gauge.

Figure 25-59B. Maintain grinder contact across the entire cutting edge. When finished, rotate the drill 180° and grind the other cutting lip. The cutting lips, point angles, and clearances must be the same. See **Figure 25-59C.**

Sharpening spade bits

Spade bits can be sharpened by grinding, honing, or filing. The two cutting lips must be even. There must be about a 10° clearance angle (angle back from cutting edge to other side of spade) on the lips and brad point. See **Figure 25-60.**

Sharpening the spur bit

A spur bit is sharpened by filing or honing the spurs and cutting lips. The spurs are sharpened like the auger bit. Both cutting lips are filed or honed evenly at the end of the bit. This maintains the 10° clearance angle. See **Figure 25-61.**

Sharpening a Forstner bit

Use an auger bit file and a hone. See **Figure 25-62.** File only the leading edges of the cutting lips. Hone only the inside surface on the sharpened rim. The surface is very narrow so you can only remove the burrs.

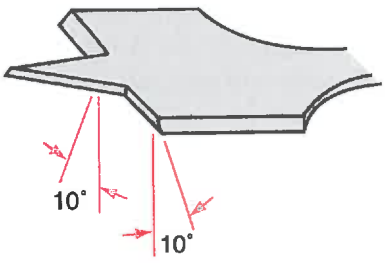


Figure 25-60. Critical cutting angles for a spade bit.

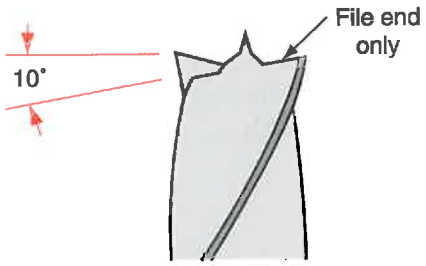


Figure 25-61. Sharpening a multispur bit.

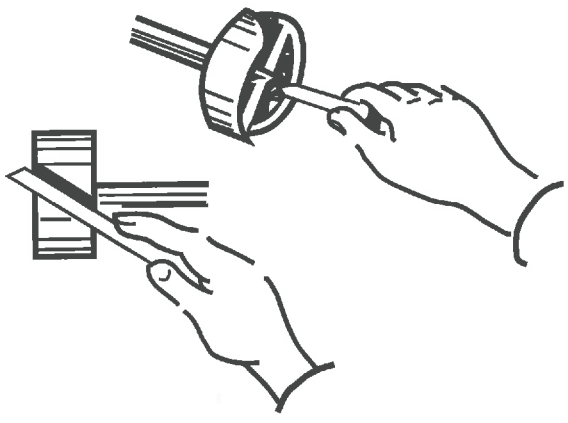


Figure 25-62. Sharpening a Forstner bit.

Sharpening the multispur bit and hole saw

These drilling tools are sharpened similarly. The teeth are sharpened like a rip saw blade. The cutting lip is filed like the Forstner bit. The center drill is sharpened like a twist drill.

Sharpening other bits

Sharpening drill points, countersinks, plug cutters, and countersink/counterbore bits may not be worthwhile. Drill points are inexpensive and best replaced. The cutting angles for other bits may be too complicated and are best replaced.

Cleaning and lubrication

All tools need periodic cleaning and lubrication. Rust and wood resins cling to tools and hamper moving parts. Rust can be wiped off with fine steel wool. Resins are removed with paint thinner. A coating of paste wax should then be applied.

Hand tools need lubrication on moving parts. Gears and bushings need lightweight oil. Often oil holes are identified by a stamp saying *OIL*. On the brace, the head, hand key, box ratchet, and chuck shell need oiling. Push drills need internal lubrication on the pawl that rotates the chuck.

Most power tools have relatively few places requiring lubrication. Many bearings are sealed. They may or may not last the life of the tool. If the bearing goes bad, it must be replaced. Grease or oil cups and fittings are found on spindles and moving parts of some older machines. Keep these filled to the proper level. Portable drills need grease in the speed reducing gears. To do so, remove the front housing and coat the teeth with gear grease. This should be done every two or three years.

Summary

A broad range of bits, cutters, and drills are used in cabinetmaking. Some are designed for use in hand tools while others are limited to power equipment. For drilling smaller holes, use twist drills. For holes ¼" (6 mm) and larger, use boring bits, such as the auger bit, machine spur, and spade bit. For a smooth, clean, flat-bottomed hole, choose a Forstner bit. Larger holes can be made with expansive drills and hole saws. For deep holes, use a bell hanger's drill or drill extension with your twist drill.

When drilling, clamp or hold your workpiece firmly. Select the proper speed when using power equipment. Too much speed will burn the wood and may ruin the bit. Also feed at a moderate rate.

Feeding too fast will chip the wood and may break the bit. Feeding too slow will cause excessive heat and will burn the wood.

Proper maintenance of drills, bits, and equipment is necessary. Most drills and bits can be sharpened by the cabinetmaker. Decide whether it is more efficient for you to sharpen the bit or have it professionally sharpened. In some instances, it may be more cost-effective to discard the old bit and buy a new one. Maintain hand and power machinery by removing rust and lubricating moving points. Parts of the machine which contact wood should be lubricated with silicone or paste wax. Gear housings and other internal parts are lubricated with oil or grease.

Test Your Knowledge

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

1. Drills and bits may be made of _____, _____, or be _____.
2. What purpose does an auger bit feed screw serve?
3. Describe how auger bit size is marked.
4. What does the HS stamped on a drill shank mean?
5. Auger bits are used primarily in the construction trades to produce holes in ____ and ____ grain.
6. You can drill holes of various shapes by grinding a(n) _____ bit.
7. Auger bits will not drill effectively _____.
   a. at an angle
   b. in face grain
   c. in edge grain
   d. in end grain
8. List the bits that can create large holes through a workpiece.
9. The Forstner bit does not have a long center point. What guides it through the hole?
10. For enlarging a hole to accept flat head screws, use a(n) _____.
    a. countersink bit
    b. twist drill
    c. drill point
    d. power bore bit
11. Diagram a section through a piece of wood that shows both a countersunk hole and counterbored hole.
12. The chuck size of a portable or stationary power drill determines the size of _____ which can be used.
13. Explain when you might use a V-block.
14. Name two methods for drilling through holes in a workpiece without splintering the wood on the back side.
15. A drill used with the drill press to make deep holes is _____.
16. Describe two methods of drilling holes at an angle on the drill press.
17. When sharpening an auger bit, file only the _____ and _____.
18. Explain why you might use dowels for a fence on a drilling jig instead of attaching a solid fence.
19. Rust can be removed from tools with _____.
20. Moving drill parts that may contact the wood are lubricated with _____ or _____.

Shaping

26

Objectives

After studying this chapter, you will be able to:

- Choose the proper shaper cutter.
- Set up and operate the spindle shaper.
- Choose the proper router bit.
- Set up and operate the overarm router.
- Set up and operate the portable router.
- Adapt the table saw, radial arm saw, and drill press for shaping.
- Select and use hand tools for shaping contours and decorative surfaces.

Important Terms

circular plane
combination plane
contour scraper
conventional router
inverted router
Moto-Tool®
overarm router
overarm router/shaper
pin routing
plunge router
shaper cutter
shaping
spindle shaper
spokeshave
Surform® tools

Shaping is the process of making contoured surfaces and edges for decorative purposes or for joinery. Cabinet cases, doors, and drawers may have shaped edges. Molding and trim are some examples of decorative products made by shaping.

Shaping equipment includes stationary power machines, portable power tools, and hand tools. Most shaping is done with stationary and portable power equipment because of accuracy, speed, and quality. See **Figure 26-1.** Power tools rotate a cutter at high speeds to produce very smooth surfaces that require little sanding. Note the high speed of the cutter can make power shaping equipment dangerous, if misused.

Shaping with Stationary Power Machines

Equipment strictly for shaping includes shapers and routers. The table saw, drill press, and radial arm saw can be adapted for shaping.

Spindle shaper

The five basic components of a ***spindle shaper*** are a spindle, table, motor, and two fences. See **Figure 26-2.** The cutter is mounted on the ***spindle*** driven by either a high speed shaper motor or standard motor equipped with belts and pulleys to

Figure 26-1. Shaping is the process of making contoured surfaces. *(Black & Decker)*

Figure 26-2. Main parts of a standard 1½ hp shaper. The fence and guard are shown in place. *(Grizzly Imports, Inc.)*

accomplish the same high speed. Spindle sizes vary from ½" to 1¼" (13 mm to 32 mm). Spindle height is set by turning a handwheel. Spindle speeds range from 4000 rpm to 10,000 rpm. Some machines have more than one speed. Turning a speed control switch or moving belts on the motor and spindle pulleys changes the rpm.

Guide workpieces into the cutter using a fence, **Figure 26-3,** miter gauge or sliding table, **Figure 26-4,** or starting pin and rub collar, **Figure 26-5.** The fences are held in place with two T-handle bolts. A table slot guides the miter gauge. Remove fences and install a starting pin to do freehand cutting. A rub collar installed with the cutter limits the depth of cut.

On some machines, stock may be fed from left to right or right to left. A reversing switch changes the spindle direction from counterclockwise to clockwise. See **Figure 26-6.** When hand feeding material, it must always be fed against the cutter rotation. Larger automated equipment may feed with the cutter rotation in what is referred to as a climb cut.

A point-of-operation guard protects you from the cutter. A vacuum dust collector installed behind the guard collects wood chips. Set the collector as close to the spindle as possible. Holding devices may be installed to guide the workpiece against the table and fence. See **Figure 26-3.**

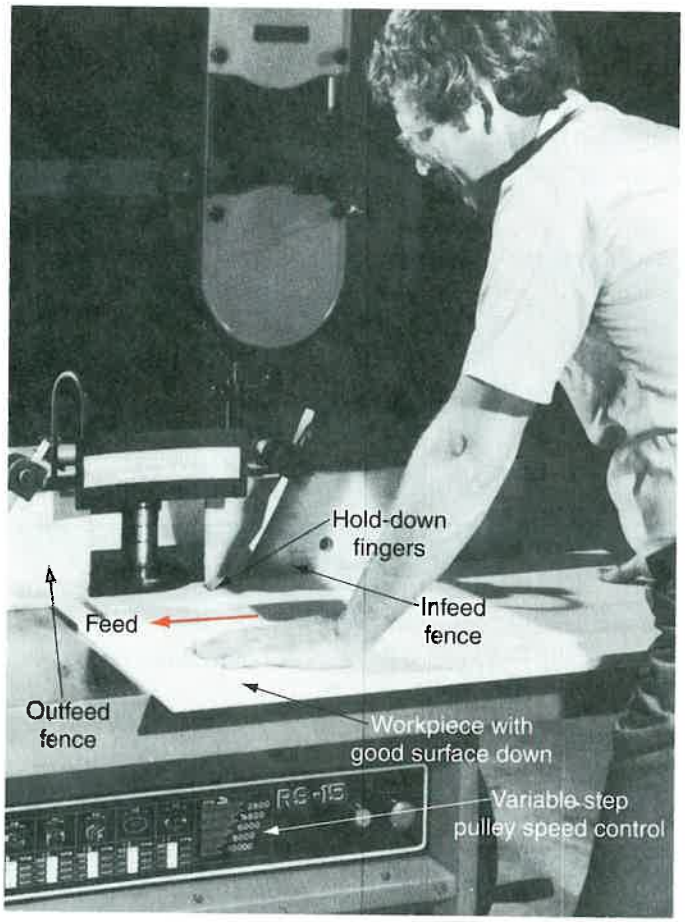


Figure 26-3. Guide straight edges along the fence. *(Delta International Machinery Corp.)*

Figure 26-4. Narrow workpieces are held in a sliding table. A backer board reduces tear out. *(Chuck Davis Cabinets)*

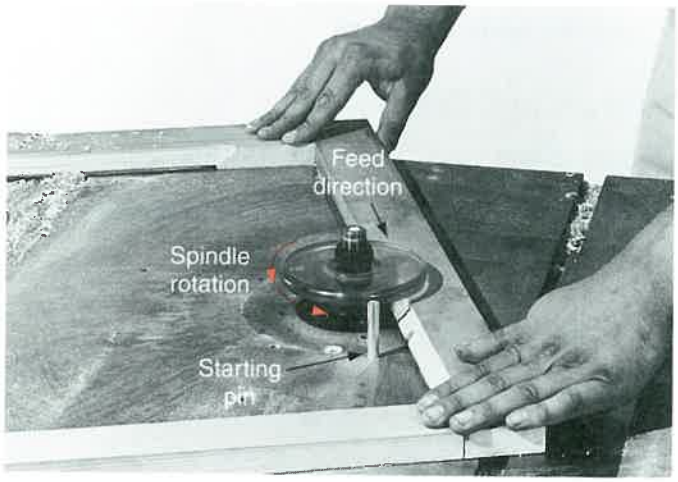


Figure 26-5. With a collar and starting pin, neither a fence nor miter gauge is needed. The clear plastic spindle-mounted guard provides operator protection. *(Delta International Machinery Corp.)*

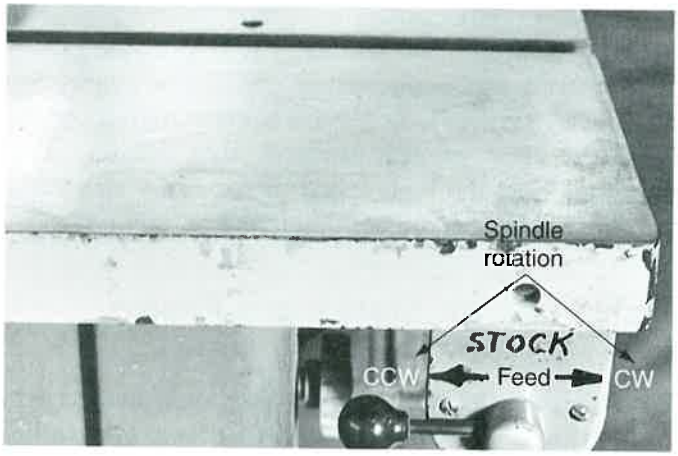


Figure 26-6. Spindle rotation controls feed direction.

Spindle shaper cutters

Shaper cutters come in a variety of sizes and shapes. See **Figure 26-7.** Numerous contours can be created with just a few cutters. This is done by varying the cutter height and using either the full cutting lip or just a portion of it. Before choosing a cutter, carefully analyze the shape you want to make. The cutter shape is just the opposite.

An additional cutter specification is a number of ***flutes,*** or ***cutting lips***. This refers to the number of cutting edges. Cutters may have from two to four flutes. Those with more flutes cut the smoothest contours. Cutters are made with bore holes of ½", ¾", 1", 1 1/8", or 1¼" to fit corresponding sized spindles. Bushings can be used to fit a cutter with a large bore to a smaller spindle. For example, some shapers are equipped with a 30 mm diameter spindle. A bushing with a 30 mm diameter inside diameter and an outside diameter of 1¼" enables the use of cutters with a 1¼" bore. Buy the correct bushing for your equipment. Do not place one bushing inside another.

Shaper cutters may be one piece or come as a set to accomplish a single task. Cutter sets have from two to six separate solid cutters that are mounted together

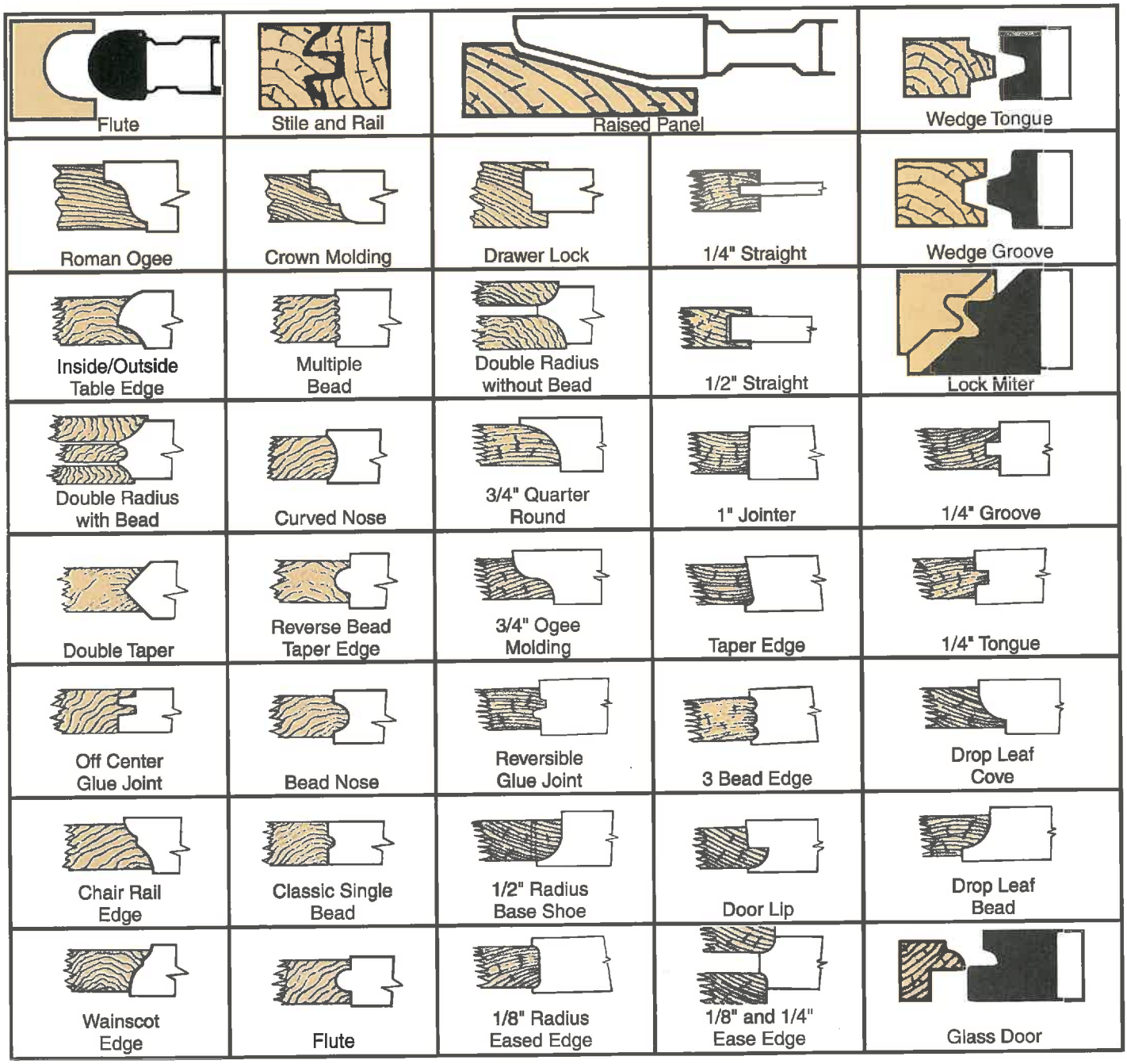


Figure 26-7. Typical cutter shapers and the workpiece edge they create. *(American Machine and Tool Co.)*

in various configurations to create the shapes required. A set of male and female cutters may cut the stiles and rails for a panel door. Other sets are used to create lock-miter joints, glue joints, *V* paneling, and tongue and groove flooring. By altering the position of one piece cutters, several shapes can be created. ***Shaper collars*** (not to be confused with rub collars) hold replaceable beveled edge profile knives. Manufacturers of profile knives may provide custom grinding. You furnish a sketch of the profile, stating which part of the wood is on the shaper table and the direction of rotation of the spindle.

Most shaper cutters produced today are carbide-tipped. They are more durable and cost-effective compared to high-speed steel cutters. Profile knives are made of high-speed steel to facilitate custom grinding.

You may find that a single cutter does not meet your needs. More than one setup of a given cutter may be required or more than one cutter could be used. You might also have to feed the workpiece vertically or at some other angle. It is very difficult to repeat the identical setups at a later time. Setups required for some shaped table edges are shown in **Figure 26-8.**

Adding to the variety, some shapers may be fitted with router bit adapters for bits with ¼" and ½" (6 mm and 13 mm) shanks.

Installing the cutter

Cutters are installed on the spindle. They may be held by a locknut and keyed washer, **Figure 26-9.** ***Rub collars*** may be placed under or over the cutter. These help to set the cutter height and depth of cut. Place the cutter so the spindle rotation causes the cutting edge to lead into the workpiece.

If your cutter design and direction of rotation allows, install the cutter so that the heaviest amount of cut (largest diameter of the cutter) is nearest the table. If a workpiece should tip while being shaped, the depth of cut is reduced but the workpiece is not damaged. Simply feed the part through again. However, by positioning the cutter with heaviest amount of cut on top, a workpiece will be damaged if it tips. As the edge rises, it moves further into the cutter and increases the depth of cut. This can ruin the workpiece.

On machines so equipped, a special keyed washer must always be placed under the locknut. The washer key fits in the spindle keyway. The key prevents the cutter from loosening the nut. This feature makes both clockwise and counterclockwise rotation safe. Consult your machines operating manual for specific instructions. Be extremely cautious about securing the cutter on the spindle. The nut must remain tight. When installing the nut, check whether the threads are left or right hand. Then, hold the spindle with one wrench while you tighten the locknut with another wrench.

Install the guard

Install a point-of-operation (PO) guard. One is the ***clear plastic spindle guard.*** See **Figure 26-10A.** It fits on the spindle under the washer and rotates with the cutter. It quickly stops if it is touched, so nothing will be drawn into the cutter. Another is the **ring guard** that is clamped to the table and positioned just above the cutter and spindle. See **Figure 26-10B.** Others are an integral part of the fence attachment.

Shaper setup and operation

There are a number of options for operating a spindle shaper. These include using the following:

- Fences.
- A rub collar and starting pin.
- A rub collar, starting pin, and template.
- Various jigs.

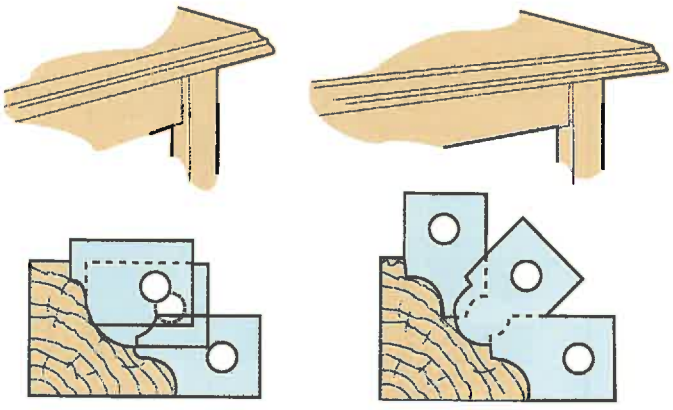


Figure 26-8. Several passes may be necessary to create the designed shape. *(Delta International Machinery Corp.)*

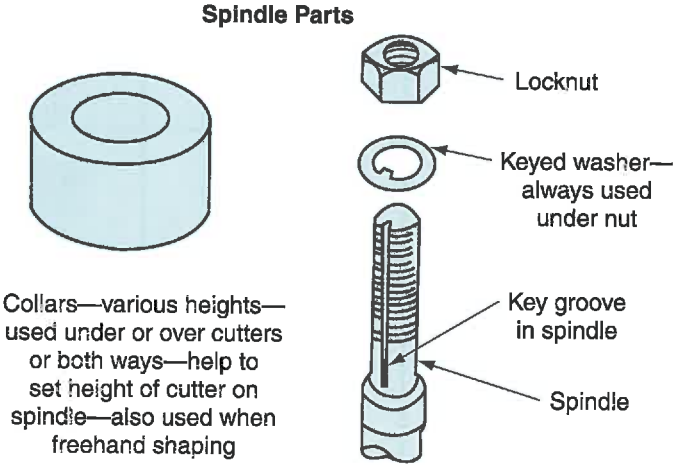
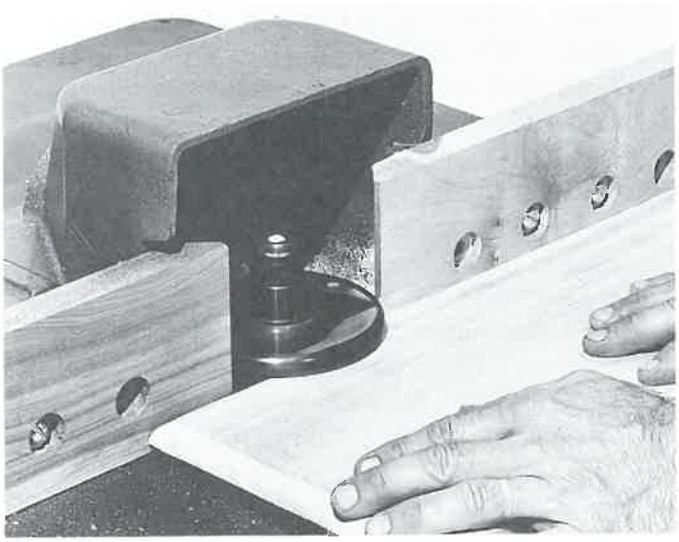


Figure 26-9. Order of items installed on a shaper spindle.



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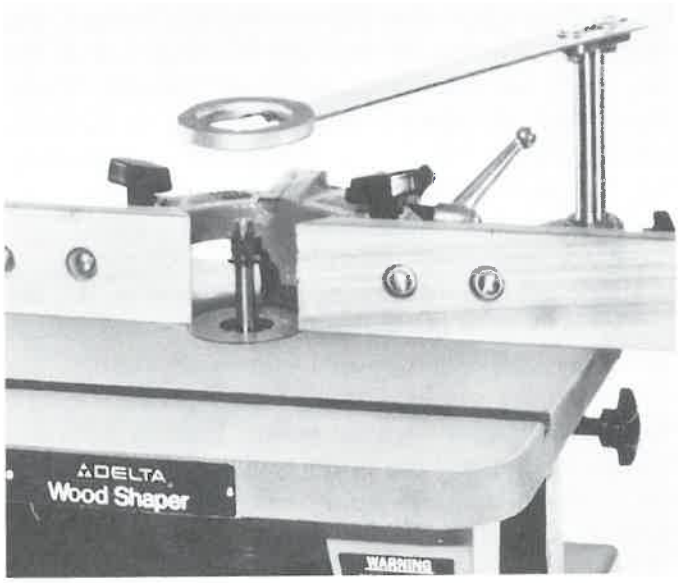


B

Figure 26-10. Shaper guards. A—Clear plastic spindle-mounted guard. B—Table-mounted ring guard is adjusted over the spindle. *(Delta International Machinery Corp.)*

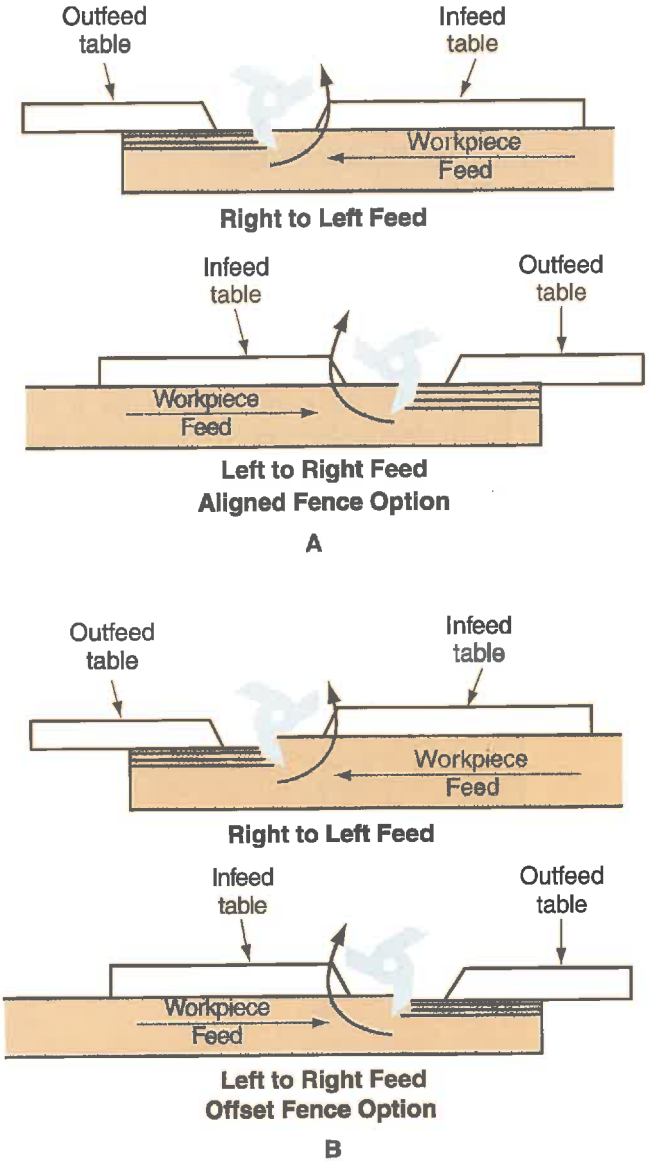


Figure 26-11. Feed direction varies with cutter rotation. Fences are aligned for shaping part of an edge. They are offset when shaping the entire edge.

Shaping with fences

Install infeed and outfeed fences when cutting straight edges. Workpieces can be guided quickly and easily along the fence across the cutter. Each fence is adjusted independently. Temporarily locate them about ¼" (6 mm) beyond the arc of the cutter.

The fences will be aligned or offset. When you are shaping only a portion of the edge, they are aligned. See **Figure 26-11A.** If the entire edge will be shaped, the fences can be offset. See **Figure 26-11B.** The infeed fence is offset for the depth of cut. The outfeed fence is aligned with the shaped workpiece edge, not with the infeed fence. The outfeed fence supports the workpiece as it exits the cutterhead.

The procedure for setting up and operating the spindle shaper is as follows:

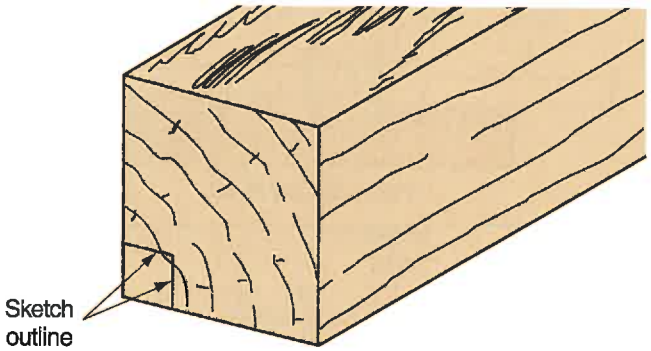
1. Turn the switch off and disconnect electrical power to the machine.
2. Obtain a squared piece of scrap stock that is the same thickness as your workpiece. This is a test board used to make adjustments.
3. Place the cutter edge against the end grain of the test board. Trace the design to be shaped. See **Figure 26-12A.**
4. Install the cutter and rub collars. Be sure to determine the spindle rotation first. Place rub collars under the cutter if it needs to be higher than the handwheel can raise the spindle.

5. Place the test board on the table. Raise or lower the spindle until the cutter aligns with the design sketched on the test board. Also, move the infeed fence to the proper depth of cut. The cutter should align with the shape traced on the end grain. See **Figure 26-12B.**
6. Position the outfeed fence even with the infeed fence for aligned cuts. Offset the outfeed fence when shaping the full edge.
7. Position and secure the point-of-operation guard. If it is a spindle mounted guard, install it under the washer and locknut.
8. Turn the spindle by hand to be sure it spins freely. There should be some clearance between the cutter, table insert, guard, and fences.
9. Turn the machine on and off quickly. Check for any loose settings or unusual noises. Verify the direction of spindle rotation.
10. Turn on the machine and feed the test board about 2" (50 mm) into the cutter. Pull the board from the cutter and turn off the machine.
11. Check the contour created. Readjust the fences and cutter height if necessary.
12. Install holding devices, depending on the cut to be made. Spring steel fingers press the workpiece against the table and fence. See **Figure 26-12.** A featherboard clamped to the fence may be sufficient. See **Figure 26-13.**
13. Now you are prepared to shape a straight edge. Hold the workpiece against the table and fence. Turn on the shaper. Feed at a moderate rate past the cutter.

There is an order for shaping edge and end grain. See **Figure 26-14A.** End grain should be done first. This is because the shaper has a tendency to chip out the trailing edge. See **Figure 26-14B.** Reduce the chance of chipping by slowing the feed rate at the end of the cut. A ***miter gauge clamp*** holds the workpiece when shaping the ends of narrow workpieces. See **Figure 26-14C.** Shape edge grain after shaping the end grain. Shaping the edge usually removes material that was chipped when shaping ends.

Workpieces must be at least 12" (305 mm) long to shape using only the fences. Narrower or shorter workpieces may be shaped using the miter gauge and fences. Hold gauge as if you were sawing.

If you are shaping on end grain, reduce splintering by using a back-up board. Place it between the workpiece and the miter gauge. Feed both past the cutter. The back-up board will support the trailing edge of the workpiece.



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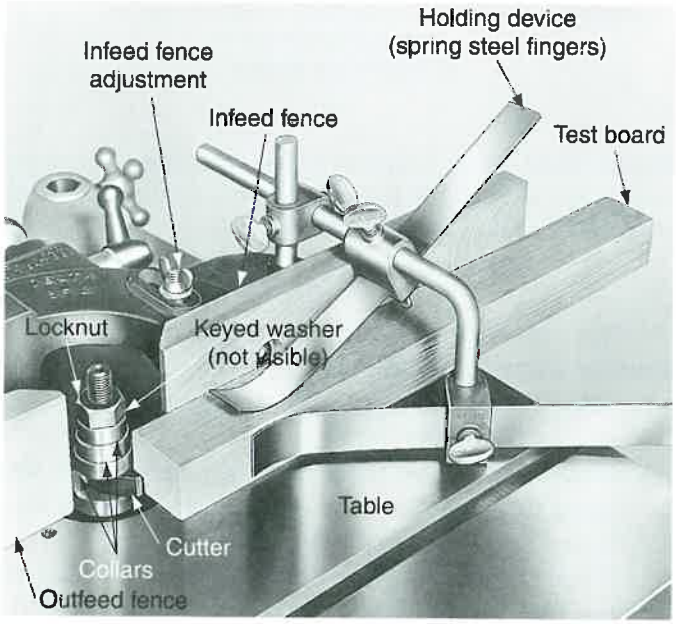


B

Figure 26-12. A—Trace the design on the test board. B—Spring steel fingers steady the workpiece as you push it across the cutter. The ring guard has been removed to show the components. *(Delta International Machinery Corp.)*

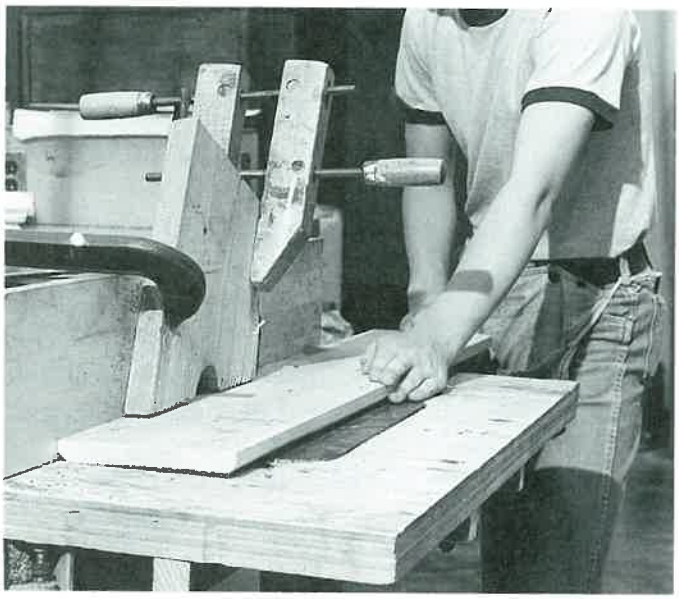


Figure 26-13. Featherboard hold-down jig. *(Delta International Machinery Corp.)*

Shaping with a rub collar and starting pin

A ***rub collar*** and ***starting pin*** are used when the fence is not appropriate. This may be for shaping irregular curves. See **Figure 26-15.** Rub collars come in sets of different diameters. Install a rub collar with a suitable diameter for the selected cutter to provide the desired depth of cut. You hold the workpiece against the starting pin before guiding it into the cutter.

Rub collars may be solid or ball bearing. Ball bearing rub collars rotate independent of the spindle. The solid rub collar rotates with the spindle and may burn the wood. The workpiece rubbing (hence the name) the rub collar must be smooth. The rub collar rides on and will follow any imperfections in the workpiece. When using a rub collar, only part of the edge can be shaped. There must be enough unshaped edge against the rub collar to guide the work. See **Figure 26-16.**

A ring guard or plastic spindle mounted guard must be attached. Keep the workpiece between you and the guarded cutter. Feed against the direction of cutter rotation. Feeding with the cutter rotation will throw the workpiece from the table and may draw your hand into the cutter.

To begin a cut, hold the workpiece against the starting pin. Then guide an edge into the cutter. With no starting pin, you would plunge the workpiece into the cutter. This would cause kickback.

The procedure for setting up and using a rub collar and starting pin is as follows:

1. Turn the switch off and disconnect power to the machine.
2. Install the diameter rub collar that will give you the depth of cut desired. The rub collar should be above the cutter. This is generally safer.

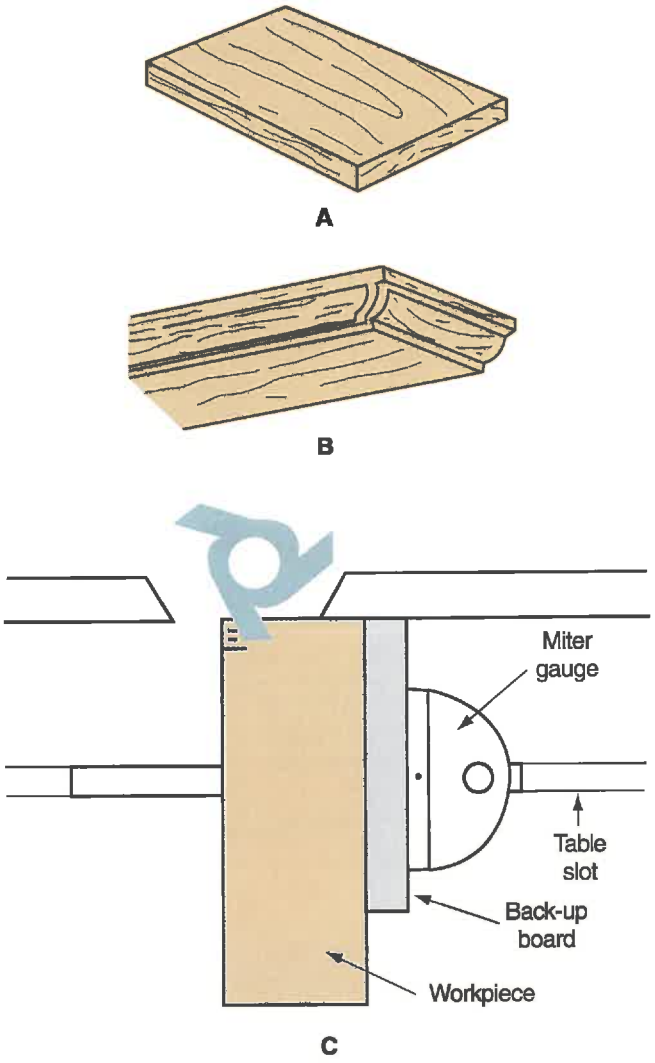


Figure 26-14. A—End grain is shaped before edge grain. B—The edges often tear out when end grain is shaped. C—A back-up board supports the trailing edge of the workpiece to prevent chipping.

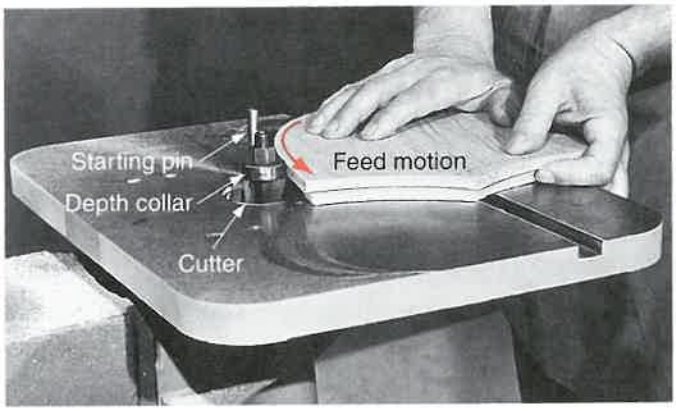


Figure 26-15. A collar and starting pin are installed for shaping irregular surfaces. The guard has been removed to show the operation. *(Delta International Machinery Corp.)*

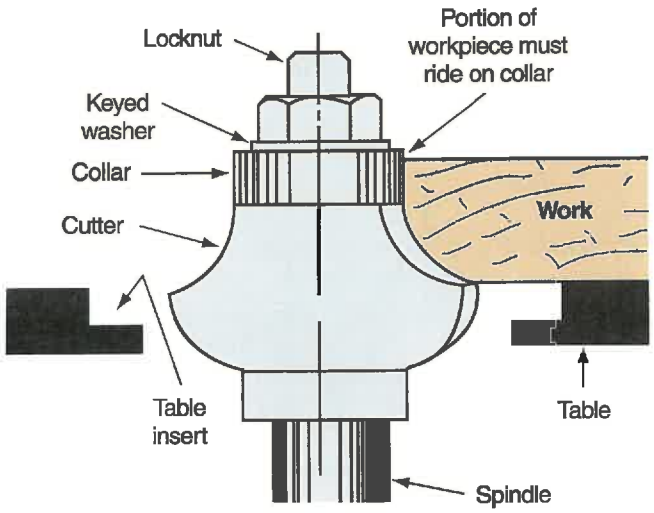


Figure 26-16. Shaping with a collar. A portion of the workpiece must ride on the collar.

3. Raise or lower the spindle to position the cutter height.
4. Thread a starting pin into a hole on the shaper table on the infeed side of the cutter.
5. Make a trial pass without the shaper running. Decide on the feed direction and how you will start the cut.
6. Decide where to begin and end the pass. Consider cutting end grain first. Avoid beginning at a corner. The cutter can catch the corner and throw the workpiece. Begin along a side or a relatively gentle curve.
7. Install the ring guard within ¼" (6 mm) of the upper workpiece surface.
8. Turn the spindle by hand to be sure it spins freely. It must not touch the guard or table insert.
9. Reconnect power to the machine. Turn the machine on and off quickly to verify direction of the cutter.
10. Turn the machine on.
11. Position the workpiece against the starting pin, but not the cutter.
12. Ease the workpiece into the cutter.
13. Start feeding after the workpiece touches the rub collar. You do not need to use the pin from this point until the end of the cut.
14. Go slowly when shaping a corner. Keep the workpiece in contact with the rub collar until the cut is complete.
15. When finished with the cut, pull the workpiece away from the cutter and turn off the machine.

Shaping with a starting pin, rub collar, and template

Templates are patterns used to duplicate workpieces. With a template, the entire workpiece edge can be shaped. The template rides on the rub collar. See **Figure 26-17.** The template can be made of fiberboard or plywood. It must be smooth and accurate.

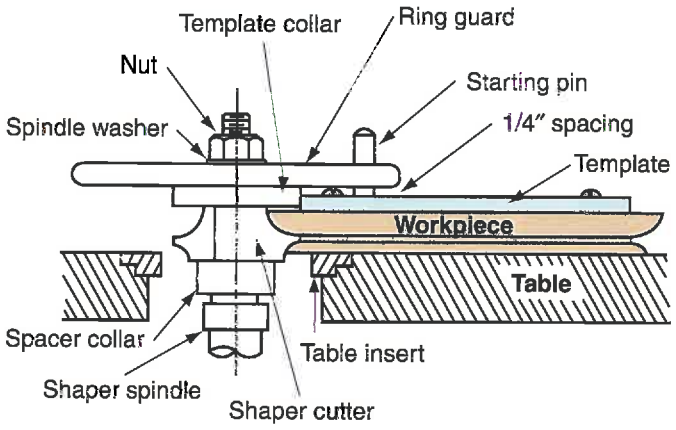


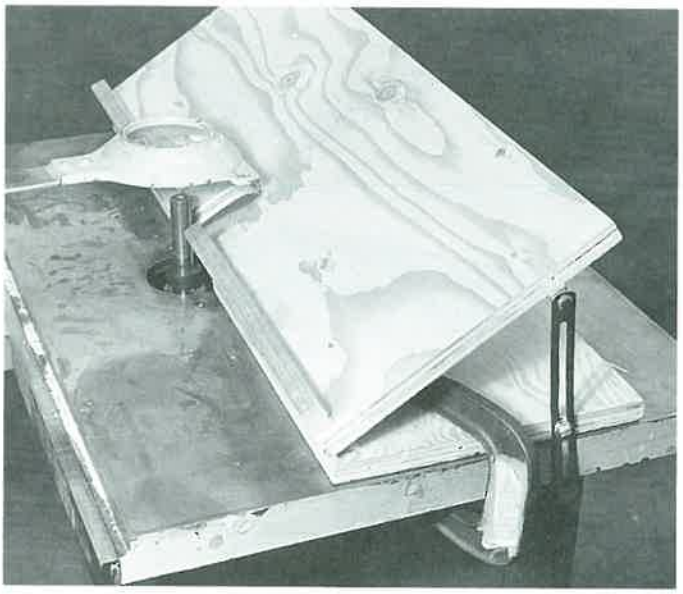
Figure 26-17. Guiding the workpiece with a template.

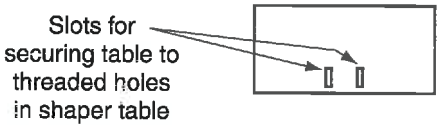
Stock is first band-sawed to approximate workpiece size. Attach the template above the workpiece with mechanical fasteners. The same feeding procedure is used for template shaping as for using a rub collar and starting pin.

Shaping with jigs

Cabinetmakers often produce jigs for various operations. The jig should be adaptable; otherwise, the time spent making it is not worthwhile. One jig is the angle jig. It supports the workpiece at an angle for shaping bevels and miters. See **Figure 26-18.** It can be clamped in position or bolted into two of the threaded table holes. You might also make a jig that slides in the table slot.

Just about any jig can be made or adapted for the shaper. However, they must be safe. Include a point-of-operation guard.





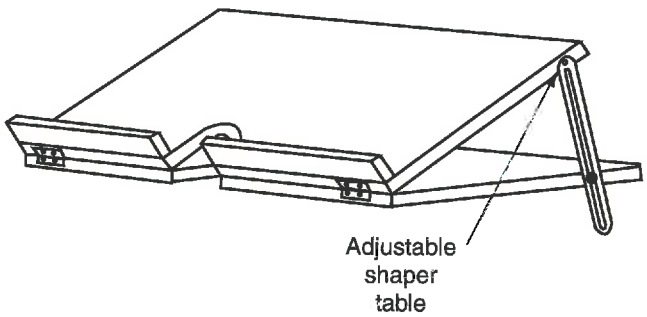


Figure 26-18. An angle jig allows you to shape edges at an angle other than 90°.

Think Safety—Act Safely when Using the Spindle Shaper

Follow these precautions when using the shaper.

- Wear eye protection, remove jewelry, and tie up loose hair and clothing.
- Install the cutter with the greatest depth of cut on the bottom.
- Make sure the locknut is tightened securely.
- The outfeed fence should be set to guide the work after it has passed the cutter.
- Always feed against the rotation of the cutter. Keep hands 4" (100 mm) away.
- Never shape pieces smaller than 12" (305 mm) without a jig or other means of support.
- Use a rub collar and starting pin when shaping irregular work.
- Examine wood for knots, grain direction, and defects.

Router bits

Overarm routers and portable routers use round shank ***router bits***. See **Figure 26-19.** Shanks are ¼", 3/8", and ½" (6 mm, 10, and 13 mm) in diameter. The bit fits into a ***collet*** on the motor. Turning a nut tightens the collet to hold the bit. Some bits are assembled shank and cutters. See **Figure 26-20.** The cutters are mounted on the arbor and held by a nut.

Router bits are constructed using different combinations of materials for the cutting edge: high speed steel, tungsten carbide, ceramics and polycrystalline diamond. Carbide may be brazed to a steel body, called carbide tipped. The entire bit may be made of solid carbide. Most bits are carbide tipped because solid carbide is too expensive. Use solid carbide bits for small cutting diameters. Carbide tips may be inserts for easy replacement.

The most expensive router bits are made of polycrystalline diamond. The cost of diamond tooling has become less expensive because of thinner slices of polycrystalline and improved sharpening techniques. The tips look much like carbide but have several advantages in a production shop:

- Greater resistance to wear, shock, and vibration—won't chip or crack.
- Stays sharp longer, and more exact over longer periods up to 60 times as long as tungsten carbide.
- Requires fewer set ups.

Router bits have two, three, or four cutting edges or ***flutes***. Use single flute cutters when a fast feed rate is more important than finished-cut quality. Two-flute cutters are used when the finished-cut quality is more important. Two-flute cutters are the most common.

Router bits may have a pilot at the end. A ***pilot*** is a round guide that limits the depth of cut by riding along the edge of the workpiece. See **Figure 26-21.** Bits with pilots are typically installed in portable routers for edge-shaping.

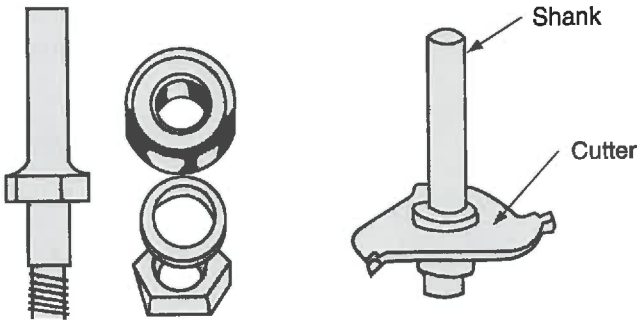


Figure 26-20. Some router bits are an assembled shank and cutter.

Figure 26-19. Router bits. Notice that some are assembled, while others are one piece. *(Bosch)*

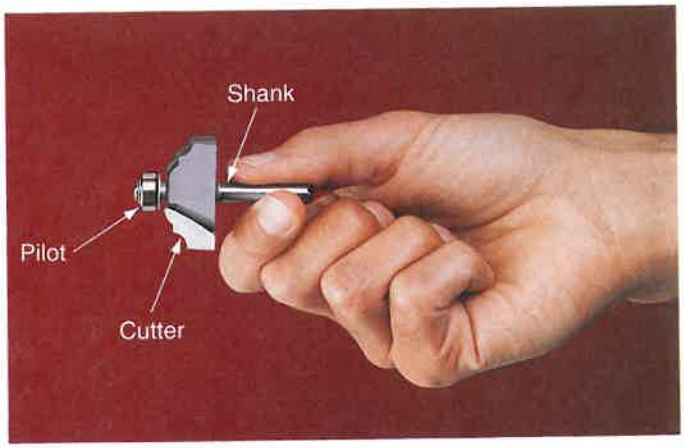


Figure 26-21. This ball bearing pilot is screwed onto the end of the shank. *(Bosch)*

The pilot may be part of the bit or it may rotate on ball bearings. Solid pilots rub the surface and may burn the wood. This is of little importance when trimming a laminate edge that will receive edgebanding. Ball bearing pilots roll instead of rubbing the workpiece.

Overarm routers and portable plunge routers are capable of lowering the bit into the workpiece. This process is called ***plunging***. For any plunging operation, you must choose a plunge-type router bit. In a carbide bit there is clearance between the carbide and the end of the bit body. The end of the flute has cutting edges.

There are many shapes and sizes of router bits. Some are shown in **Figure 26-22.** Several are designed simply to create a decorative edge. Others have special purposes. For example, the dovetail and rabbeting bits are for making joints. Trimmer bits are used to trim laminate and veneer flush with an edge. Slotting bits make slots for T-molding in table edges. The stile and rail bit set is an example of a shank with removable cutters. By rearranging cutters, you can cut both the stile and rail joint for frame and panel construction. The panel bit cuts the raised panel.

Install larger router bits in more powerful routers. Use large diameter bits at a lower rpm than smaller ones. See **Figure 26-23.** In order to attain a high-quality cut with the large bits, select routers with variable speed controls. If your router doesn't have built-in speed control, consider adding a router speed control or purchasing a new router that has one.

A second aspect of speed is the rate at which you move the router along the workpiece, as well as with a miter gauge router table moving the workpiece past the router. Moving too quickly will produce a rough finish. Moving too slowly will allow heat to build and leave burn marks. A good feed rate will cause some load on the motor and produce thin shavings. Fine sawdust may indicate a slow feed rate or a dull bit.

Keep the cutting edges of bits in good condition. Cutting edges can be damaged by coming into contact with other material.

Bit Diameter		Maximum Speed
Inches	Metric	RPM
1	25.4	24,000
1 1/8 to 2	28.6 to 50.8	18,000
2 1/8 to 2 1/2	54 to 63.5	16,000
2 5/8 to 3 1/2	66.7 to 88.9	12,000

Figure 26-23. General guidelines for router speeds depending on bit diameters.

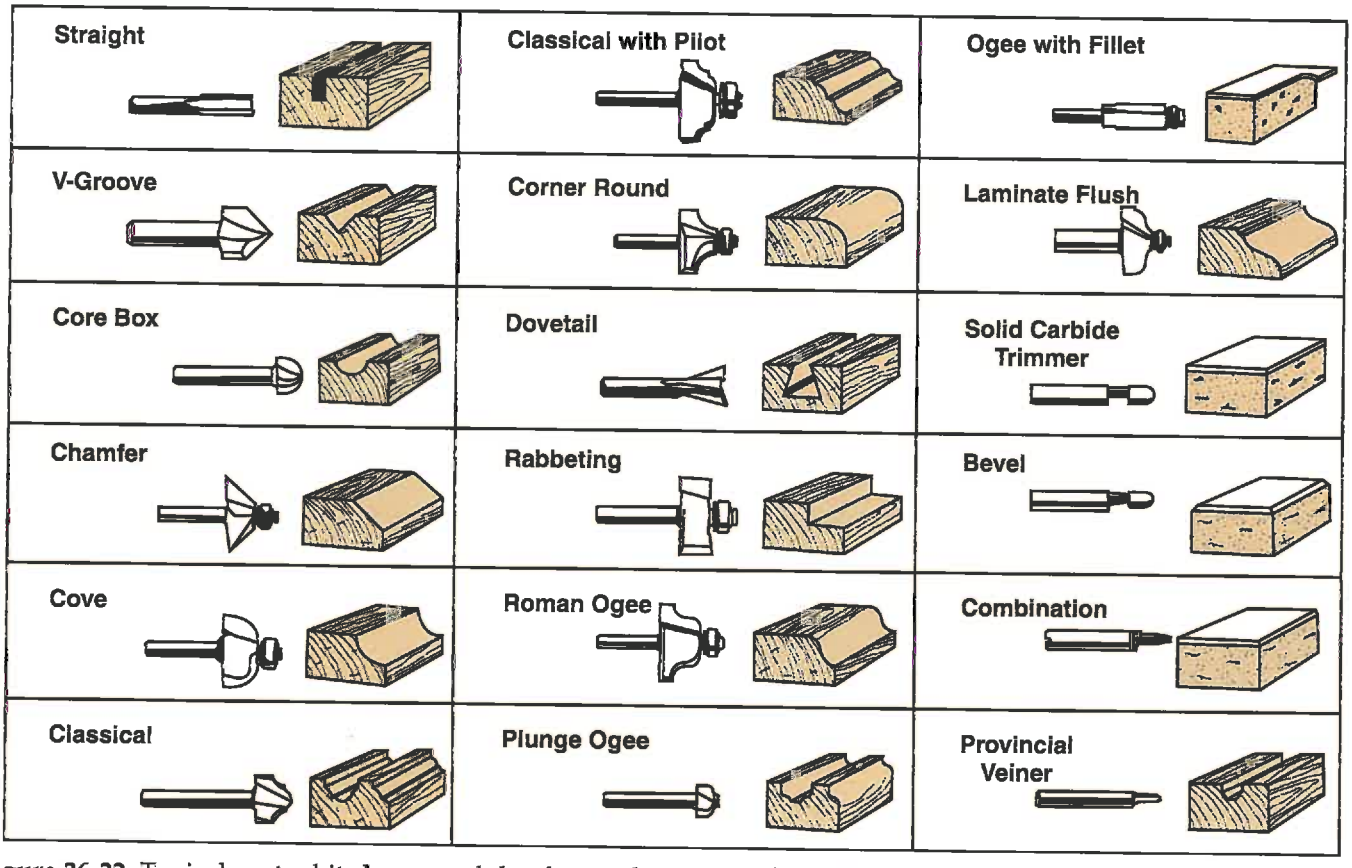


Figure 26-22. Typical router bit shapes and the shapes they create. *(Bosch)*

Caution

The cutting edge should not contact objects other than those that it is intended to cut. When placing bits in a container for shipment for repair or sharpening, protection is required to prevent further damage.

Overarm router

Overarm routers are very practical shaping devices. They are much like the shaper, except the cutter is located above the workpiece. Both floor and bench models are available. See **Figure 26-24.**

Overarm routers use shank mounted bits. The bit is held in a collet on the overarm. A handwheel is used to raise and lower the table. The workpiece is positioned on the table just under the bit. A foot control or feed lever lowers the bit into the workpiece. The depth the bit enters the workpiece is set with a depth stop. The table contains a removable guide pin for *pin routing*. The pin height is altered using a height selector.

Installing bits in the overarm router

Router bits are installed in a collet. The procedure is as follows:

1. Turn the switch off and disconnect power to the router.
2. Engage the spindle lock. This prevents the router shaft from turning.
3. Remove the PO guard.
4. Loosen the collet nut with an open-end wrench.
5. Insert the bit and tighten the collet nut.
6. Replace the PO guard.
7. Disengage the arbor lock.

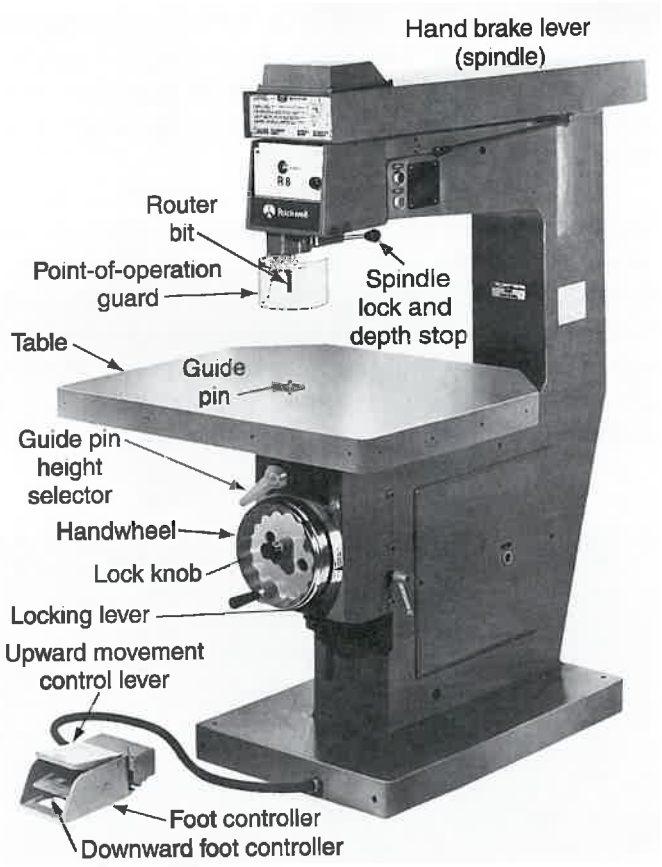
Overarm router operation

There are several options for using the overarm router. These options include:

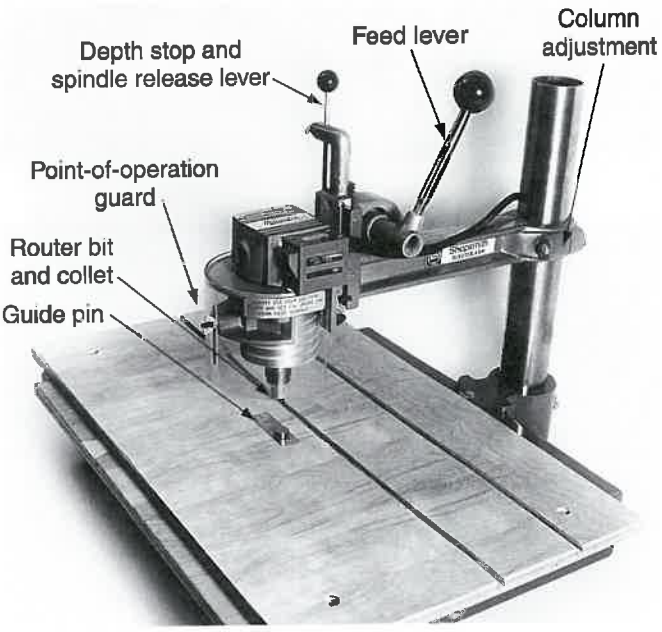
- Routing with a fence.
- Freehand shaping.
- Pin routing.

Using a fence

The fence is installed for shaping edges or cutting grooves. See **Figure 26-25.** Align both fences if only a portion of the edge will be shaped. Offset the infeed and outfeed fences if the entire edge will be shaped. The infeed fence generally is located on the left because the cutter spins clockwise. Set the cutter height by raising or lowering the table and/or bit. Bench top models do not have a



A



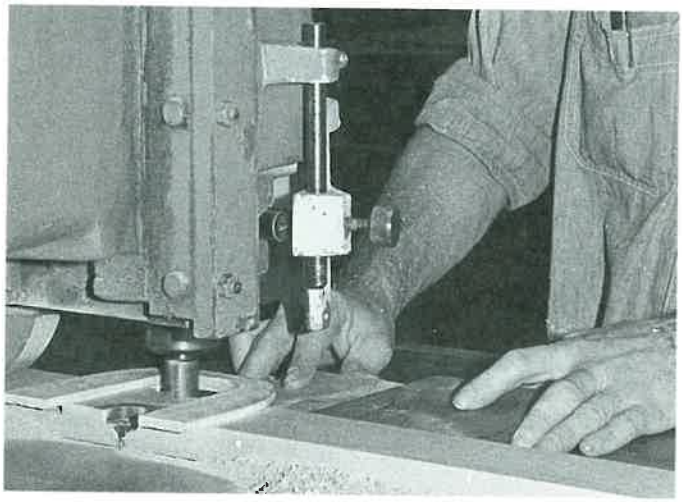
B

Figure 26-24. A—Components of a floor mounted router. *(Delta International Machinery Corp.)* B—Where space is limited, a bench model overarm router is appropriate. *(Shopsmith)*

movable table. Bit height is set by adjusting the column clamp or feed lever. Mark the end grain of the workpiece to set the depth as you did when adjusting the spindle shaper. Feed the workpieces from left to right.

You may need to make a fence for a bench-mounted overarm router. Install T-nuts on the underside of the table. Make two slots in the fence arms. Insert bolts through the fence arms into the T-nuts. Then depth-of-cut adjustments can be made easily. The fence must be in two sections for shaping an entire workpiece edge. The infeed fence is adjusted separately.

A



B

Figure 26-25. Overarm routing with a fence. A—Notice the point-of-operation guard is set very close to the workpiece. This fence is a solid piece of lumber. *(Delta International Machinery Corp.)* B—A U-shaped guard is fastened around the bit. *(Craft Products)*

Freehand routing

Your initial experience with freehand shaping with an overarm router should be done only under the direct supervision of an experienced operator. Since no fence or guide is used, you must hold the workpiece firmly. See **Figure 26-26.** Otherwise, it could be thrown from the table.

The procedure for freehand routing is as follows:

1. Copy the design onto the wood.
2. Install a small diameter plunge-type router bit.
3. Raise the table so the workpiece is just under the bit.
4. Set the depth stops which determine how far the bit enters the workpiece.
5. Turn on the router.
6. Press the foot pedal to gently lower the bit into the workpiece. For bench models, lower the bit with the feed lever.
7. While shaping, keep your hands 4" (102 mm) away from the cutter.
8. Raise the bit.
9. Turn off the machine and remove the completed component.

Pin routing

Pin routing is a unique way to make duplicate parts or a design. It involves attaching the workpiece over a template. The template shape is the design to be duplicated. Holes or grooves in the underside of the template follow the guide pin. See **Figure 26-27.** At the same time, the cutter above is shaping the workpiece.

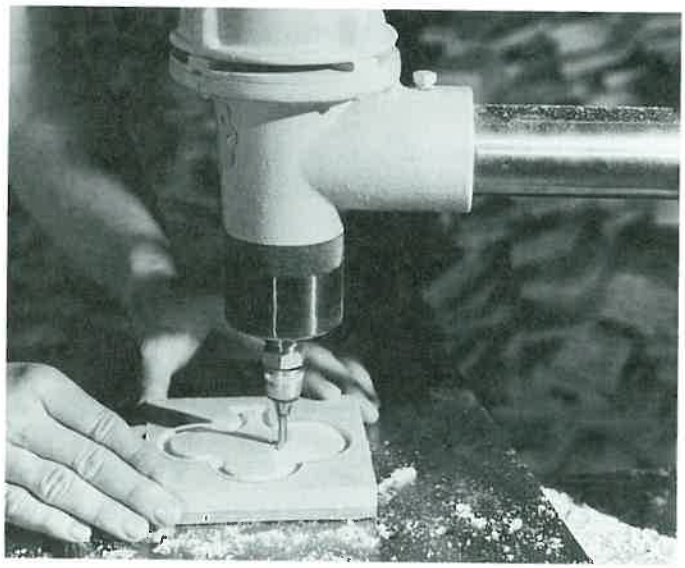
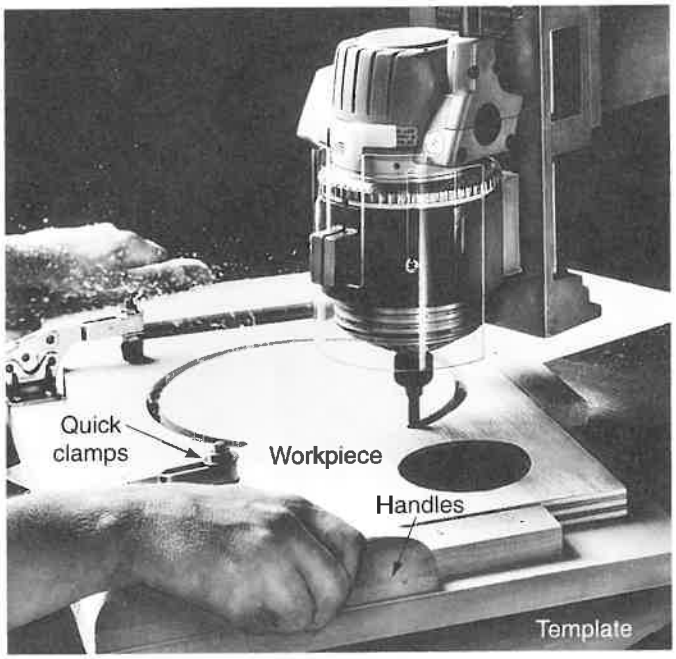


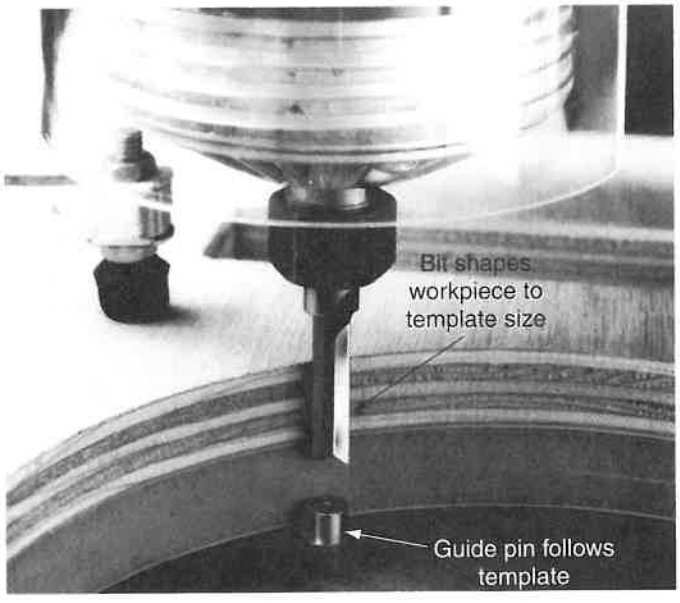
Figure 26-26. Freehand routing. The guard has been removed to show the operation. *(Delta International Machinery Corp.)*

The procedure for pin routing is as follows:

1. Install a plunge-type router bit in the collet.
2. Install the guide pin in the table. The pin you use should be the same diameter or smaller than the slot in the prepared template. If slot is wider, make a pass against each side.
3. Lower the bit using the lower foot pedal.



A



B

Figure 26-27. Overarm pin routing with a template. A—The workpiece is held to the template with clamps. Holding the handles assures your fingers are away from the point of operation. B—Close-up of the pin function. The pin rides in the template while the cutter above shapes the workpiece.

4. Attach the workpiece to the template with clamps or fasteners. Place the workpiece and template assembly next to the bit.
5. Adjust the table height to set the approximate depth of cut. You cannot move the table on bench-top routers.
6. Adjust the depth stop on the overarm. This determines the exact depth of cut. A shallow cut would provide a decorative surface. A deep cut could cut completely through the workpiece. This is done to cut parts that are duplicates of the template.
7. Raise the bit with the foot pedal.
8. Set the point-of-operation guard ¼" (6 mm) above the workpiece.
9. Lower the template over the guide pin. This also locates the workpiece properly under the cutter. See **Figure 26-28.**
10. Start the machine.
11. Lower the bit by pressing the foot pedal. The bench model overarm router usually does not have a foot lever. A feed lever on the head is used. Hold the workpiece securely with one hand as you turn the lever.
12. Advance the workpiece as guided by the pin and template.
13. When the cut is finished, raise the bit and turn off the machine.

Template making

Accurate template making is essential to high quality pin routing. The product is only as precise as the template. Use ¾" (19 mm) lumber or fiberboard. Particleboard and plywood could serve short production runs or designs requiring less precision. The grooves or openings in the template must be smooth. They should be at least 3/8" (10 mm) deep and as wide as the pin diameter.

Pin routing without templates

It is not necessary to use a template when pin routing. You can shape edges by guiding the workpiece against the pin. See **Figure 26-29.** The router bit you choose should be larger in diameter than the pin. You cannot shape the entire edge of the workpiece. Some portion must ride on the guide pin.

Overarm router/shaper

The *overarm router/shaper* is a versatile machine. See **Figure 26-30.** When used as a router, the motor is mounted above. It is locked in place with a bolt. The bit is fed into the workpiece by

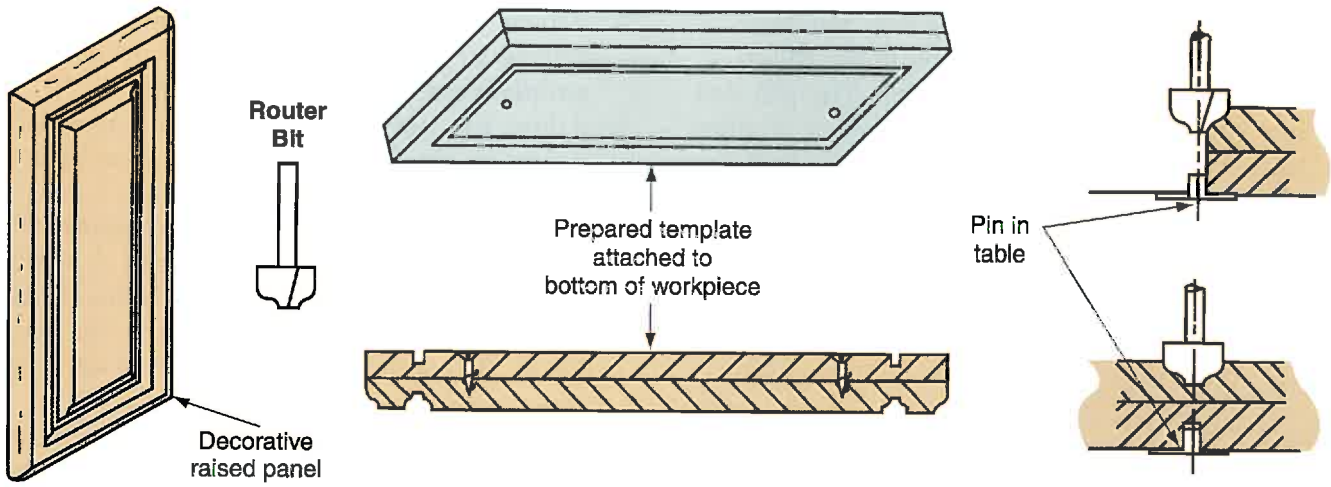


Figure 26-28. The prepared template for making the raised panel has a groove cut in the bottom. Right—The pin follows along the edge, then in the groove, to complete the panel.

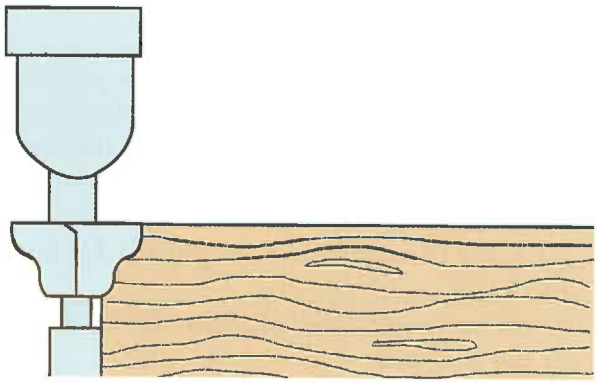


Figure 26-29. Pin routing without a template. A portion of the workpiece rides against the pin. You cannot shape the entire edge by this method.

raising the table. This is done with a foot lever. The exact height is adjusted with two depth stops. A table insert is placed in the hole where the shaper cutter would be. When used as a shaper, the motor head is clamped under the table. Cutter height is set with a fine thread adjustment feature.

Operation of the overarm router/shaper is the same as that for each individual machine. Material is fed against the rotation of the cutter. Align or offset the infeed and outfeed fences as required.

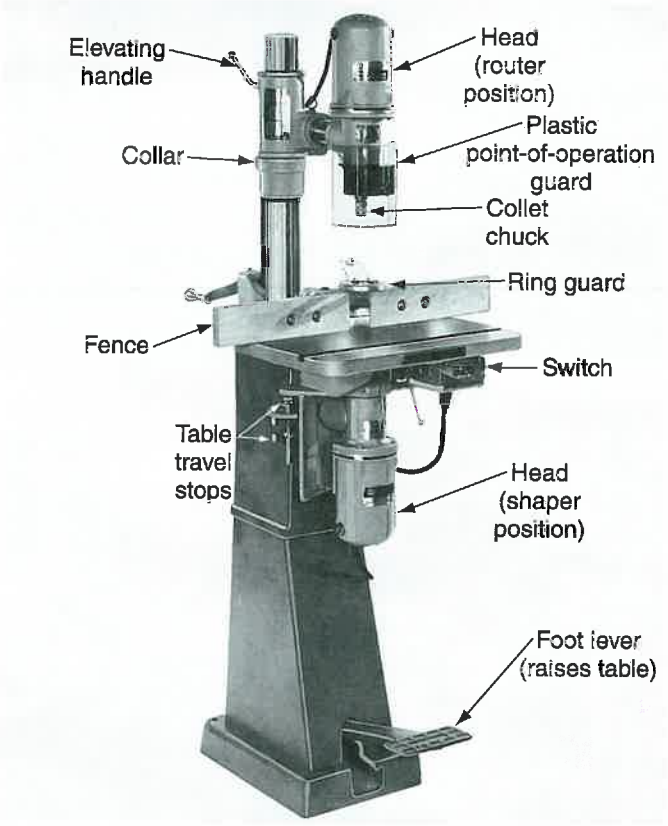


Figure 26-30. An overarm router/shaper combines the function of two machines into one compact, floor-standing model. *(Delta International Machinery Corp.)*

Think Safety—Act Safely when Using the Overarm Router

The overarm router can be a dangerous machine if not used properly. Follow these safety precautions.

- Always wear eye protection.
- Do not work with loose clothing, hair, or jewelry.
- Do pin routing with a template, rather than freehand, if possible.
- The overarm should be clamped securely to the column.
- Lock or clamp the table in place after setting the approximate height.
- Install all guards so they clear the work, cutter, and clamps.
- Check bits twice for tightness and sharpness when installing them.
- Feed the work in the correct direction.
- Keep hands clear of the cutter.

Inverted router

The *inverted router* is much like an overarm router, except that the bit is located below the workpiece. See **Figure 26-31.** This machine is designed primarily for pin routing. It boasts some advantages above overarm routers, including: quick setup, fast plunge cuts, and better depth control since the part faces down. It also holds a safety advantage in that the operator has less exposure to the cutting tool.

A unique spiral bit is installed in the inverted router. It helps hold the workpiece to the table as the cut is made. Several depth stops determine how far the bit extends out of the table. Pressing a foot pedal raises the bit. A pedal lock holds the spindle in an *UP* position for shaping work. A ¼", 3/8", or ½" (6 mm, 10 mm, or 13 mm) guide pin is installed in the retractable pin assembly. The guide pin is lowered by pneumatic controls.

Several applications of the inverted pin router are shown in **Figure 26-32.**

Table saw

The *table saw* is adaptable for shaping using a *molding cutterhead* and special table insert. The cutterhead functions well on straight surfaces for shaping part of the edge. A portion of the edge must remain since the table supports it.

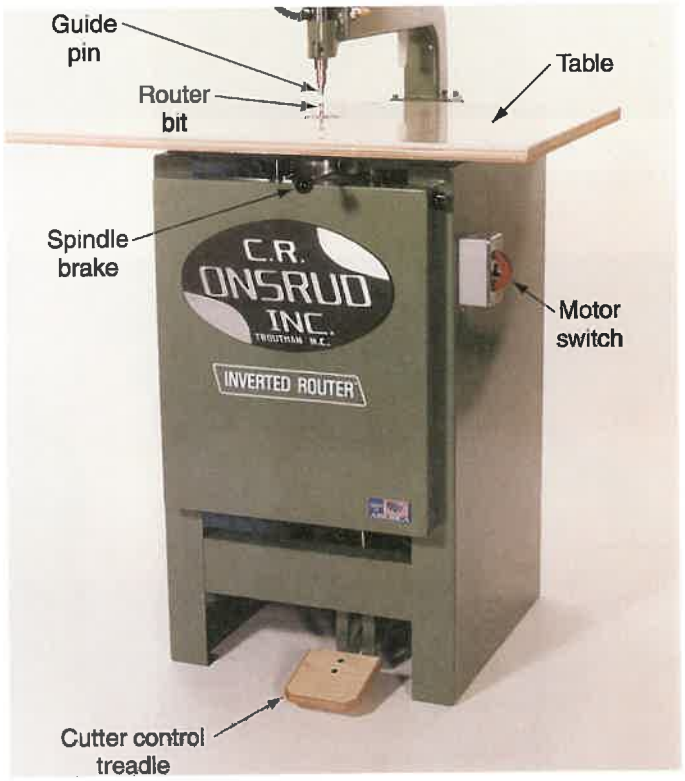
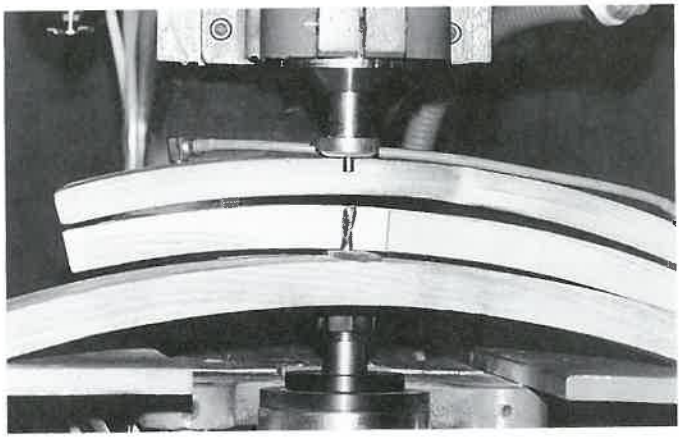


Figure 26-31. The inverted router has the guide pin above the bit. *(C.R. Onsrud)*

Three matching knives are inserted in a cutterhead and secured by set screws. See **Figure 26-33.** Install the cutterhead using the blade installation procedure discussed in *Chapter 21.* Replace the normal table insert with the large opening insert.

Attach a wood auxiliary fence to the table saw fence when edge shaping. See **Figure 26-34.** Make a cutout in the wood fence so the fence can be positioned over the cutterhead. Lower the molding head below the table surface. Move the fence slightly over the cutter. Turn on the saw and raise the cutter just over the height at which you will be shaping. This procedure allows you to set the fence for the proper cutterhead height and depth of cut.

A



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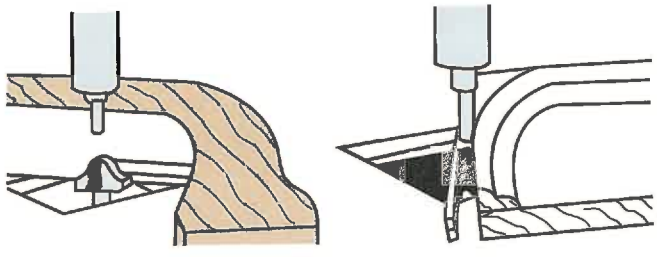
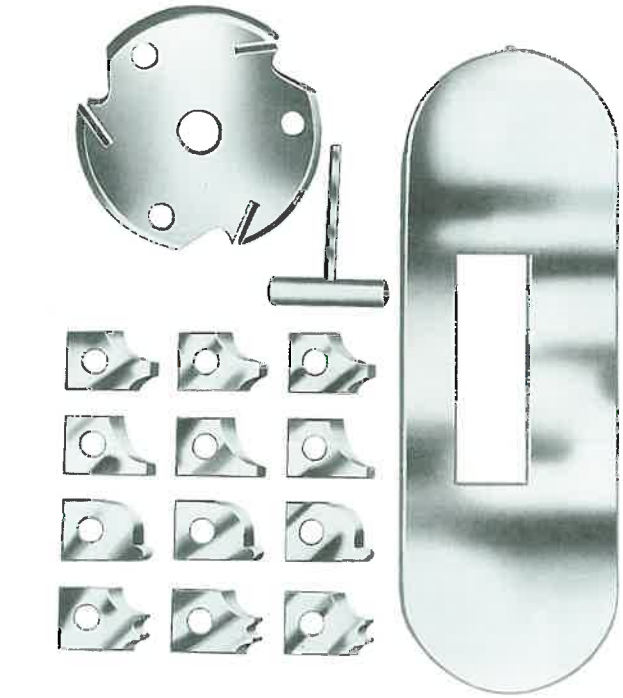


C D

Figure 26-32. Typical inverted router operations. A—Guiding the workpiece with a template. B—Duplicating a curved component. C—Shaping a portion of an edge. D—Trimming an edge flush to the molding. *(C.R. Onsrud)*

Clamp *featherboards* to the fence and table to help guide the workpiece. Use a push stick when working within 4" (100 mm) of the point-of-operation. The cutterhead can be tilted for shaping at an angle. If tilted too far, the knives could damage the table insert. With the power disconnected, always rotate the cutterhead by hand once to make sure it does not contact the table insert or fence.

The table saw can also be used for shaping faces. Use the miter gauge or fence. See **Figure 26-35.** Be sure the cutterhead height does not exceed the workpiece thickness. Hold the workpiece firmly since the cutter has a tendency to raise it.



A

B

Figure 26-33. A—Attachments needed to convert a table saw into a shaper. *(Delta International Machinery Corp.)* B—Tighten three matching knives in the cutterhead. *(Chuck Davis Cabinets)*

Ploughing

Ploughing is a shaping operation done with a table saw blade. You make a concave cut diagonally across the table. Often you cut the workpiece in half for two pieces of cove molding. See **Figure 26-36.** To perform the ploughing operation, proceed as follows:

1. Set the saw blade to the desired height.
2. Set the width of the desired cut with a parallel frame.
3. Place the frame over the saw blade. One side touches the blade where it enters the table. The other touches where it comes out of the table.

Figure 26-34. Shaping an edge on the table saw. *(Chuck Davis Cabinets)*

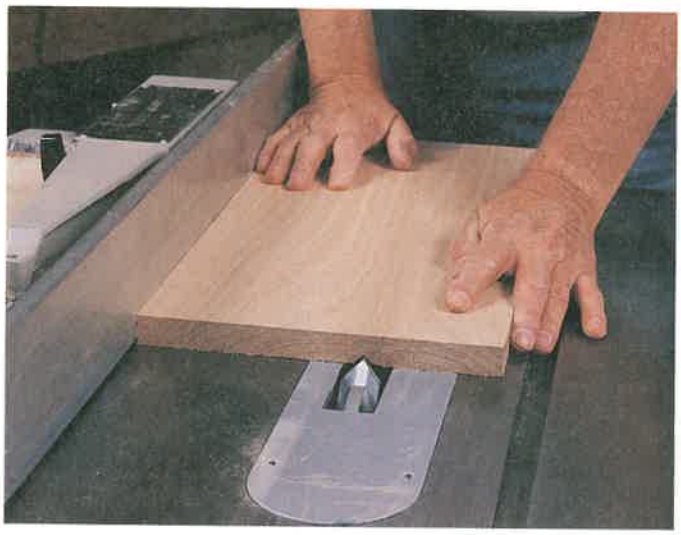
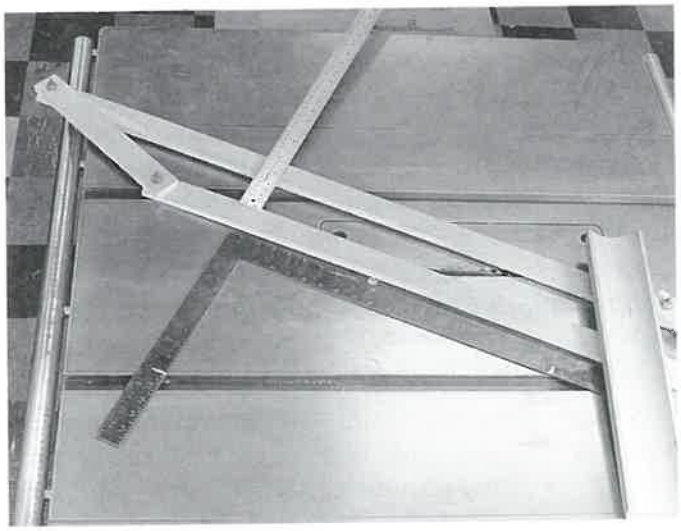


Figure 26-35. Shaping a face on the table saw. Guards removed to show operation. *(Chuck Davis Cabinets)*

4. Position a framing square against the frame. With chalk, mark where the square touches the miter gauge slot. This gives the angle and position for the secondary fence.
5. Lower the blade completely.
6. Clamp the secondary fence in place.
7. Raise the blade about 1/16" (2 mm) for each pass.
8. You can cut the workpiece in half for cove molding.



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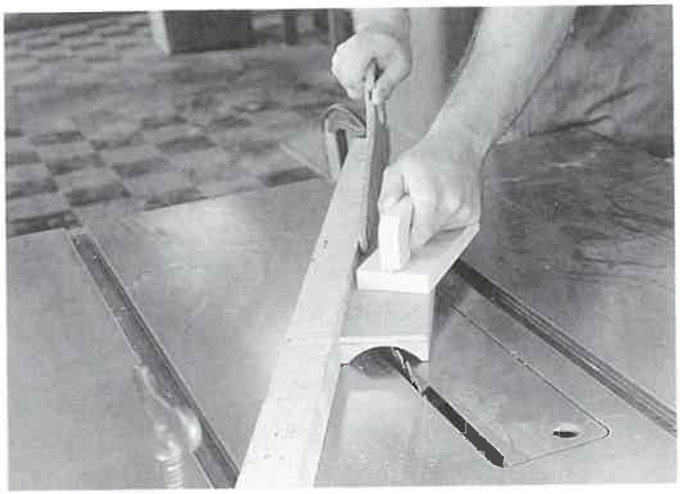

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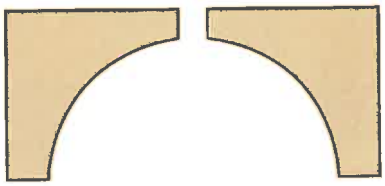


C

Figure 26-36. A—Setting the angle of the auxiliary fence for plough cutting. B—Making the cut. C—Saw the shaped piece in half for two cove moldings.

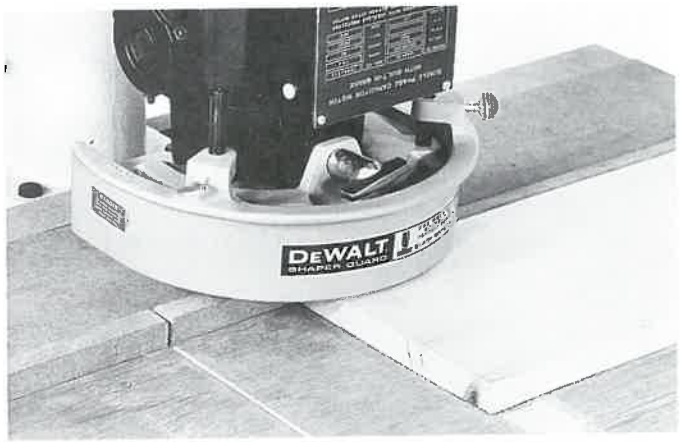
Radial arm saw

A ***radial arm*** adapts to shaping. Fit it with the table saw cutterhead assembly and guard or drill press spindle adapter. You can shape in the rip or crosscut mode, and at an angle. See **Figure 26-37.**

Each radial arm saw manufacturer produces adapters so router bits and shaper cutters can be installed. The adapter threads onto the saw arbor and has a bolt to accept cutters. The router bit adapter has a collet to accept round shank router bits.

When using the molding head in the crosscut position, make a cutout in the saw fence. This allows the cutterhead to pass through from the retracted position.

Use standard radial arm saw techniques when shaping. Remember to always feed *AGAINST* the rotation of the cutterhead.



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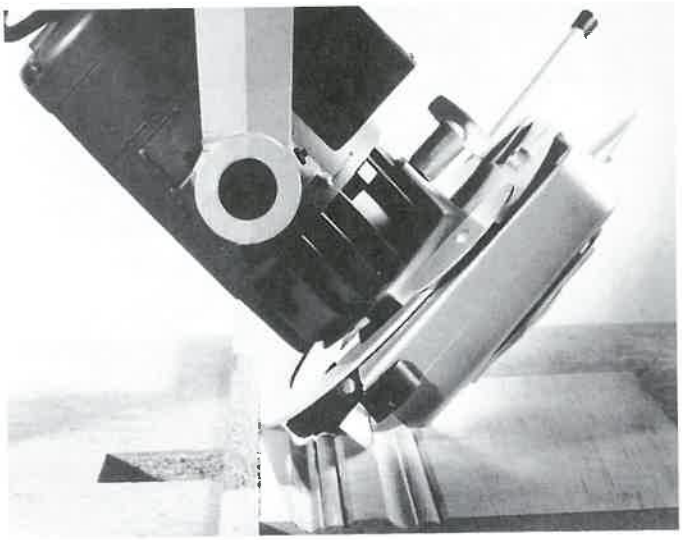


B

Figure 26-37. A—A cutterhead guard is necessary when the cutterhead is set in the horizontal shaping position. B—Shaping at an angle. *(DeWalt)*

Drill press

A *drill press* is adaptable to shaping and routing. See **Figure 26-38.** Tighten router bits in the chuck. For a threaded spindle, unscrew the drill press chuck and screw on the proper shaping adapter. A shaper adapter accepts ½" bore shaper cutters. For a router bit, there is a collet adapter.

The hole in the drill press table must be large enough to allow the cutter to pass through. If it is not, bolt a secondary wood table to the drill press table. Use ¾" (19 mm) plywood, fiberboard, or particleboard with a plastic laminate face. Attach fences or a starting pin as needed. See **Figure 26-39.** Install a PO guard around the cutterhead. You might also place featherboards or another type of holder to guide the workpiece.

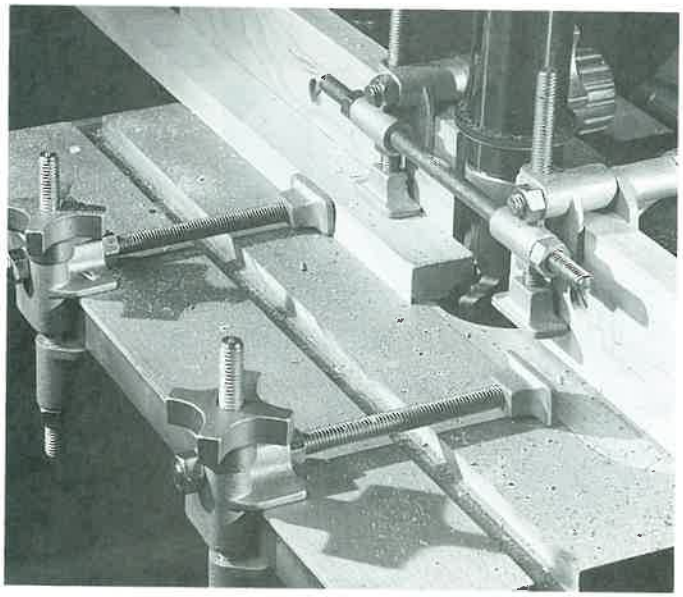


Figure 26-38. Convert the drill press to a shaper by replacing the chuck with a spindle adapter. *(Shopsmith, Inc.)*

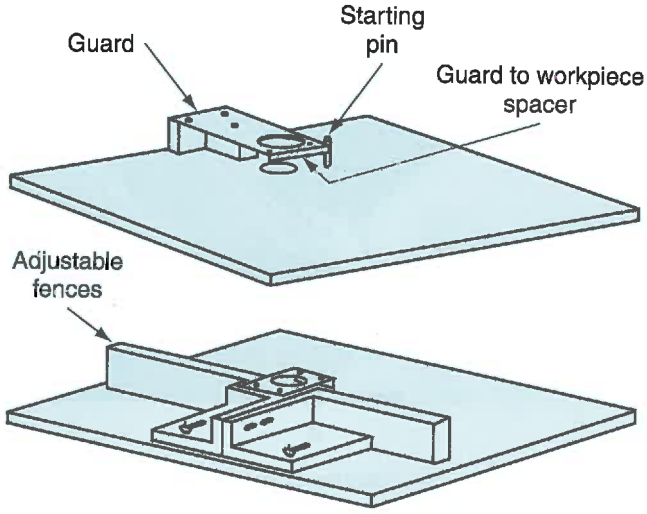


Figure 26-39. Wood tables for drill press routing.

Shaping with Portable Power Tools

Several portable power tools are available for shaping. These include the portable router, laminate trimmer, and Moto-Tool®.

Shaping with the portable router

One of the cabinetmaker's most preferred shaping tools is the *portable router*. The router's versatility and ease of use make it appropriate for almost any shaping operation.

The parts of a router are shown in **Figure 26-40.** A router consists of a motor clamped in a base. Motors vary from ½ hp in light-duty models to 3¼ hp for heavy-duty models. A 1½ hp or 2 hp router is adequate for most operations. On the end of the motor arbor is a collet to hold the bit. Collet sizes are ¼", 3/8", and ½" (6.3, 9.5 and 12.7 mm). Depth of cut is set by changing the motor position in the base using a depth adjusting ring. A plastic subbase may be attached to the base.

Conventional and plunge routers

Many router operations call for you to insert the rotating bit into the face of a workpiece. This process is called plunging. Router names are based on the router's ability to plunge cut. Conventional routers are preset to a fixed depth of cut. To plunge the bit into the face of a workpiece, you have to balance the router on the edge of the base, start the motor, and carefully tilt the bit into the wood. This often results in less accurate cuts and possible injury, such as cut fingers.

Figure 26-40. Portable router.

With ***plunge routers***, the entire motor and bit assembly slides up and down (against spring tension) on two posts connected to the base. See **Figure 26-41.** To plunge the bit into the workpiece, simply set the base on the wood, start the motor, and press down. A locking mechanism holds the depth of cut.

Plunge routers have their drawbacks. The depth adjustment mechanism on plunge routers is harder to set accurately. This is because of play in the up/down movement of the motor and in the locking mechanism. Also, most models have a large hole in the base. A large hole size can be remedied by installing a subbase with a smaller hole.

Methods of guiding the router

A router, without any accessory, is guided free hand across the workpiece. However, most cuts must conform to a straight or circular shape.

A good straightedge is the metal type used for circular saws. For edging solid surface countertops, use a straightedge made for that purpose. A squared piece of lumber of suitable length will also do. The base of the router rides along the straightedge. See **Figure 26-42.** The straightedge is clamped a certain distance from the cut to be made. This distance to the cut is the radius of the base, minus the radius of the cutter. See **Figure 26-43.**

Router guides are provided by the manufacturer. They include fences, circle guides, and other accessories for producing straight or curved cuts. See **Figure 26-44.** Most are attached to the router base. The distance is adjusted with wing nuts.

Other methods of guiding the cut include pilots and templates. Pilots are used for shaping edges. Templates are used for producing multiple products.

Figure 26-41 Plunge router motor moves up and down on spring-loaded posts. (*Ryobi America Corp.*)

Installing bits and setting depth

Select the proper router bit to create the shape or joint. Insert it into the collet. You may have to remove the motor from the base to do so. Insert the bit into the collet at least ½" (13 mm). If the router is equipped with an arbor lock, engage it so the motor shaft won't turn as you tighten the collet. Most routers come with a special wrench to fit the collet nut. Routers without an arbor lock will have a second special wrench to fit the arbor. Place the motor back in the base if it was removed.

To set the depth of cut, lightly clamp the motor in the base. Measure and set the distance the bit protrudes from the base. Fine adjustments are made by turning a depth ring. Have the base clamp loose. Tighten the base clamp with moderate pressure against the depth ring. Markings on the ring and base indicate how far to turn for a certain change in depth of cut.

Figure 26-42. The router base rides along the straight edge for grooving this door panel. (*Black & Decker*)

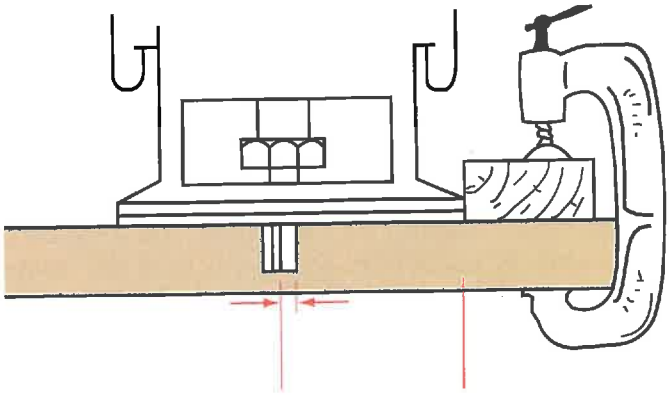


Figure 26-43. Calculate the distance the straightedge must be from the cut to be made.

A

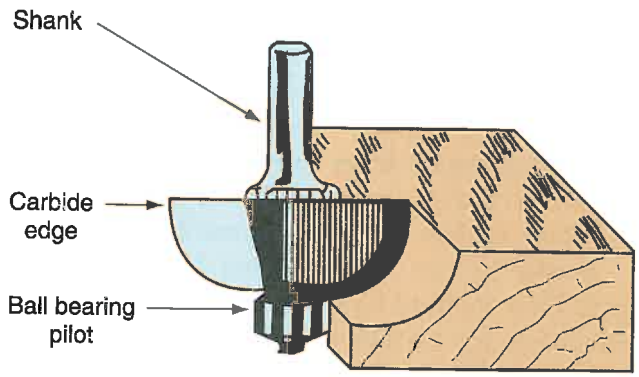
B

Figure 26-44. Router guides provided by the manufacturer. A-Fence. *(Chuck Davis Cabinets)* B—Circle guide. *(Black & Decker)*

Edge shaping

Edge shaping can be done with a fence or with bits having a pilot. With a fence, edge shaping is limited to the distance the fence can extend. See **Figure 26-45.** However, most edge shaping is done with bits having a pilot. A pilot rides along the edge of the workpiece. See **Figure 26-46.** The edge must be smooth; otherwise, the pilot follows the defects. Preset the depth of cut. For a plunge router, lock the depth before turning on the router. The rotation of the cutter is clockwise; therefore, feed the router from left to right along an edge facing you. Use slight pressure to keep the pilot against the workpiece. Feed at a moderate rate. If the motor slows considerably, you are feeding too fast or taking too deep of cut. Feeding too slowly will cause the bit to heat and burn the wood.

Figure 26-45. Shaping an edge using a router fence to guide the bit. *(Chuck Davis Cabinets)*



A

B

Figure 26-46. A—Shaping an edge with a pilot to guide the bit. B—The pilot rides along the edge of the workpiece. *(Chuck Davis Cabinets)*

Routing a dado

Dados are slots across the grain pattern. To rout a dado, clamp a straightedge to the workpiece. Choose a straight bit. Set the depth of cut. Hold the router against the straightedge. Turn on the machine and proceed across the workpiece. See **Figure 26-47.** Slow the rate of speed as the bit exits the workpiece. This minimizes chipping. You might also back up the edge with another board.

Some dados are wider than the largest diameter straight bit. You might use straightedges on both sides of the router. One straightedge determines the location of the first cut. The second one controls the width of the dado.

Routing a groove or flute

Grooves and flutes run with the grain of the wood. Generally, you can attach a fence to the router. The flutes being cut in **Figure 26-44** show a fence and jig setup to guide the router. Notice that the depth of cut is changed for each flute on the molding.

Freehand routing

Routers come in handy for removing excess material in preparation for a wood carving. See **Figure 26-48.** The design is copied on the surface and then cut with a router. This must be done freehand since no attachment would follow the intricate shape. To rout some of the interior detail, the bit must be plunged into the workpiece. A plunge router is better for this purpose as discussed earlier. Finally, the woodworker uses hand tools to finish the carving.

Figure 26-47. Guide the router with a straightedge to cut a dado. *(Chuck Davis Cabinets)*

Routing joints

With the proper setup or jig, the portable router can cut a number of cabinet joints. In fact, some joints, such as a dovetail joint, are cut accurately with a portable router and jig. Cabinet joints are discussed in *Chapter 29*.

Routing with templates

Templates are often used to guide the portable router. On a portable router, you have two choices for guiding the router with a template. You can use the outer edge of the subbase; or, you may attach a template guide to the router base. It serves much like a collar.

When guiding the router along the subbase, the template must be larger than the design. See **Figure 26-49.** For example, proceed as follows to rout the holes for a speaker mounting panel:

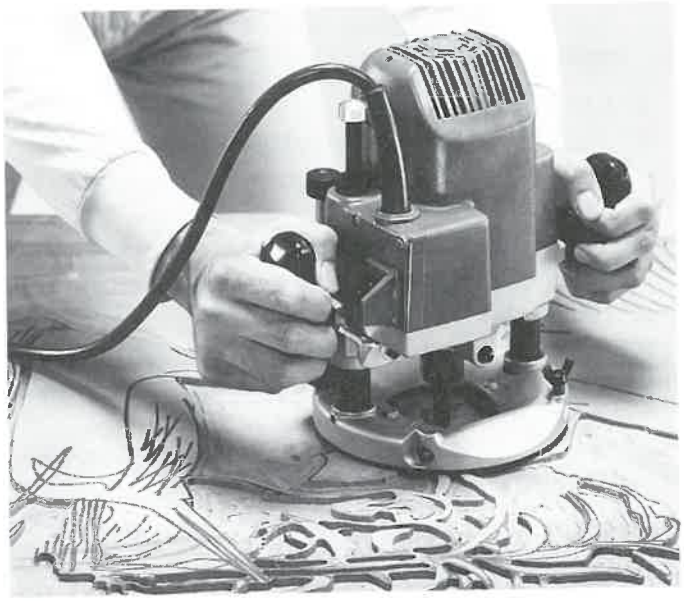


Figure 26-48. Work on carving may begin with routing out excess material. *(Makita U.S.A., Inc.)*

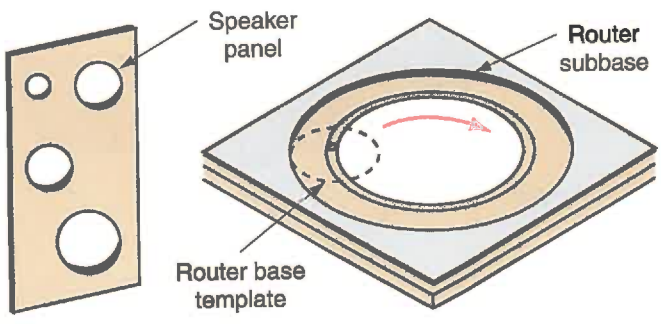


Figure 26-49. The router subbase may ride along the template to guide the bit.

1. Determine the hole size.
2. Select a plunge router with straight router bit.
3. Subtract the cutter radius from the subbase radius. This measurement then is the amount the template should be oversize. For example, suppose you are using a ½" (12.7 mm) bit in a 6" (152.4 mm) diameter (3" or 76.2 mm radius) router subbase:

$$\text{template oversize} = \frac{6}{2} - \frac{1/2}{2}$$

$$\text{template oversize} = 3 - 1/4$$

$$\text{template oversize} = \mathbf{2\ 3/4''}$$

Or

$$\text{template oversize} = \frac{152.4}{2} - \frac{12.7}{2}$$

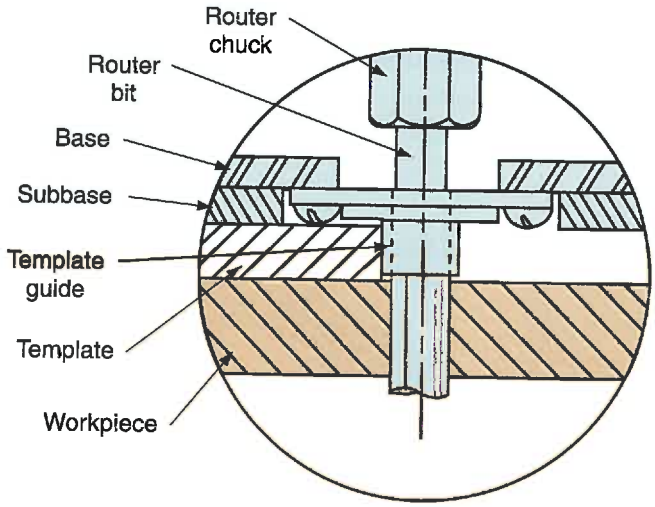
$$\text{template oversize} = 76.2 - 6.3$$

$$\text{template oversize} = \mathbf{69.9\ mm}$$

Therefore, the template must be 2¾" (69.9 mm) larger than the design at any point.

4. Cut the template.
5. Align and clamp the template over the workpiece.
6. Plunge the router bit into the workpiece to cut out the hole.

A ***template guide*** is a router accessory that fits inside the center of the subbase. Screws attach it to the router base. See **Figure 26-50.** As you guide the router, the template guide rubs on the template and follows the contour. See **Figure 26-51.** The template openings can be made smaller than that where the subbase guides the router. Just as when guiding the subbase along a template, the template must be larger than the hole. In this instance, substitute the diameter of the template guide. Few guides are interchangeable among manufacturers' routers.

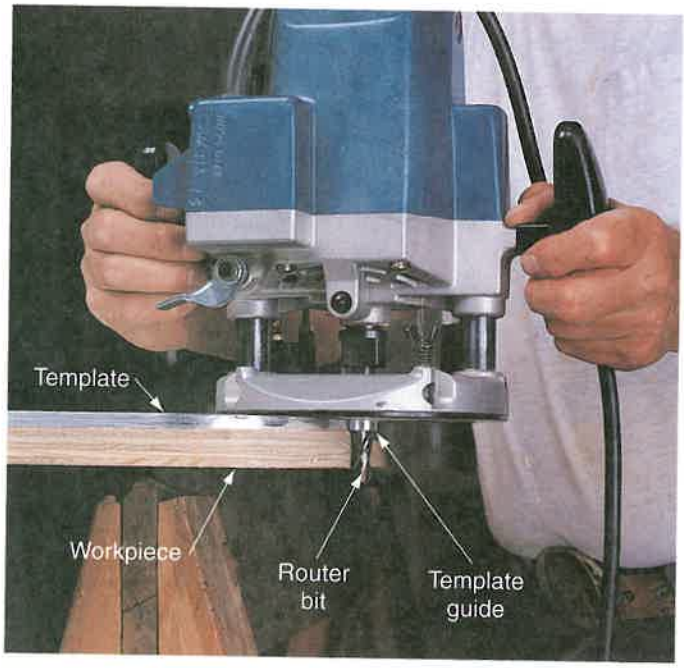


Template Guide Detail

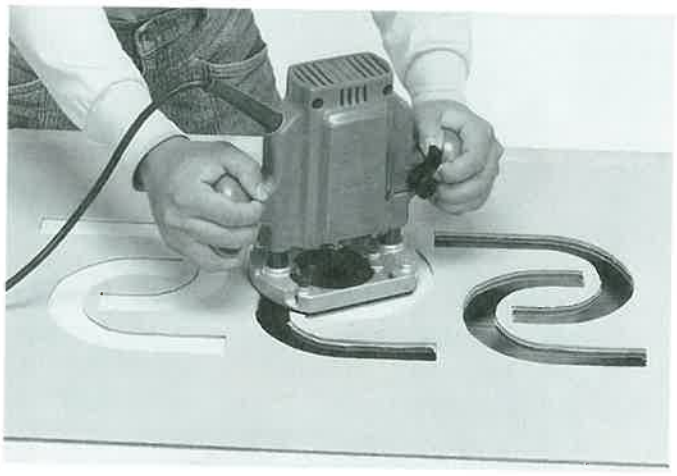
Figure 26-50. A template guide, attached to the base, may ride along the template to guide the bit.

Router jigs

There are a number of jigs available that make the router an even more versatile tool. The one shown in **Figure 26-52** produces carved cabinet door fronts. Other jigs make the router applicable for cutting joints.



A



B

Figure 26-51. Routing with a template guide. A—The template is clamped over the workpiece. *(Chuck Davis Cabinets)* B—The template guide rides along a template. *(Bosch)*

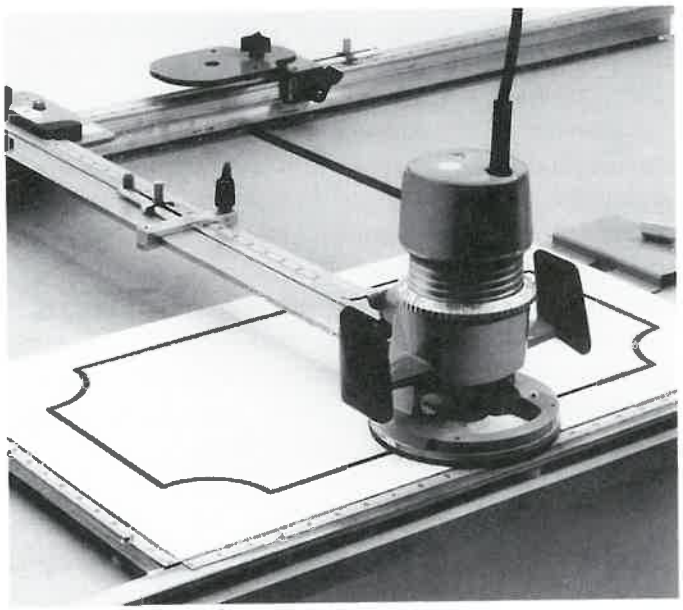


Figure 26-52. This jig reproduces cabinet door designs. *(Bosch)*

Table mounted portable router

The portable router can be mounted under a table for use as a shaper. See **Figure 26-53.** Router tables are commercially available or you can make your own. The base is attached to the table with screws or bolts. The router motor moves in the base to determine the depth of cut.

Setup and operating procedures are much like the shaper. Use a fence for straightedge routing. Use a router bit with a pilot to shape irregular surfaces. A ring-type point-of-operation guard must be in place. Feed from left to right.

Think Safety—Act Safely when Using Portable Routers

The portable router can be one of the cabinetmaker's favorite tools, if used properly. Follow these safety precautions.

- Select a plunge router for plunge operations.
- Wear eye protection, remove jewelry, and tie up loose hair and clothing.
- Insert bits into the collet at least ½" (13 mm).
- Tighten the base fence, or other attachments before turning on the machine.
- Feed the router at a moderate rate. Slow feeding results in burned wood. Fast feeding causes a rippled, washboard effect on the surface.
- Always let the router come to a complete stop before setting it down.
- Turn the switch off and disconnect power to the router before making adjustments or installing bits.

A

B

Figure 26-53. A—Mounting a router under a commercial router table. B—The router is then used like a shaper.

Laminate trimmer

The laminate trimmer is a smaller version of a router. It is specially designed to trim plastic laminate overhang at the edge of the substrate. The laminate trimmer is discussed in detail in *Chapter 36.*

Shaping with the Moto-Tool®

The Moto-Tool will shape intricate areas—wood carved surfaces and moldings are examples. Straight shank cutters with spiral cutting lips remove excess material quickly. The tool will also hold twist drills, abrasive disks and drums, and miniature grinding wheels. See **Figure 26-54.**

With a shaping bit, set the Moto-Tool at the highest speed. For larger areas, install a spherical or cylindrical bit. For small areas, install a small radius, straight bit. While shaping, guide the tool carefully. It will chew away wood from any surface it touches.

Shaping with a power carving tool

The portable power carving tool accomplishes many of the same tasks as a chisel. See **Figure 26-55.**

Figure 26-54. A Moto-Tool® comes with various bits. Shaping bits remove material quickly from small areas. *(Dremel)*

Figure 26-55. Power carving tool. *(Ryobi North America, Inc.)*

The tool has flat, gouge and *V* profile bits that range from 3 mm to 6 mm in width. A powered reciprocating motion is pressure activated.

Use the 10,400 strokes per minute speed when carving hardwoods. Work in a comfortable position and press the tool firmly into the wood. Remove small amounts of material with each pass for the most satisfactory cuts. The 12,500 strokes per minute speed cuts hinge mortises in medium to soft woods quickly. Decorative carvings are accomplished with ease and precision. Thin lumber panels are less likely to split compared to a wood carving chisel and mallet.

Shaping with hand tools

Hand tools for shaping include spokeshaves, specialty planes, Surform® tools, and contour scrapers. The spokeshave and curved plane create smooth contours. Some Surform tool shapes irregular contours. Contour scrapers remove small defects left by other tools.

Spokeshave

There are two types of ***spokeshaves***. One is for convex surfaces. It has a flat bottom about ¾" (19 mm) wide. See **Figure 26-56.** The other is for concave surfaces. It has a convex (curved) base. When sharpened and adjusted properly, the spokeshave is an effective tool. Originally, the tool was designed to shape wagon wheel spokes.

A spokeshave works like a plane. Push or pull the tool along the workpiece in a planing motion. See **Figure 26-57.** Work along the grain to avoid splintering the wood. Wood chips are removed with a blade about 2" (50 mm) long. The blade is installed similar to a bench plane iron. It is held by a lever cap. A thumb screw tightens the cap against the blade. Two adjusting nuts align the blade parallel to the bottom of the spokeshave.

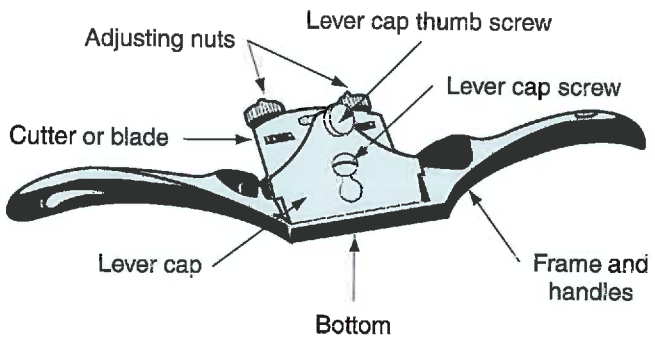


Figure 26-56. Spokeshave. *(Stanley Tools)*

Turn the spokeshave at a slight angle on large radius curves. Less forward pressure will be required. Watch for grain direction changes. Otherwise, the tool may skip and/or gouge the workpiece.

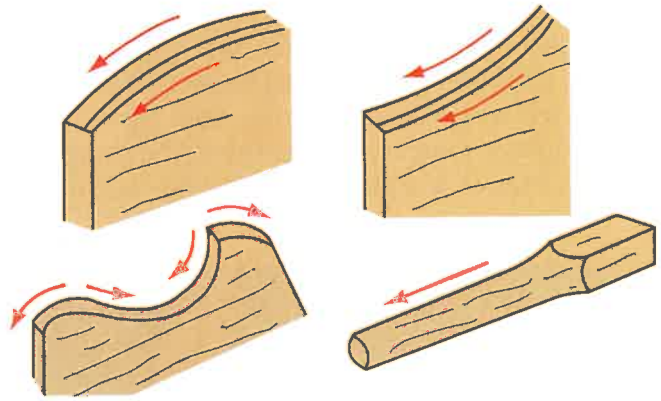
Circular plane

The ***circular plane*** has a flexible sole that adjusts to match the intended contour. See **Figure 26-58.** Depth of cut is adjusted like a bench plane. Turn the adjusting nut to flex the sole.

Combination plane

A ***combination plane*** allows you to do contouring. A set of changeable tool bits are shaped for ploughing, tonguing, beading, reeding, fluting, and sash shaping. See **Figure 26-59.** An adjustable fence helps position the plane.

Set up and use a combination plane like a regular plane. However, hold it at 90° to the work. Setup includes installing and adjusting the cutter. A notch on each cutter fits over the depth adjusting screw.



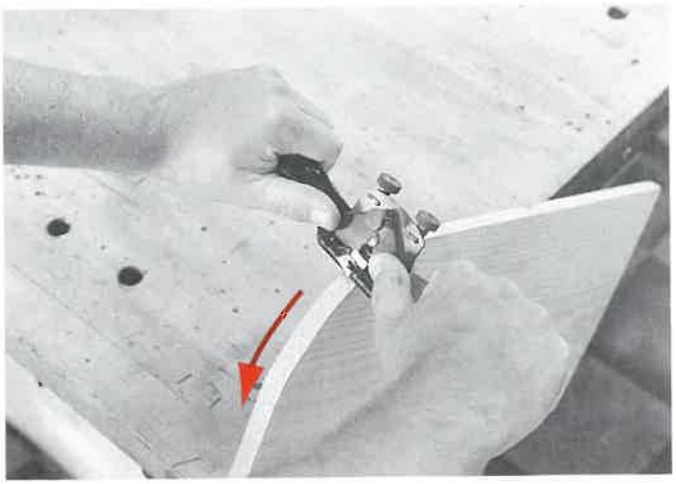
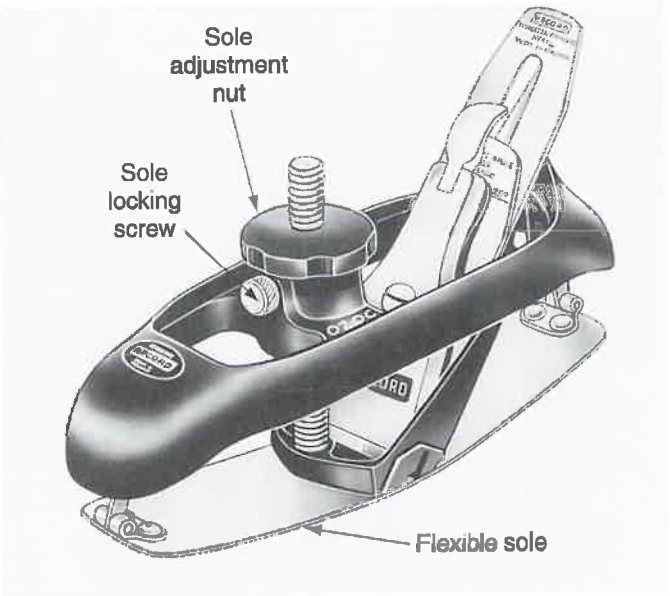


Figure 26-57. Push or pull the spokeshave around contours with the blade leaning away from the direction of cut.

Surform® tools

Surform tools have perforated metal blades with many individual cutting edges. See **Figure 26-60.** You can use Surform tools on many materials, such as lumber, plywood, fiberboard, plastics, fiberglass, and some types of aluminum. Surform tool shapes include flat, half round, round, and curved.

Using the Surform plane at different angles results in different amounts of wood removed. See **Figure 26-61.** When pushed at an angle to the right, the Surform plane removes the maximum material. With the Surform plane body parallel to the workpiece, produced chips are smaller and the surface is smoother. With the Surform plane handle to the left, a smooth surface that will require very little sanding results.



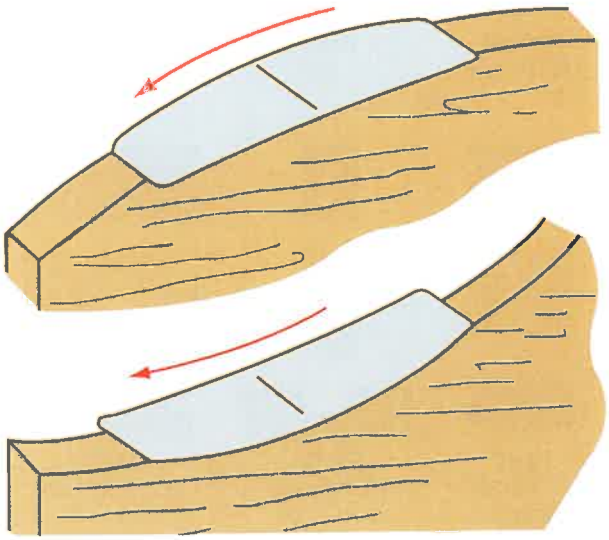


Figure 26-58. A circular plane smoothes convex and concave curves. *(Record-Ridgeway)*

Surform planes and files have optional blades that provide a flat regular cut for woods, a flat fine cut for soft metals, and round and half-round regular cut for woods. The edge of the flat cut blades has an edge cut feature for inside corners. Other blades, which are used for sanding wood, plastic, paint, and varnish, are made of steel that is coated with tungsten carbide. This coating is 46 grit and 80 grit.

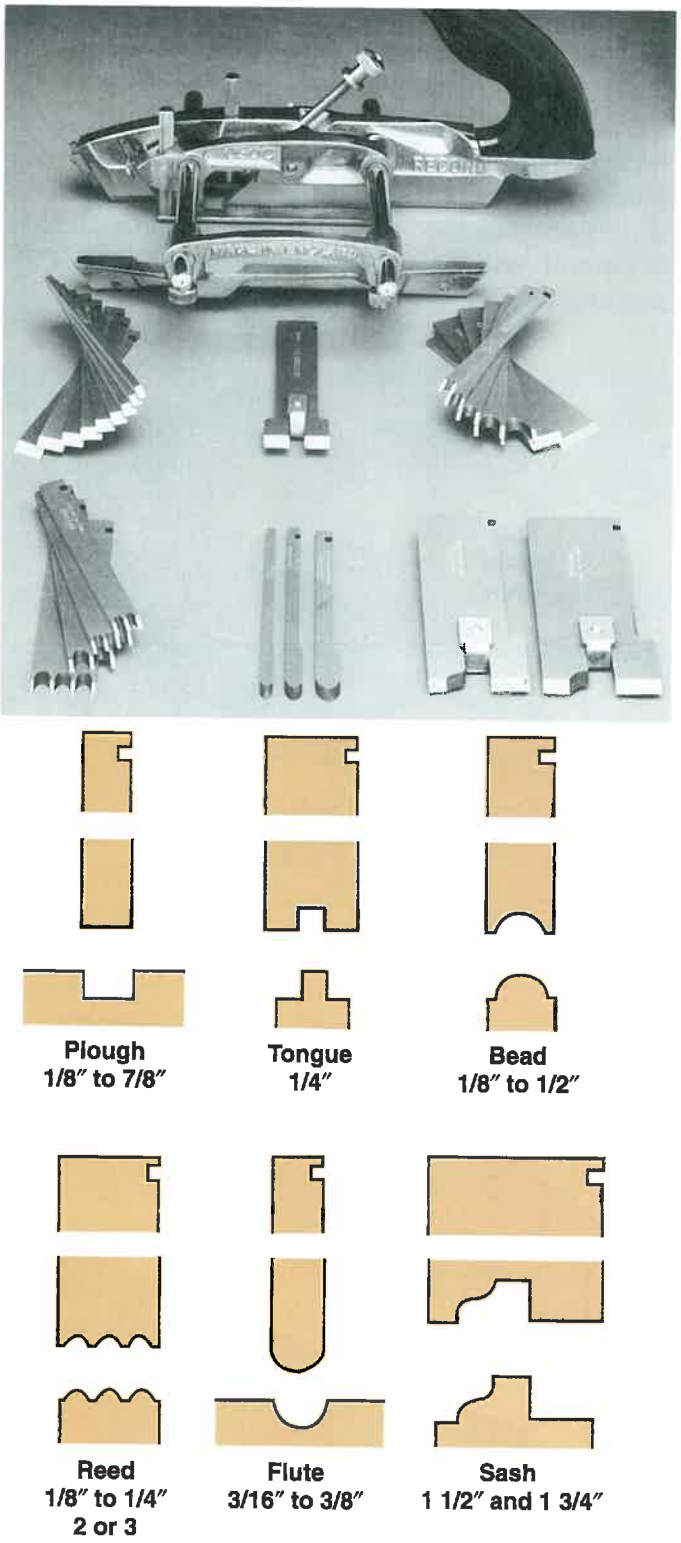


Figure 26-59. Shape lumber by hand with a combination plane. *(Record-Ridgeway)*

Draw knife

A ***draw knife*** is appropriate for creating chamfers and for roughing out curved contours. Use it with care, it can easily follow the grain causing deep cuts. See **Figure 26-62.** It has an open-beveled blade with handles on both ends.

Contour Scrapers

A ***contour scraper*** is a form of curved hand scraper. See **Figure 26-63.** It smoothes shaped surfaces. Using and maintaining scrapers was discussed in *Chapter 24.*

Maintaining Shaping Tools

High quality shaping depends on sharp tools and well-maintained machines and equipment. Hand tool sharpening techniques for the spokeshave and contour scraper are the same as those discussed in *Chapter 24* for bench planes and hand scrapers. However, sharpening shaper cutters and router bits requires special procedures.

Shaper cutters and router bits may be solid carbide, carbide-tipped, or high-speed steel. High-speed steel cutters are ground, then honed on a stone. Carbide cutters and bits should be sharpened only on special machines by grinding technicians.

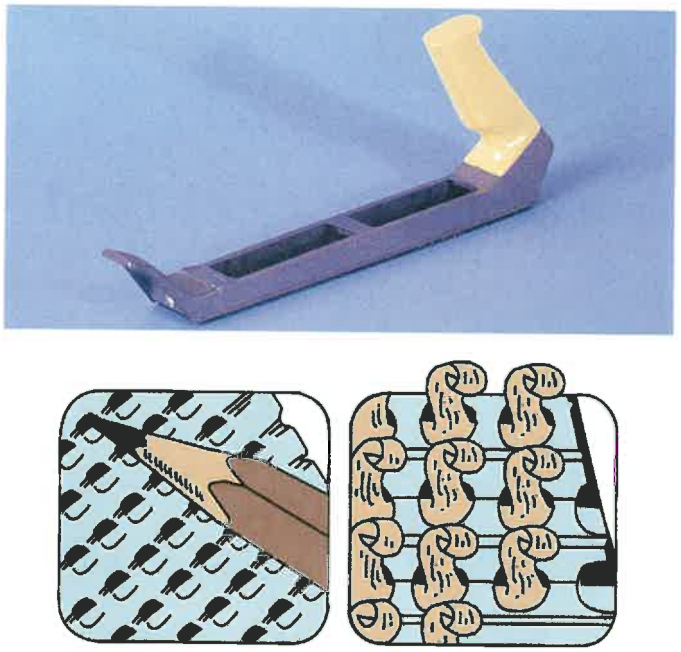


Figure 26-60. The hardened steel teeth of a Surform® tool remove material without clogging. *(Stanley Tools)*

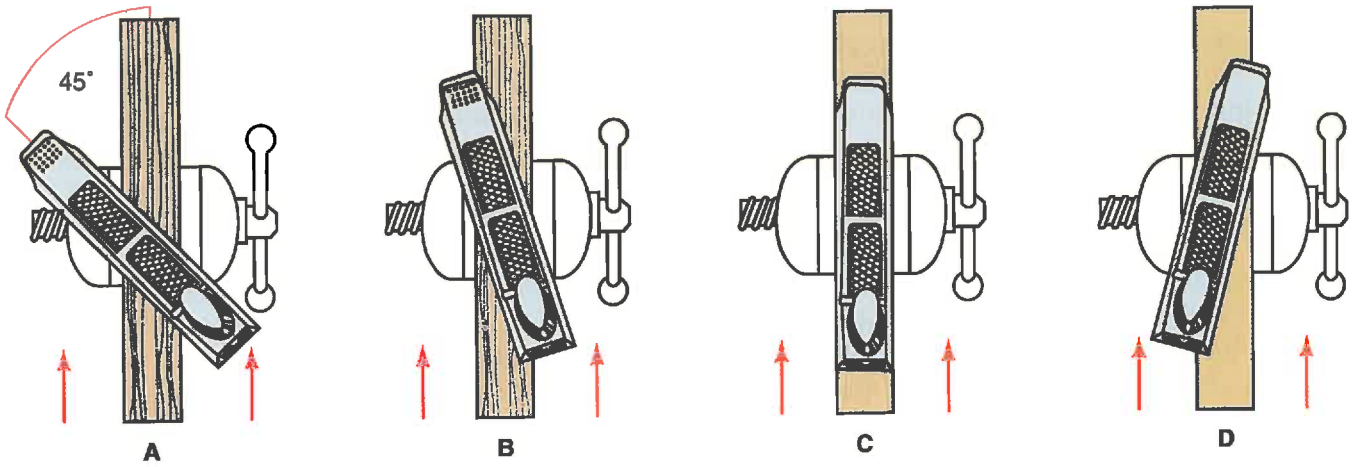


Figure 26-61. Surface quality is controlled by the Surform® plane's position. A—To remove a maximum amount of material, simply hold the tool at 45° to the direction of the stroke. B—To remove less material and obtain a smoother surface, reduce angle. C—To finely smooth the work surface, simply direct the tool parallel to it. D—And you can achieve an almost polishing effect by directing the tool at a slightly reversed angle. *(Stanley Tools)*

Figure 26-62. A draw knife shapes table legs quickly. *(American Machine and Tool Co.)*

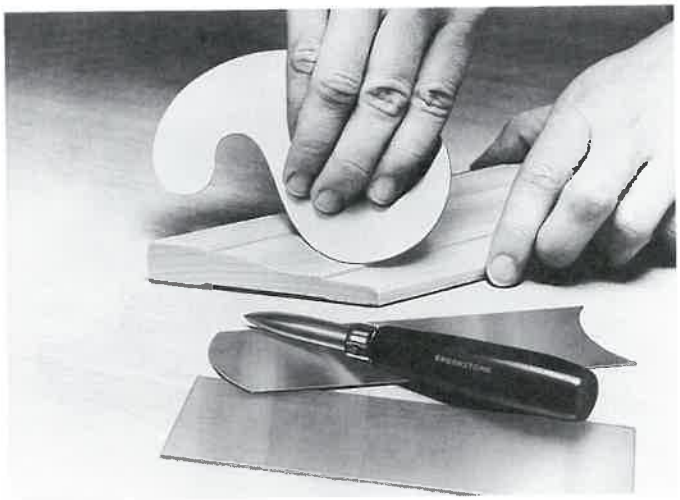


Figure 26-63. Contour scrapers smooth irregular surfaces. *(Brookstone)*

The cost of carbide cutters is nearly the same as high-speed steel. However, since they perform 10 to 20 times longer between grindings than high-speed steel cutters their true cost is lower.

Preventive maintenance is very important. Removing built-up resins on cutters with solvents will prolong the life of the cutting edge.

Generally, you can tell when a cutter is getting dull. It creates a loud high-pitched noise. The workpiece becomes more difficult to feed. The chips are smaller and more dust is created. There is greater heat buildup. Heat can cause bits to lose their hardness (temper). The bit then requires more frequent sharpening.

Sharpening Shaper Cutters

Grind cutters only when the cutting lip is chipped. Grind only the flat front surface of the cutting lip. Grinding the bevel edge will change the shape. Hold the bit against the side of the wheel. Take very light cuts, just enough to regain the cutting edge.

Grinding should rarely be necessary. Most often, the cutter can be sharpened by honing. Place the cutter's face on the stone's surface. Move it back and forth over the corner of the stone as shown in **Figure 26-64.** Lightly touch the bevel of the cutter with a slip stone to remove burrs.

Sharpening Router Bits

Router bits can be ground using the attachment shown in **Figure 26-65.** The procedure is as follows:

1. Turn the switch off and disconnect your router and turn it upside down.
2. Secure a small cup grinding wheel in the router collet as if installing a bit.

3. Secure the router bit in the grinding jig. Adjust the jig so the cutter is at its highest position.
4. Align the router's depth of cut mechanism. The grinding surface of the wheel must be just below the bit.
5. Connect power and turn on the router.
6. Lower the bit just until a few sparks fly.
7. Grind the full length of the cutting lip. Reduce the bevel on the cutting edge to .003" (.076 mm).
8. Rotate the router bit 180° in the jig. Repeat Step 7.
9. Strop the cutting edge to remove burrs. You can sharpen the bit by honing many times between grindings. Use the honing procedure for shaper cutters.

Cleaning and Lubricating Machinery

Shaping machines operate at high speeds. To maintain those speeds, bearings must be friction free. Most bearings are sealed.

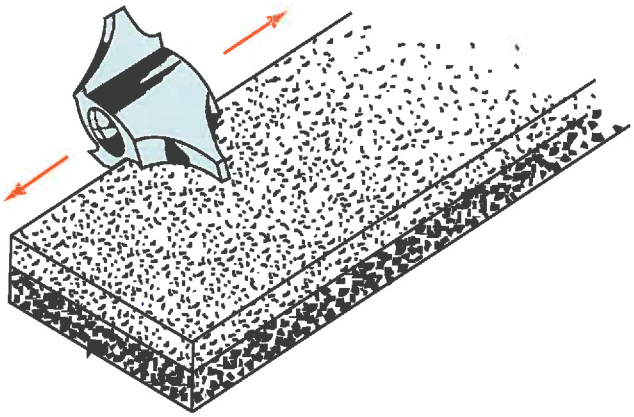


Figure 26-64. Hone only the leading surface on shaper cutters and router bits.

Various slide and screw mechanisms on machinery should be lubricated. Use lubricating oil in areas where there is no dust. (Dust will adhere to oil. An accumulation will prevent free movement of slides and screws.) Use silicone spray or paraffin where dust is present. Also, wood will not absorb these lubricants, so use them on table surfaces.

Inspect machine belts regularly. Proper tension maintains spindle and collet speeds. The belt should not move side-to-side more than recommended in the owner's manual.

Maintaining portable tools is relatively simple. Keep them clean and free of rust. Apply silicone or wax to slides and locking mechanisms. Router bases and motor housings are often aluminum. Handle them with care. Use the proper wrenches, packaged with new machines, when making adjustments. Adjustable jaw wrenches tend to strip the corners on locknuts and collets.

Recharging Cordless Tools

Battery-operated cordless tools allow free movement around the workplace. There is no power cord to interfere. See **Figure 26-66.** With substantial improvements in battery technology, there has been a steady introduction of new products featuring higher torque and longer operation between charges. This has resulted in a large variety of cordless tools available to the cabinetmaker. Trim saws, driver/drills, hammer drills, are some of the more common.

Keep an extra fully charged battery available for use while the spent battery is being recharged. Some newer products have electronic chargers that

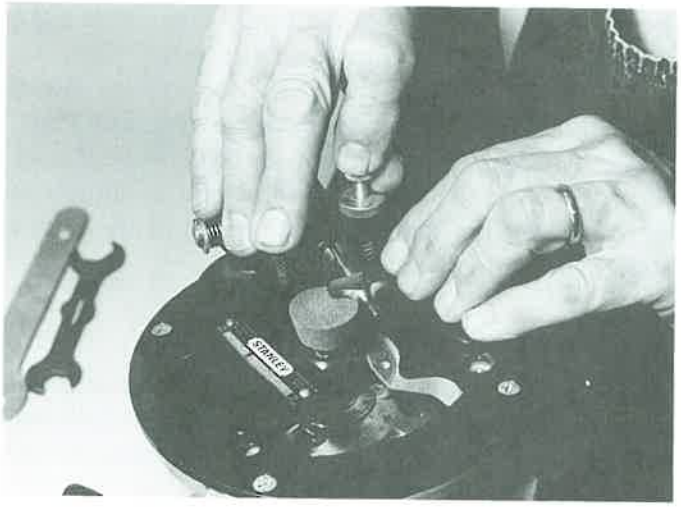


Figure 26-65. This grinding jig allows you to sharpen router bits. *(Stanley Tools)*

Figure 26-66. Charge cordless tools according to manufacturer's instructions.

provide power is small increments to avoid building up battery cell damaging heat. These chargers can provide a complete charge in as little as 15 minutes. Turn the tool's switch off and remove the battery. Then insert the battery in the charger.

Perform the charging at a room temperature ranging from 50°F to 104°F (10°C to 40°C). Provide adequate air circulation around the charger when charging.

Summary

Shaping meets many functional and design needs in cabinetmaking. Smooth contours and decorative effects are achieved by using the right tool, machine, and cutter.

Stationary shaping machines include the spindle shaper, overarm router, inverted router, and overarm router/shaper. You can also adapt the table saw, radial arm saw, and drill press for shaping. Portable shaping tools include the portable router, plunge router, laminate trimmer, and Moto-Tool. Hand tools include the spokeshave, circular plane, combination plane, Surform tools, draw knife, and contour scrapers.

Take extra caution when setting up power equipment, install point-of-operation guards. Select the proper bit or cutter for the job. Check the tightness of the bit twice. If possible, avoid freehand shaping by using fences, starting pins, jigs, or other means of guiding the tool or workpiece.

Test Your Knowledge

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

1. Why is it essential that you use a keyed washer when installing a shaper cutter?
2. Describe two types of spindle shaper guards.
3. The spindle shaper uses a(n) _____ cutter while routers use _____ bits.
4. List, in order, the items placed on the spindle when installing a shaper cutter.
5. Describe four options for guiding the workpiece when using a spindle shaper.
6. Explain when a shaper's infeed and outfeed fences are aligned, and when they are not.
7. List the order for shaping four sides of a board.
8. Describe how a router bit pilot and shaper collar function similarly.
9. Explain how to set bit depth for both floor standing and bench model overarm routers.
10. Router bits with cutting lips on the ends are for _____.
11. Why must you feed against the rotation of the cutter for any power shaping machine?
12. For pin routing, the guide pin is _____.
    a. directly under the router bit
    b. directly under the shaper cutter
    c. offset to the infeed side
    d. offset to the outfeed side
13. Is it necessary to have a template when pin routing?
14. Identify the method for setting bit depth on the overarm router/shaper.
15. What safety advantage is gained by using an inverted router rather then an overarm router?
16. The table saw is adaptable for shaping by installing a(n) _____.
17. To use a shaper cutter or router bit on the radial arm saw, you must install a(n) _____ or _____.
18. A drill press adaptable for shaping or routing _____.
    a. must be variable speed
    b. should be a 20" (508 mm) model
    c. turns both clockwise and counterclockwise
    d. has a chuck threaded to the spindle
19. Depth of cut for a portable router is set by changing the _____ position in the _____.
20. Describe the primary differences between conventional and plunge routers.
21. Name two methods used to guide the portable router.
22. For which portable router operations do you use a bit with pilot?
23. Explain why a spokeshave is more appropriate for curves than is a smooth plane.
24. The angle at which the Surform tool is pushed determines the _____.
25. Shaper cutters and router bits are ground and honed on _____.
    a. all surfaces
    b. the front surface of each cutting lip
    c. on the back side of each cutting lip
    d. the edge of the lip

The Multi-Pro router is used for intricate carving work. (*Dremel*)

Turning

27

Objectives

After studying this chapter, you will be able to:

- Identify components made by spindle and faceplate turning.
- Select lumber for turning.
- Mount stock between centers or on a faceplate.
- Work with turning tools to create desired shapes.
- Follow steps to turn cylinders, beads, coves, and grooves.

Important Terms

center finder
dead center
duplicator
faceplate
headstock
inboard turning
lathe chuck
lathe guard
live center
outboard turning
parting tool
round-nose tool
spear-point tool
spur center
tailstock
tailstock quill
tool rest
turning
turning squares
turning tools

Figure 27-1. Between-center turning for making spindle products. The guard was removed to show the operation.

Figure 27-2. These bedposts were turned between centers. *(J.P. Stevens).*

Turning processes produce round parts on a lathe. Stock is mounted between centers, or on a faceplate. A turning tool is held against and moved along the rotating workpiece to remove material. ***Spindle turning,*** or ***between-center turning,*** creates cylindrical, tapered, or contoured parts. See **Figure 27-1.** These include table and chair legs, stair banisters, and bedposts. See **Figure 27-2.** When the workpiece is mounted on a faceplate, you can turn the face as well as the edges. See **Figure 27-3.** This produces products such as bowls, knobs, pulls, stool seats, and tabletops. Stock can be held by other methods as discussed later in the chapter.

Lathes

There are ***lathes*** for production turning and for small cabinet shop or home use. Production lathes turn numerous parts automatically. The turning tool, or bit, is guided by electromechanical or computerized controls. Discussed in this chapter are the standard and bowl lathes. Suitable for small cabinet shop and home use, these turn one part at a time. They make custom products or duplicate damaged parts when restoring furniture. A duplicator accessory allows you to turn multiple parts.

Standard lathe

Most wood turning operations are performed on the standard lathe. See **Figure 27-4.** The machine

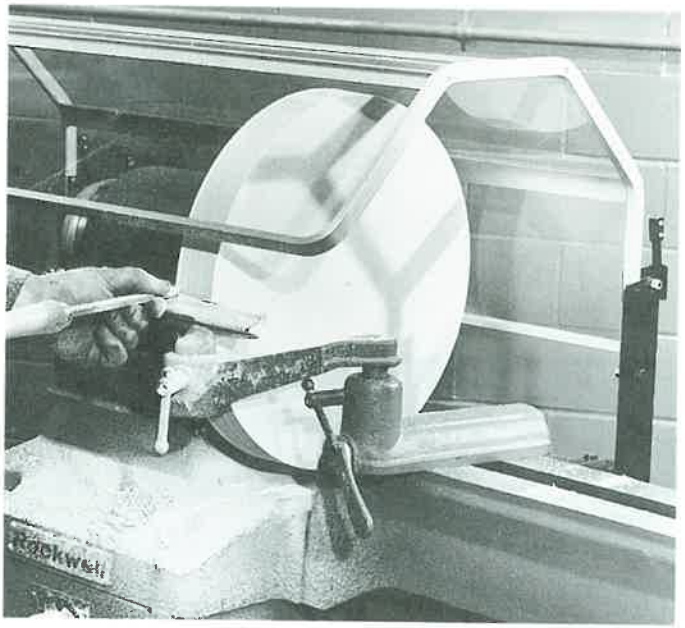


Figure 27-3. Face plate turning. *(Delta International Machinery Corp.)*

consists of the headstock, bed, tailstock, tool rest, and guard. The headstock houses the spindle that drives the workpiece. There are threads at both ends of the spindle on which a faceplate can be mounted. The spindle is hollow and tapered to accept a center. The tapered center and spindle form a friction fit to hold the center in place. To the right of the headstock is the bed. It consists of two flat rails on which the tool rest and tailstock are mounted. The tool rest and tailstock move along the bed to accommodate any workpiece length. The bed aligns the tailstock quill with the center of the spindle. The hollow, tapered tailstock quill holds the second center between which stock may be mounted. The bed also supports an adjustable tool rest. On some lathes, there is a gap between the headstock and bed. A gap bed lathe allows larger diameter parts to be faceplate turned.

Standard lathe sizes are measured by swing, overall bed length, and distance between centers.

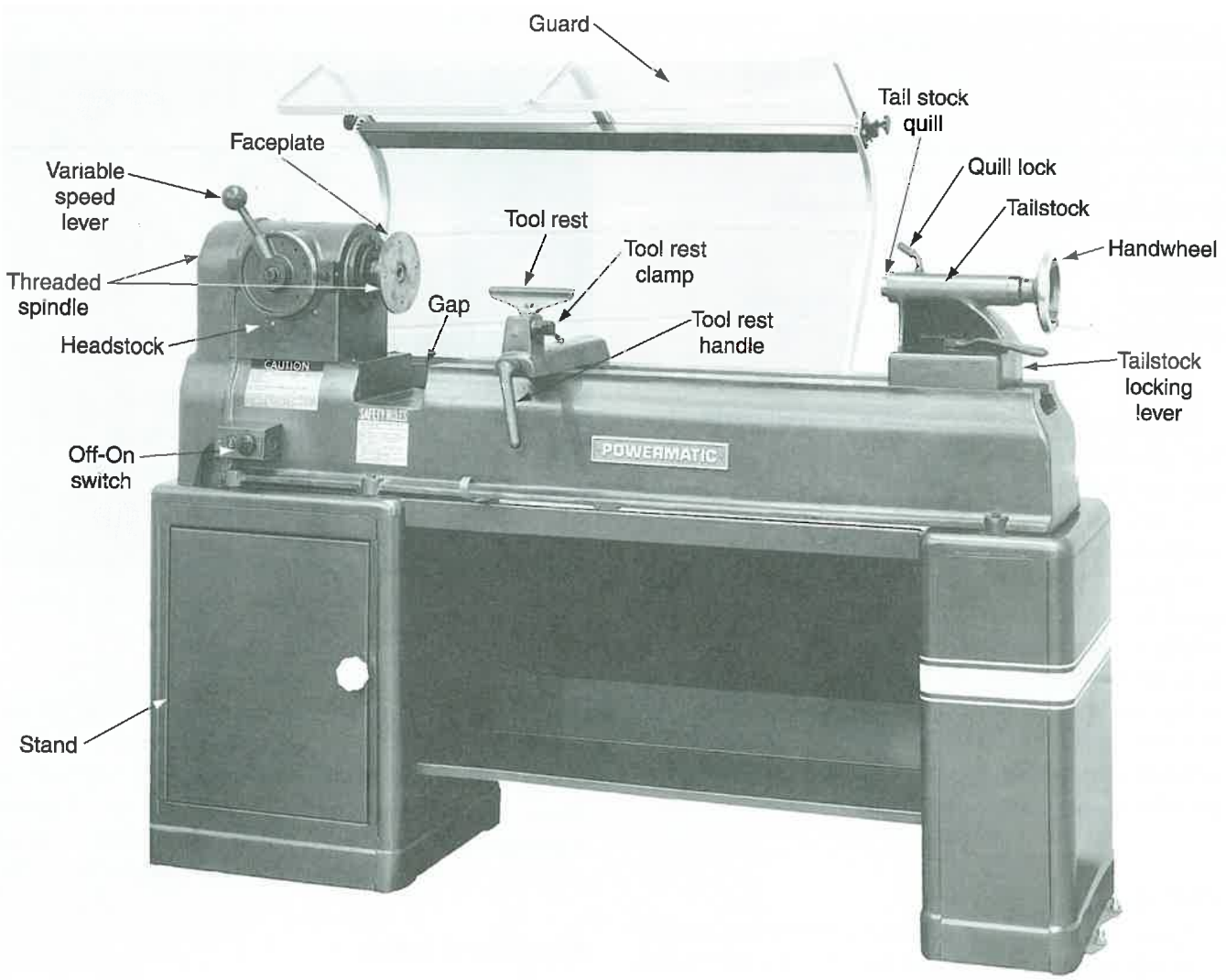


Figure 27-4. The standard wood turning lathe. *(Powermatic)*

The swing is the largest diameter workpiece that can be turned. The overall bedlength is the distance between the headstock and the end of the bed. The distance between centers determines the maximum length of stock that can be turned.

Lathe speed is set with a variable speed lever or with step pulleys. An *OFF-ON* switch will be near the headstock. Sometimes, the switch and speed control are on one lever.

The user is protected from flying chips by a clear plastic or wire mesh guard. It mounts on the back of the lathe. Lift the guard and rest it in an upward position when mounting stock. When the spindle is turning, lower the guard into place.

Bowl lathe

The bowl lathe is a special machine for faceplate turning only. See **Figure 27-5.** Many of its parts are the same as the standard lathe.

Turning Tools

Turning tools include a number of chisel-like cutters. A standard set has a gouge, a skew, a parting tool, a round-nose tool, and a spear-point tool. All are about 17" (430 mm) long. See **Figure 27-6.** Carbide-tipped cutting edges are more durable, but are not necessary for most operations.

Turning is either a cutting or scraping action, depending on how the tool is held. See **Figure 27-7.** For cutting, hold the tool on the rest at a slightly upward angle. A scraping action occurs when the tool is held at about 90° to the workpiece center.

The sharpness and angle of the cutting tool control the smoothness of the cut. However, grain direction and pattern are also factors. Certain portions of the circumference remain rough. See **Figure 27-8.** A scraping action enhances this roughness because chips can be torn, especially from open grain wood. Careful turning with sharp tools, especially a cutting action with the skew, reduces the need for abrasives. This is important since abrasives can leave crossgrain scratches.

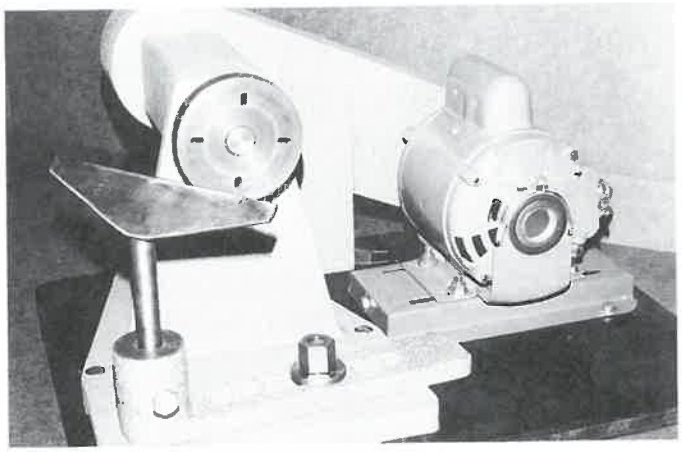


Figure 27-5. The bowl lathe is for faceplate turning only. *(Brodhead-Garrett)*

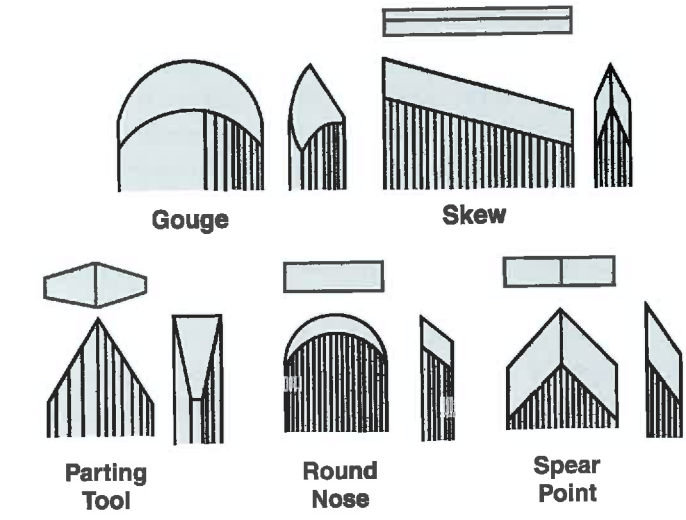


Figure 27-6. Top—Carving tools commonly used for relief carving. Middle—Gouges are used for general shaping *(Stanley Tools)* Bottom—Shapes and angles.

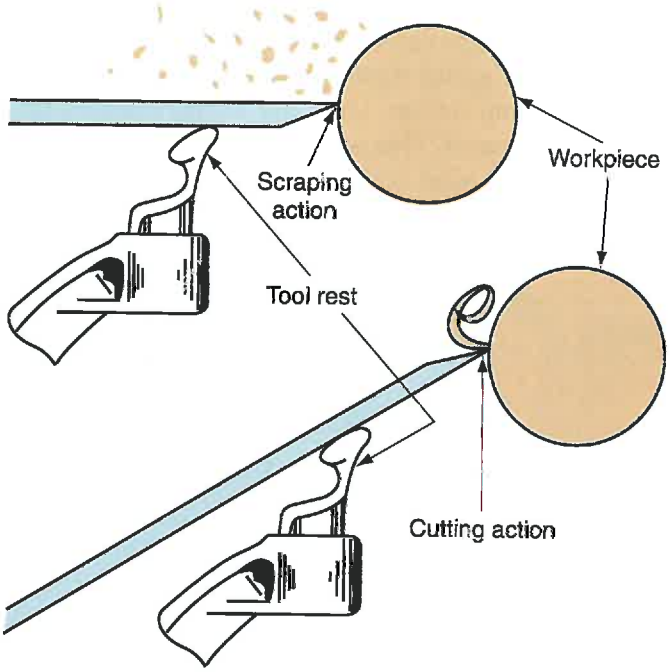


Figure 27-7. Turning can be a cutting or scraping action.

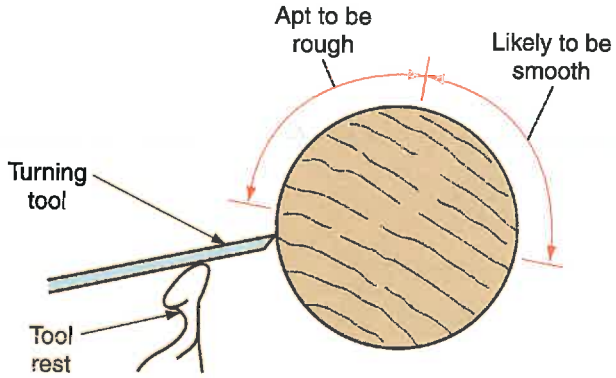
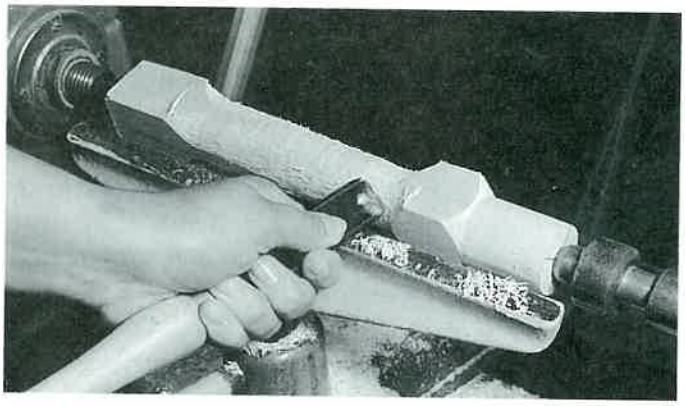


Figure 27-8. Grain direction affects the smoothness of the surface.

The gouge rough-cuts stock to near workpiece diameter. It can be used for either cutting or scraping. See **Figure 27-9.** The parting tool is held in the scraping or cutting position to produce square shoulders, inside corners, and grooves. See **Figure 27-10.** Select the round-nose tool, held in the scraping position, for concave curves. See **Figure 27-11.** The spear-point tool scrapes *V* grooves, beads, chamfers, inside corners, and square shoulders. See **Figure 27-12.** The skew cuts or scrapes *V* grooves, beads, cylinders, tapers, and other shapes. The tool is made so versatile simply by holding it at different angles. See **Figure 27-13.** Skew cutting, done carefully, greatly reduces the need for sanding when spindle turning. This is why the skew is generally used last for detail work. With faceplate turning, it is difficult to control the skew. The point tends to catch in end grain and gouge the wood.



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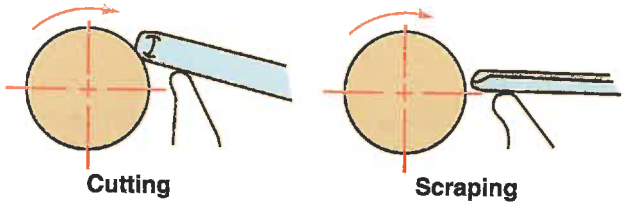
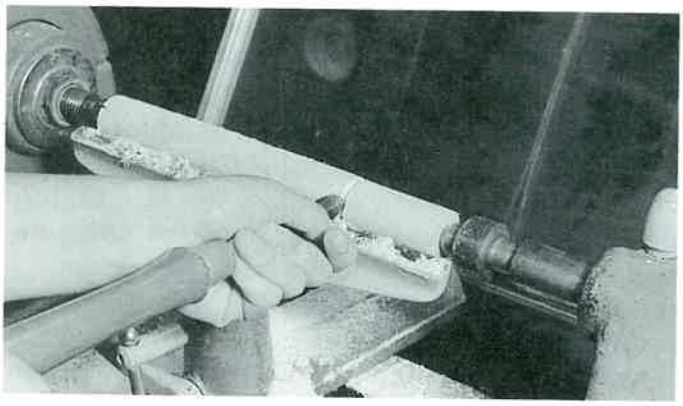


B

Figure 27-9. Cutting and scraping with gouge. The guard was removed to show the operation.



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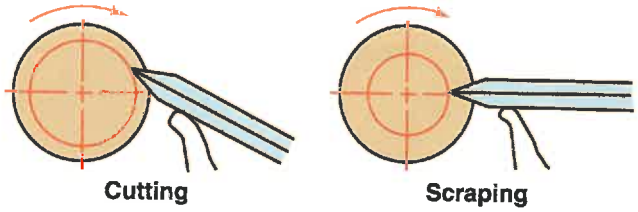
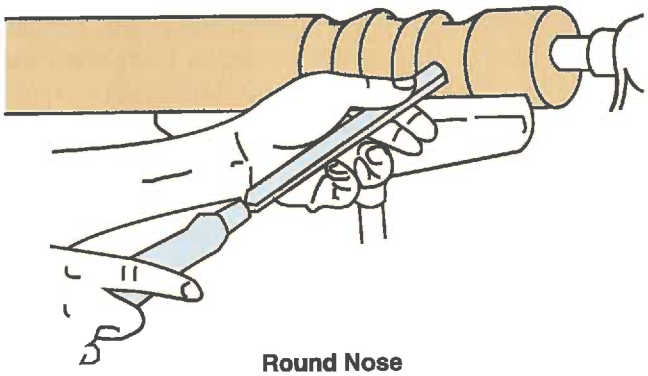


B

Figure 27-10. Cutting and scraping with the parting tool. The guard was removed to show the operation.

The cabinetmaker often finds that special shaped tools are valuable. For example, a square-end tool, which looks like a long chisel, performs similarly to the spear-point tool. Some suppliers sell this and other tool shapes in add-on sets.

A



B

Figure 27-11. Scraping a cove with the round-nose tool The guard was removed to show the operation.

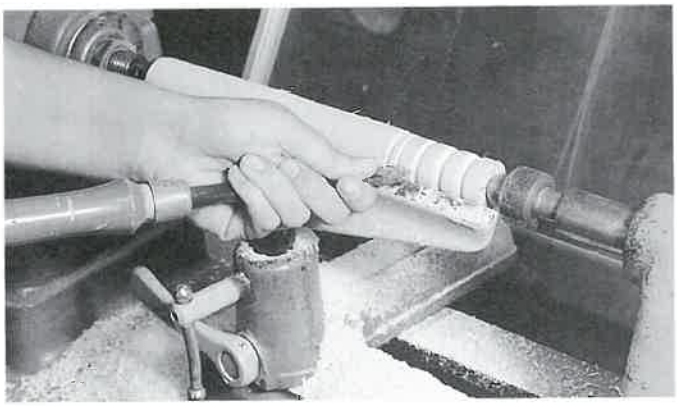
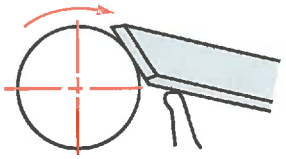
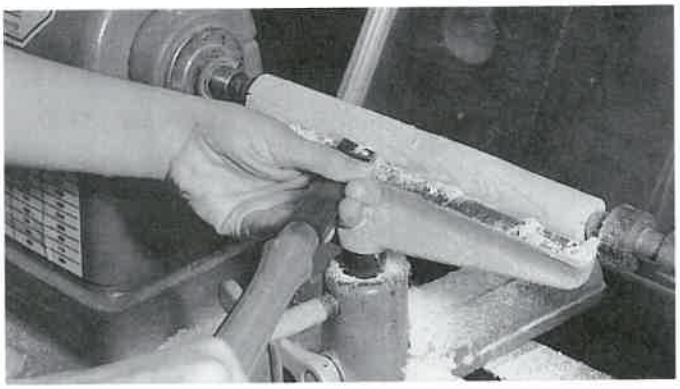


Figure 27-12. Scraping V-grooves with the spear-point tool. The guard was removed to show the operation.

Knife inserts made for a special handle are available. See **Figure 27-14.** The knives turn shapes that would be difficult, if not impossible, to create with standard turning tools. The knife is secured in the handle and used in a scraping position. A cutting action would lift up chips and might ruin fine detail.





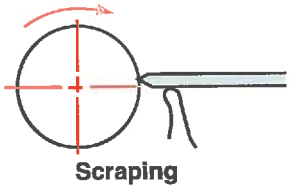


Figure 27-13. Scraping and cutting with the skew. The guard was removed to show the operation.

Another option is to grind tool shapes for special purposes. Suppose a number of duplicate decorative spindles are needed. Each spindle has several beads, coves, and ogee shapes that would be difficult to turn with standard tools. You can create the shapes out of good quality steel or an old flat file. Grind and hone the cutting edge, then attach a handle.

Tool holding

A ***tool rest*** supports the turning tool during your operation. It adjusts vertically and laterally, and it pivots. Position the rest 1/8" (3 mm) away from the workpiece and about the same distance above the work center line. See **Figure 27-15.**

Tool rests come in different widths. A short width tool rest might be mounted when turning a knob. Install a longer rest when turning table legs, chair rungs, and long spindles. A 90° tool rest can be positioned over the bed for turning the face and edge of a product.

Turning is a two-handed operation; both hands are needed to control and move the tool. How you hold the turning tool is a matter of preference. Most cabinetmakers hold the handle in their right hand. The left hand thumb is placed on the top of the tool and your fingers are under it. The tool's depth of cut is guided by your index finger against the tool rest. Another hold has the hand over the blade and thumb underneath. The user's little finger rubs against the tool rest to control depth of cut.

Feed the chisel with moderate pressure. Forcing it into your work will result in a rough surface and may gouge the wood. Apply just enough force to maintain a cutting or scraping action. Otherwise, the tool simply rubs against the wood.

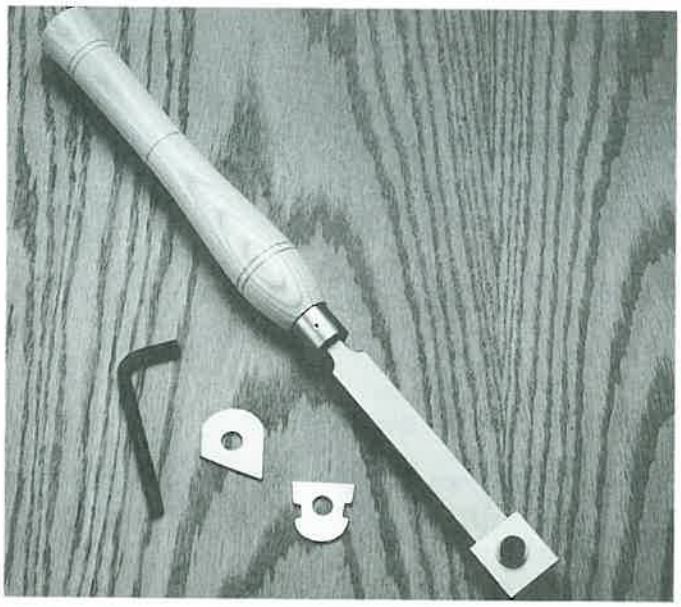


Figure 27-14. Interchangeable cutters allow you to create additional contours. *(Shopsmith)*

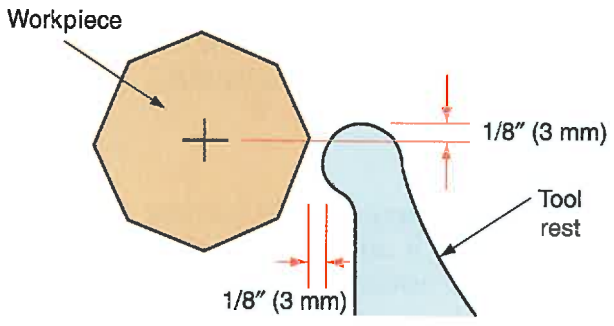


Figure 27-15. Position of the tool rest.

Mounting Stock

As stated earlier, stock can be mounted one of several ways: between centers, faceplate, screw-thread faceplate, or lathe chuck. See **Figure 27-16.**

When spindle turning, stock is mounted between a spur (drive) center and a live or dead center. The ***spur center*** has a cone point and four sharp spurs that drive the workpiece. Its ***Morse taper*** shank fits snugly into the spindle. Inserted into the tailstock quill, another center supports the workpiece. The ***dead center*** has a cup with a sharp circular rim and center point. A dead center remains stationary while the workpiece turns against it. To reduce heat buildup, apply oil or wax. The ***live center*** has a ball bearing and cupped point. The workpiece does not rotate against the point. Rather, the ball bearing allows the center to turn with the workpiece. This prevents the workpiece from burning or becoming loose. These problems occur with dead centers.

When faceplate turning, secure stock with several screws to a faceplate. ***Faceplates***, ranging in diameters from 2" to 6" (51 mm to 153 mm), thread onto either the inboard or outboard side of the headstock. ***Inboard turning*** is done with the faceplate mounted on the bed side of the headstock. ***Outboard turning*** is done with the faceplate mounted on the spindle side opposite the bed. You need a separate ***tripod stand*** for the tool rest when outboard turning. The advantage of outboard

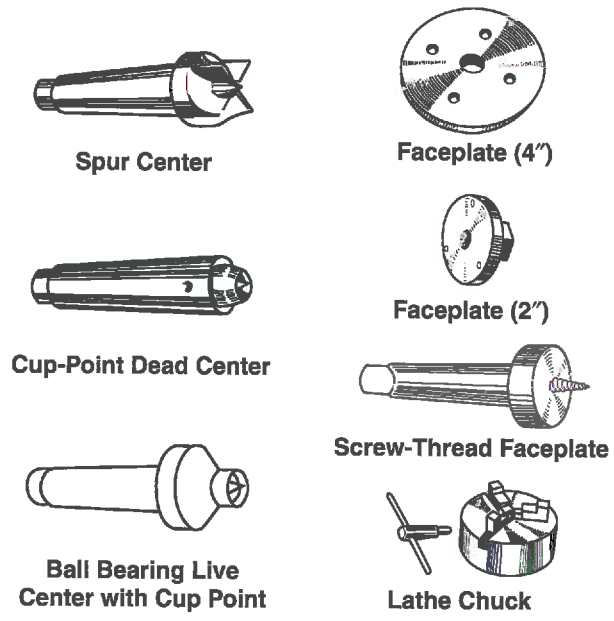


Figure 27-16. Stock is mounted with various accessories. *(Delta International Machinery Corp.)*

turning is that part diameters up to 16" (406 mm) can be created. Workpiece weight should control the turning speed.

A handwheel is threaded onto the outboard end of the spindle. It may serve as a faceplate if there are holes for screws drilled in it. However, it also lets you turn the spindle by hand when checking tool rest and workpiece clearance. Place your hand against it to stop a coasting lathe. Never grab the rotating workpiece to stop it. You may wind up having a hand full of splinters.

For turning small parts, such as knobs and pulls, use a ***screw-thread faceplate***, also called a ***screw center***. The faceplate, usually 1½" (38 mm) in diameter, has a ¾" to 1" (19 mm to 25 mm) threaded screw-like center. To mount stock, drill a pilot hole, then thread the stock onto the screw. See **Figure 27-17.**

When you need to turn without centers, but do not want screws in your workpiece, choose a ***lathe chuck***. The chuck mounts on the spindle and can hold round stock from 1/8" (3 mm) up to 4" or 6" (101 mm or 153 mm) in diameter. See **Figure 27-18.** The chuck can also be inserted in the tailstock for drilling operations. The workpiece is mounted on a faceplate. Insert a drill bit in the chuck and move the tailstock close to your work. Turn the tailstock handwheel to feed the bit into the rotating wood.

Lathe Speeds

Lathe speeds are controlled by one of two methods. Some machines have step pulleys on both the motor and spindle. Speed is determined by the size relationship between pulleys. Mount the belt on small motor and large spindle pulleys for slow speeds. Using a large motor pulley results in higher speeds. Most lathes are variable speed and adjusted while the machine is running. Lathe speeds are usually printed on the stand or near the speed lever. Otherwise, use a tachometer or calculate the speed mathematically based on the pulley sizes and motor rpm. You must know the speed range settings for turning. See **Figure 27-19.** A rule of thumb is to use slow speeds for large work and fast speeds for small work. Established maximum speeds have been set for various turning operations. These are for the protection of the machine and operator.

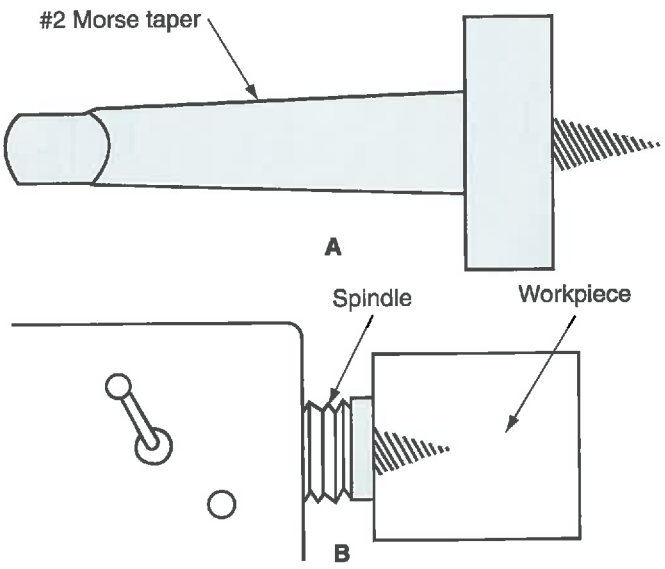


Figure 27-17. Mounting a workpiece on a screw-thread faceplate. A—Insert the faceplate into the spindle. B—Thread on the workpiece.

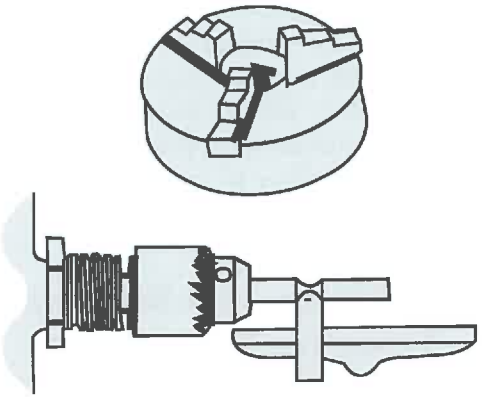


Figure 27-18. Small parts can be held in a lathe chuck.

DANGER

DO NOT EXCEED THESE RECOMMENDED SPEEDS. SERIOUS INJURY CAN RESULT IF PARTS BEING TURNED ARE THROWN FROM THE LATHE.

Dia. of Work	Roughing R.P.M.	Gen Cutting R.P.M.	Finishing R.P.M.
Under 2	1520	3000	3000
2 to 4	760	1600	2480
4 to 6	510	1080	1650
6 to 8	380	810	1240
8 to 10	300	650	1000
10 to 12	255	540	830
12 to 14	220	460	710
14 to 16	190	400	620

Figure 27-19. Always refer to speed instructions. *(Powermatic)*

Lumber

Carefully select clear lumber for turning. Some species turn better than others. Refer to *Figure 12-45.* Stock with defects, such as knots and cracks, is unacceptable.

Close grain hardwoods, such as maple, are the best for turning. Walnut and mahogany are also good. Open grain woods, such as oak, are more difficult to turn and require a cutting action. A scraping action tears the grain.

Softwoods are difficult to turn. They tend to split and tear. Like open grain hardwoods, softwoods are best turned with a cutting action. If scraped, a fuzzy, rough surface will result. Extra sanding is necessary.

It is advisable to buy turning squares for spindle turning. Turning squares are square lumber samples of varying sizes and lengths, selected for their straight grain and few defects.

Select quarter sawn lumber for faceplate turning. It tends not to tear, splinter, or warp. When you glue layers together to increase thickness, alternate each layer 90°.

Think Safety—Act Safely when Using the Wood Lathe

- Wear eye protection, remove jewelry, secure loose hair and clothing.
- Keep tools clean and sharp with handles in good condition.
- Never turn stock that has checks, knots, weak glue joints, or other defects.
- Make certain all stock is properly mounted.
- Always have safety shield in place while turning.
- Rotate stock by hand after mounting it to ensure it clears the tool rest.
- Lock the tail stock and tool rest securely before turning on power.
- Never lay turning tools on the lathe. Place them in a nearby rack.
- Turn rough square stock or large dimensioned stock at a slow speed.
- Stop the machine before adjusting the tailstock or tool rest.
- Remove excess shavings only with the machine stopped.

Between-Center Turning

Between-center turning, or spindle turning as it is often called, involves several steps. You must prepare and mount the material, select spindle speeds, and then proceed through a series of turning operations.

Preparing material for turning between centers

Turning generally begins with a length of square stock that is 2" to 4" (51 to 102 mm) longer than the designed component. It might be solid wood or several layers laminated together. Begin with stock having the ends cut square.

Locate centers

Locate the center of each end by drawing diagonal lines. Then use a scratch awl or drill to make a hole in both ends where the diagonals meet. See **Figure 27-20A.** Next, saw a kerf along the diagonal lines on the spur center end of the stock. See **Figure 27-20B.** This further ensures a solid hold when the stock is turned.

If you choose to begin turning with round stock, a ***center finder*** is useful. See **Figure 27-21.** Hold it against the edge and end of the stock and draw one diagonal. Then turn it 90° and draw another diagonal. Their intersection marks the center.

Bevel corners

Once the you locate centers, bevel the corners of the workpiece. Do this only to sections that will be turned. Beveling reduces tearing or splintering on corners where the material is weakest. Some turnings have both square and round sections along their length. With a pencil, mark those portions that are to be beveled. The corners can be taken off with a plane,

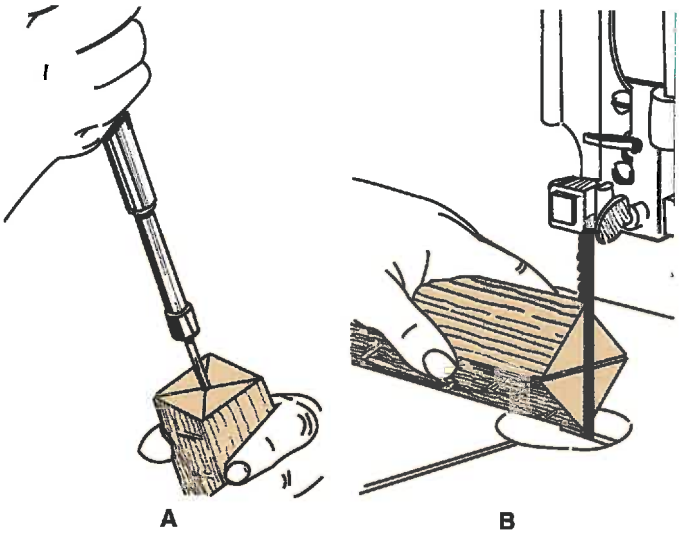


Figure 27-20. Mark the center and make kerfs in the drive end of the workpiece.

jointer, band saw, or table saw. See **Figure 27-22.** Do not bevel corners within 1" (25 mm) of sections that are to be left square. For example, the portion of a table leg that meets the table top and apron often is not turned.

Setting speed

Adjust the spindle speed on step pulley lathes to the roughing rpm before mounting the stock. This allows you to check the speed without the hazard of rotating mounted stock too fast. Refer to the speed table on the lathe.

Set the speed on variable speed lathes while the lathe is running. Refer to the speed table or digital speed readout every time you turn on the machine.

Mounting stock for between-center turning

Mounting involves inserting the spur center into the stock and securing the stock between the headstock and tailstock. The step-by-step procedure is as follows:

1. Place the workpiece on the bed of the lathe touching the headstock.
2. Secure the tailstock about 4" (100 mm) beyond the workpiece length.
3. If the spur center is still in the spindle, remove it with a knockout rod. Insert the rod through the hollow spindle from the outboard end. Hold the center with your hand so it cannot fall out and be damaged. Be careful not to hold the center directly in line with the spurs. Rap the center free with the knockout rod.
4. Align the spur center in kerfed end of the stock. With a soft-face hammer or mallet, strike the center to seat it. See **Figure 27-23A.**
5. Insert a dead or live center into the tailstock quill. See **Figure 27-23B.**
6. Slide the spur center into the spindle without letting the workpiece pull free.
7. Turn the tailstock handwheel to insert the center 1/32" to 1/16" (1 mm to 2 mm) into the other end of the workpiece. The distance marks on the quill should show 1" to 2" (25 mm to 51 mm). If you see all the marks on the quill, move the tailstock closer. Then reset the quill.
8. Tighten the quill lock.
9. With the guard in place, turn the workpiece by hand. It should move freely and clear the tool rest support.
10. If a dead center is used, lubricate it. Release the quill lock and back off the center. Rub candle wax or place two drops of oil on the center. Repeat this procedure several times while turning. Reset the center and tighten the quill lock.
11. Turn the machine on and off quickly. Let the workpiece coast to a stop.
12. Grip the stock to be sure it is still mounted tightly.
13. Install and adjust the tool rest. It should be 1/8" (3 mm) from the workpiece and 1/8" (3 mm) above the work center line.
14. Once again, turn the workpiece by hand, making sure it clears the tool rest.

Figure 27-21. Center finder for round stock. *(American Machine and Tool Co.)*

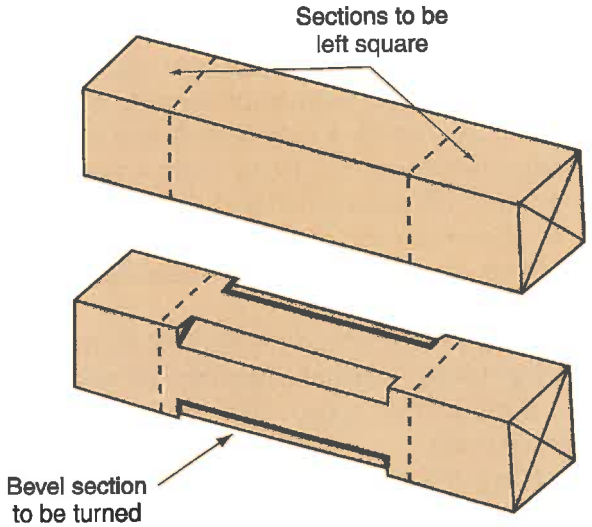
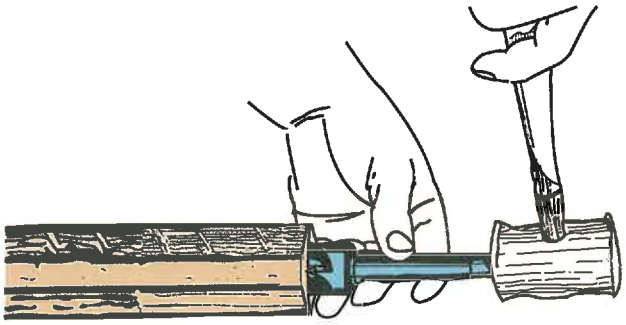


Figure 27-22. Bevel the edges of sections to be turned.

Turning operations

Several terms will be used when describing *turning operations*. They are:

- ***In.*** Feeding the tool toward the centerline of the lathe.
- ***Out.*** Moving the tool away from the centerline of the lathe. This is limited mostly to faceplate turning.



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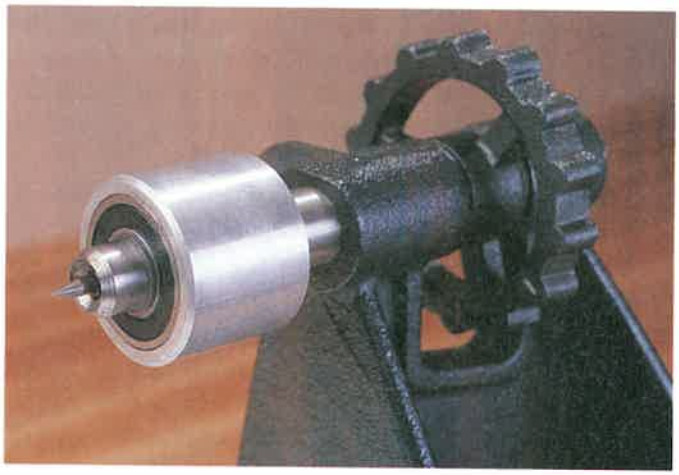


B

C

Figure 27-23. Mounting stock between centers. A—Drive the spur center into the workpiece. B—Insert the live (or dead) center into the tailstock quill. C—Insert the spur center into the spindle and press the cup into the other end of the workpiece. *(American Machine and Tool Co.)*

- ***Left.*** Moving the cutting edge of the turning tool toward the headstock.
- ***Right.*** Moving the cutting edge of the turning tool toward the tailstock.

Rough turning

Rough turning balances, or centers, the workpiece. With the gouge, begin turning those sections to be round. See **Figure 27-24.** Avoid touching portions marked to be left square. Use the gouge for rough turning as follows:

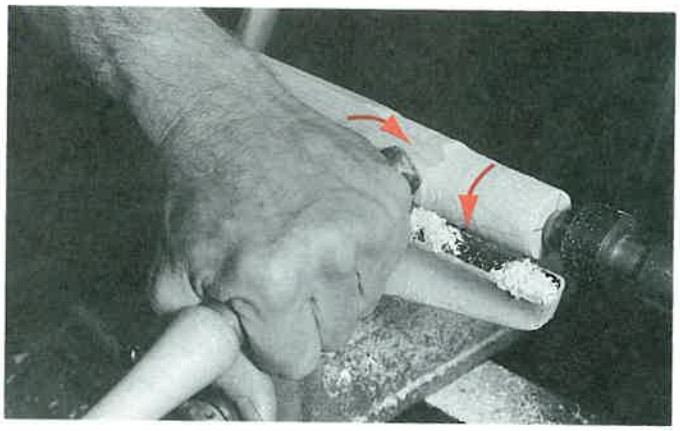


Figure 27-24. Rough-turn 3″ to 4″ (76 mm to 102 mm) sections to bring the stock to a constant diameter. The guard was removed to show the operation.

1. Lower the guard and turn on the lathe at rough cutting speed.
2. Hold the gouge handle about 15° down from horizontal and 15° to the left. You may have to alter these angles as the workpiece becomes smaller.
3. Roll the gouge clockwise about 30° to 45°. The right side of the cutting edge will contact the wood first. This will throw chips to the side so they do not block your vision.
4. Turn 3″ or 4″ (76 mm or 102 mm) sections at a time. Cut to the right, starting about 3″ (76 mm) from the tailstock end.
5. Turn only until the stock is round. Do not turn to the final diameter at this point.
6. Turn off the machine and move the tool rest when necessary.

To rough turn areas where square and round sections meet, use the method shown in **Figure 27-25.**

Turning to approximate diameter

The desired contour of the part may contain a number of different diameters, curves, and square shoulders. Lay out the location of these diameters on the rough-turned stock. Then, with a pencil, mark lines every 2″ (51 mm) or when the diameters change size, as shown on the drawing. See **Figure 27-26A.** On a piece of paper, mark the diameter each line denotes.

Next, adjust the speed for general turning. Set it according to the current diameter of your workpiece. Reduce the speed 10% to 15% if square sections remain.

Use the parting tool to locate diameters. At each of your layout lines, turn diameters 1/8″ (3 mm) greater than the dimensions indicate. See **Figure 27-26B.**

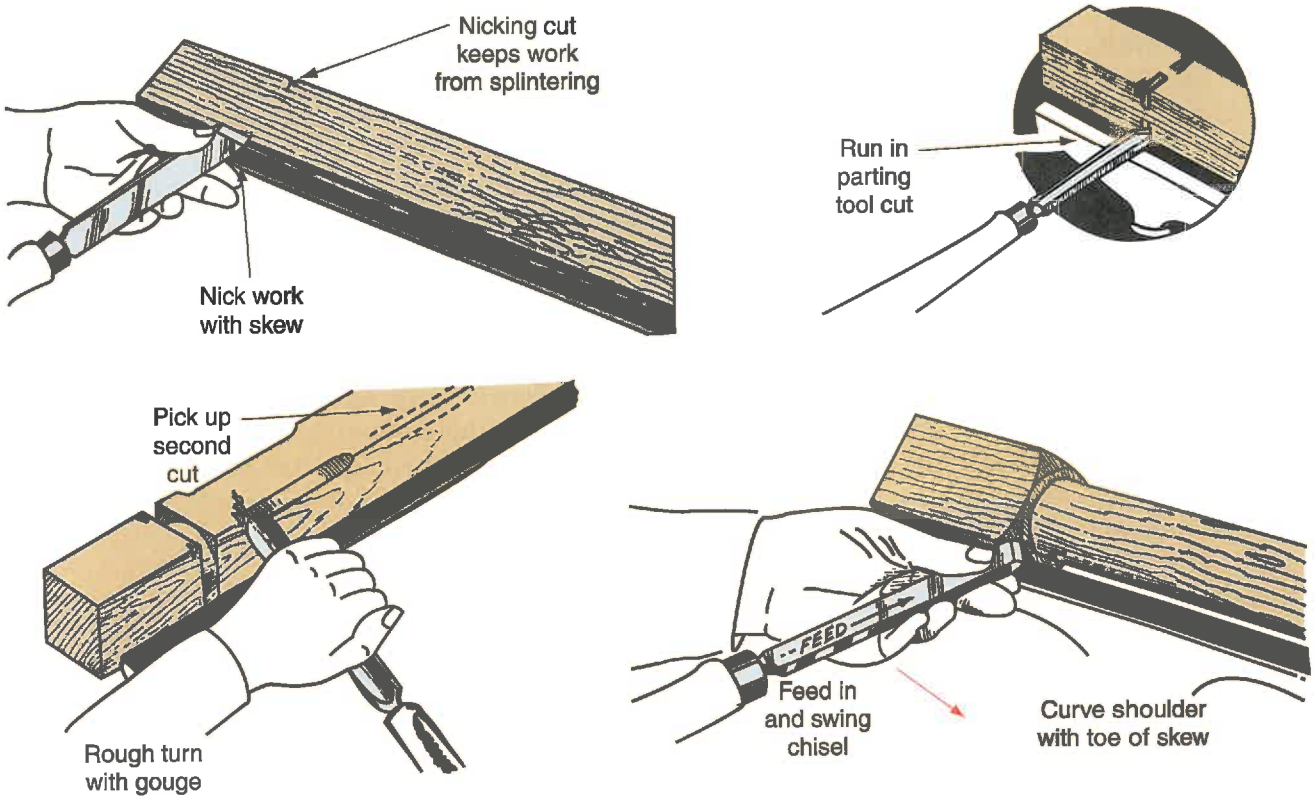


Figure 27-25. Use the skew, parting tool, and gouge where square and round sections meet. *(Delta International Machinery Corp.)*

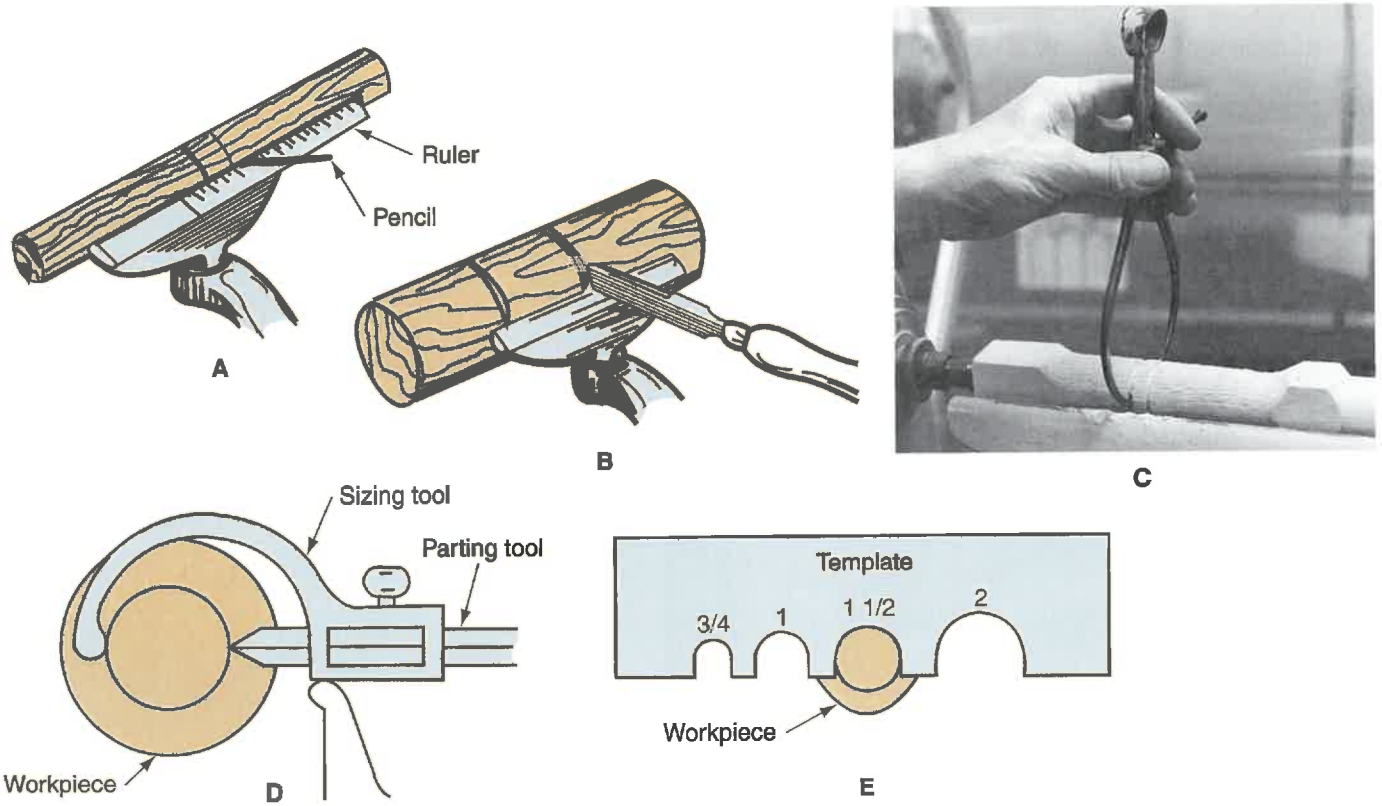


Figure 27-26. A—Lay out locations of different diameters. B—With the parting tool, turn to approximate diameter at each of the layout lines. *(Delta International Machinery Corp.)* C—Checking diameter with calipers. D—Turning the diameter with parting tool and sizing tool. E—Checking diameter with a template.

Check the diameter several times as you turn to prevent undercutting the dimension. You can check by several methods. One is to use outside calipers preset to 1/8" (3 mm) greater than the finished diameter. See **Figure 27-26C.** Periodically, turn off the lathe. Place the caliper in the groove. Stop turning when the caliper slips over the workpiece. Two other methods are a sizing tool and template See **Figure 27-26D** and **Figure 27-26E.**

Cut with the parting tool as follows:

1. Set the tool rest about ¼" (6 mm) below center. Lower the guard. Rotate the workpiece twice by hand, then turn on the machine.
2. Point the tool straight into the workpiece, with the handle down about 15°.
3. As the diameter is reduced, the handle may need to be raised horizontal.
4. Remember to stop the lathe and check each diameter you turn.

Planning is essential to successful turning. Turn and smooth all contours greater than ¾" (19 mm) first. Then contour small diameters. Leaving small diameter sections for last reduces chatter. ***Chatter*** is a noisy vibration caused by a flexing workpiece. It often increases while scraping with dull turning tools. A series of rough surface rings is produced as the workpiece vibrates against the turning tool. If this occurs, reduce pressure on the tool. Then check the sharpness of your tool. If neither helps, turn the machine off. Check that the workpiece is secure between the centers.

Another remedy for chatter is to use a steady rest. See **Figure 27-27.** The ***steady rest*** rollers contact the workpiece on the side opposite the tool. This prevents flexing of long, small diameter spindles. Position the steady rest against a short center section turned to the approximate diameter. Select a location where details are minimal. Turn and smooth the workpiece except for the supported section. Then remove the steady rest and complete the workpiece.

Once grooves have been made with the parting tool to locate diameters, continue turning with the gouge. Use the grooves as a guide to rough turn the contours. Stop turning when you near the approximate diameters. The final details are made with other turning tools.

Turning cylinders and tapers

Cylinders are the same diameter from one end to the other. ***Tapers*** are cone-shaped. These are first turned with a gouge. Then use a skew or block plane to smooth them. See **Figure 27-28.** To scrape with a skew, place the skew flat on the tool rest. Have the cutting edge even with the workpiece center. For a cutting action, tip the point of the skew slightly up as you feed the tool along the tool rest. The cutting action should be performed by more experienced wood turners. A novice tends to let the point of the skew touch the workpiece. It catches and gouges the wood. Make contact with the workpiece in the middle of the

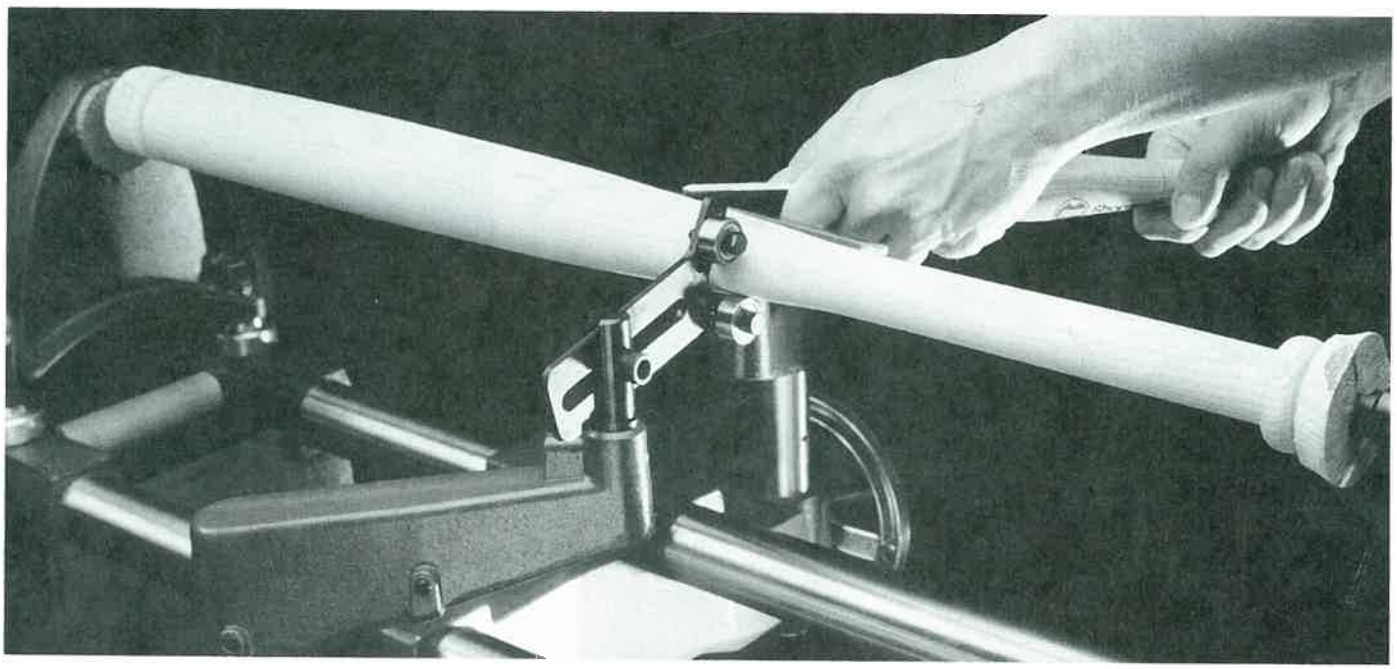


Figure 27-27. A steady rest increases stability and reduces chatter. The guard was removed to show the operation. *(Shopsmith)*

cutting edge only. Start about 3" (76 mm) from the tailstock end and cut or scrape in either direction.

Use a block plane to smooth a cylinder or taper after turning to approximate diameter. Place the sole of the plane on the tool rest. Turn the plane about 15° to the spindle. Move the plane left or right and maintain a cutting action. The block plane will straighten variations in diameters from one end to the other.

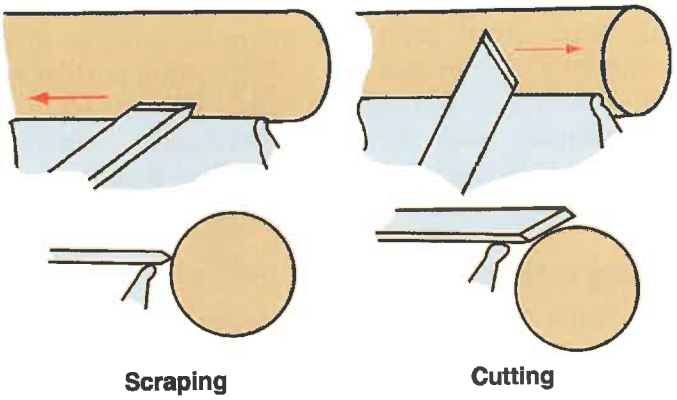
Turning V-grooves

V-grooves can be scraped with the spear-point tool or cut with a skew. See **Figure 27-29.** Place the spearpoint tool flat on the rest. Feed it into the wood to the desired depth. With a skew, only the corner touches the tool rest. Hold the skew on edge and feed it to the desired depth. Angle the tool left or right to widen and deepen the groove.

Turning beads

Beads are turned with a spear-point tool or skew. See **Figure 27-30.** Use a parting tool (if beads are separated) and reach the proper diameter. To scrape a bead, hold the spear-point tool horizontal. Feed the cutting edge into the groove, while moving the handle left or right according to the curve. Keep the point from cutting into the next bead by slightly rotating the tool.

With the skew, cut with the heel end half of the blade's edge. The handle should be down about 15° to 25°. Start near the center of the bead. As you cut, roll the tool into the groove twice to form each half of the bead.



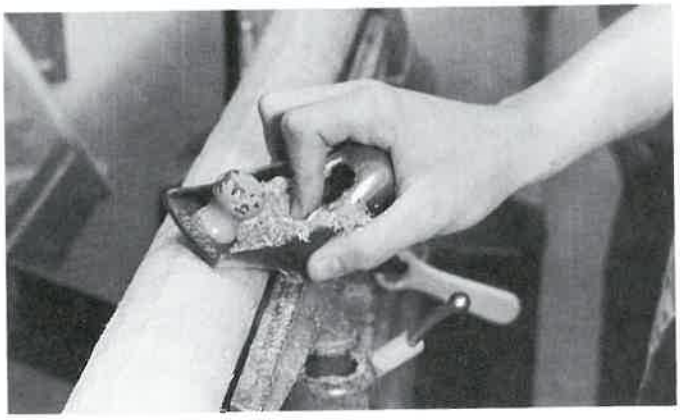


Figure 27-28. Turning a cylinder by scraping, cutting, or planing. The guard was removed to show the operation.

Turning coves

Coves, or concave curves, are made with the round-nose tool in the scraping position. See **Figure 27-31.** Rough-cut the cove with a gouge. Then, adjust a caliper to the smallest diameter of the cove. Feed the round-nose tool into the center of the cove. Pivot the tool to form a smooth contour.

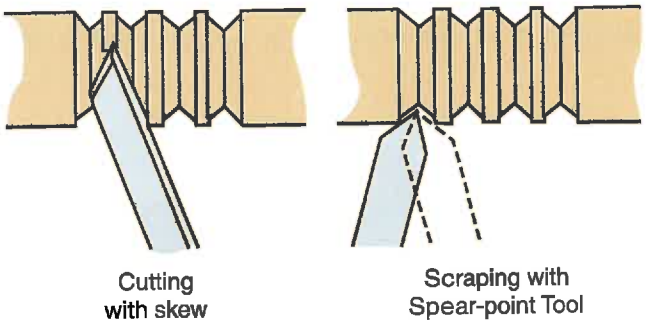


Figure 27-29. Turning V-grooves by cutting and scraping.

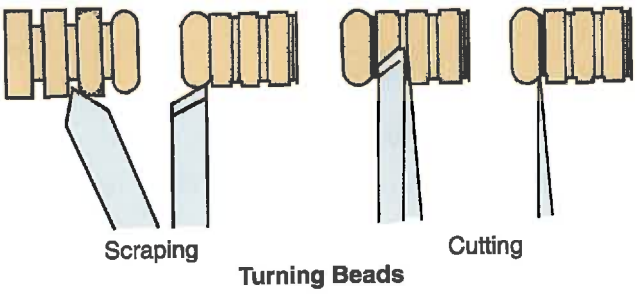


Figure 27-30. Turning beads by scraping with a spear-point tool or cutting with a skew. *(Delta International Machinery Corp.)*

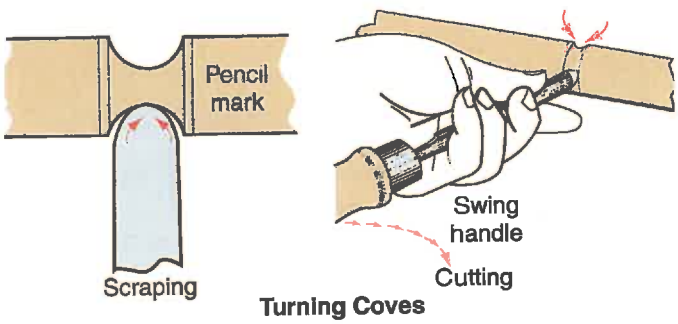


Figure 27-31. Turning coves with the round-nose tool.

Turning shoulders

Shoulders are turned with the parting tool, gouge, and skew. See **Figure 27-32.** Feed the parting tool in to the approximate diameter. Then turn down the shoulder with a gouge and finish with a skew. True the shoulder by feeding the tip of a skew along the shoulder's face.

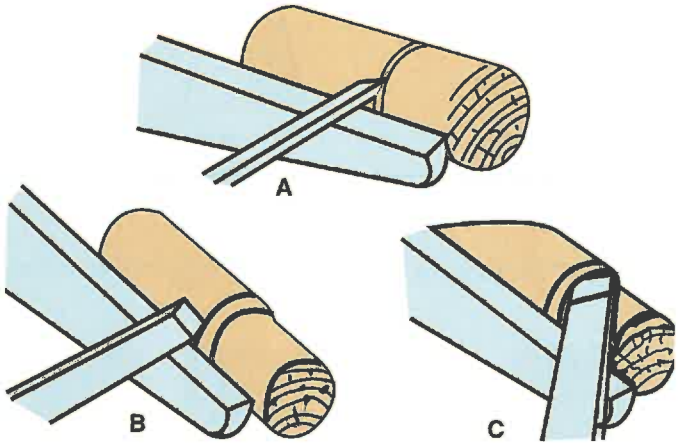
Turning complex shapes

Turned products rarely consist of just one shape. Most are a combination of curves, shoulders, beads, and grooves. These products require that you use a number of tools and techniques. See **Figure 27-33.** Plan the cutting sequence carefully.

Turning glued-up stock

Turnings are not always made of solid lumber. Several layers of stock may be glued together. With different species of wood, you get interesting color combinations.

Stock may also be glued together for special purposes. For example, suppose you are turning a spindle for a lamp stand. You need a hole through the center for the electrical cord. The length of the spindle could prevent drilling a straight hole through it. One remedy is to use two pieces of stock. Saw or rout a groove through both. Then, glue them together with the grooves aligned, and a square plug about 1" (25 mm) long in each end. See **Figure 27-34.** The plugs provide a firm contact for the centers while turning. Drill them out later.



Turning Shoulders

Figure 27-32. Turning shoulders. *(Delta International Machinery Corp.)*

Split turnings

Split turnings are glued-up workpieces that are separated after being turned. You might turn a piece of stock round, then split it for half-round molding. See **Figure 27-35.** Glue the components together, separated by sized, or sealed, paper. Choosing the correct paper is important. Notebook paper is recommended. To identify sized paper, write on it with a ball point pen. If the inked line bleeds (spreads), the paper is not sized. After turning, split the pieces on the paper line with a chisel and mallet.

Turning duplicate workpieces

Cabinets and furniture often make use of several identical turned parts. For example, spindles in a chair back should look alike. Duplicating parts may be done in several ways. The most difficult practice is to measure each detail independently. A better method is to use a template. The best practice is to mount a duplicating accessory to the lathe.

Using a template

Make a template of heavy paper or sheet metal. Linear dimensions can be placed on the template's straight edge. The other edge is cut to the shape of the desired contour. See **Figure 27-36.** Rough turn

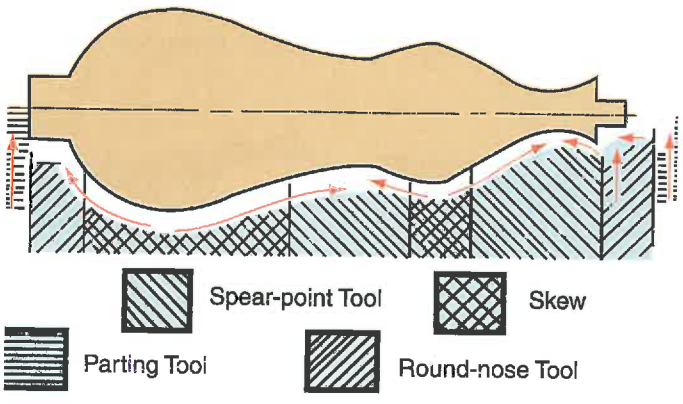


Figure 27-33. Complex shapes require a number of turning operations.

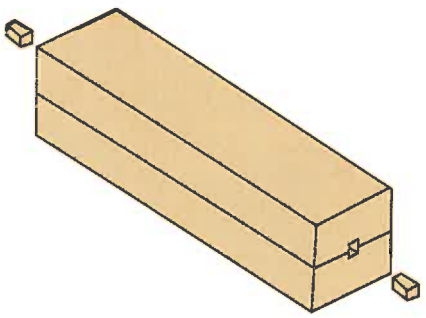
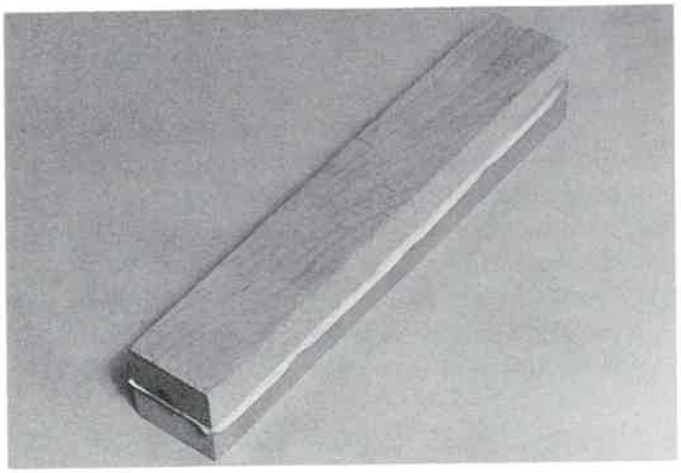
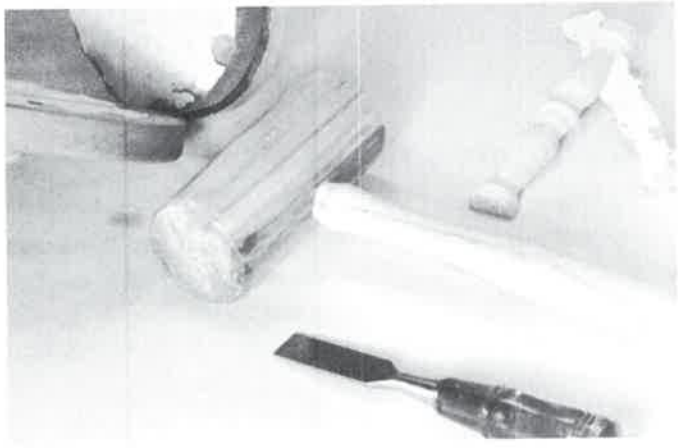


Figure 27-34. Groove, glue, and plug a workpiece that needs a hole through it.



A



B

Figure 27-35. Split turning. A—Glue two pieces of stock together, separated by sized paper. B—Turn the desired shape, then split the parts with a mallet and chisel.

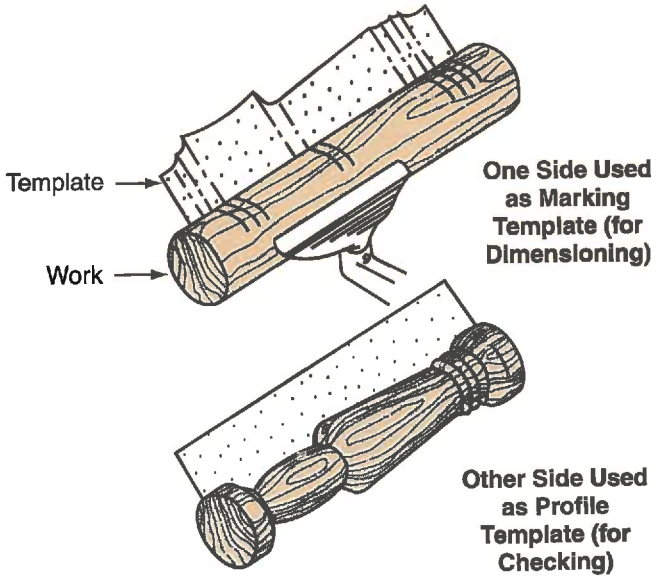


Figure 27-36. Duplicate parts are sized with a template. *(Shopsmith)*

the workpiece round. Then mark the linear distances and cut depths with a parting tool. As you continue turning the workpiece, stop the lathe periodically to compare your turning with the template. When the turned contour matches the template, remove tool marks with abrasive paper.

Using a duplicator

A duplicator is the best tool for creating many similar parts. See **Figure 27-37.** The procedure to use this accessory is as follows.

1. Rough turn all workpieces to a diameter that is ¼" (6 mm) larger than the largest diameter of the finished part.
2. Prepare and attach a contoured hardboard template to the duplicator.
3. Mount the duplicator parallel to the center line of the lathe.
4. Set the tool guide stylus against the hardboard template.
5. Determine the tool offset (workpiece radius) at both ends of the spindle.
6. Measure these distances from the tool bit to the centerpoints of the live and dead centers. Add 1/16" (2 mm) for smoothing.
7. Tighten the duplicator to the lathe bed and mount the workpiece.
8. Contour all sections. Move the tool laterally by turning the feed knob with one hand. Move the tool in or out with the other hand.
9. Remove 1/8" to ¼" (3 mm to 6 mm) layers.
10. Stop when the stylus touches the template.
11. Remove the duplicator and sand the spindle as necessary.

Turning oval spindles

Oval spindles are made by mounting and turning stock three times on three different centers.

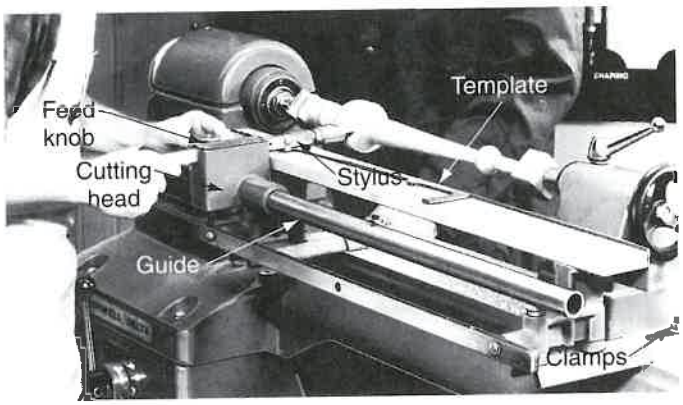


Figure 27-37. Duplicator attachment. The guard was removed to show the operation. *(Rockwell International)*

The spindles that support the table in *Figure 2-32D* are oval. The trick to oval turning is laying out the centers. To turn oval spindles, follow this procedure:

1. Lay out oval shape on paper. See **Figure 27-38A.**
2. Draw a circle slightly larger than the oval. Mark the circle's center as A. See **Figure 27-38B.**
3. Without changing your compass, draw a circle tangent to one arc (lower portion) of your oval shape. Mark that circle's center as B. See **Figure 27-38C.**
4. Draw a third circle tangent to the other arc (upper portion) of your oval shape. Mark that circle's center as C. See **Figure 27-38D.**
5. Measure the distance between centers.
6. Lay out the three centers on each end of the stock. See **Figure 27-38E.** Make saw kerfs for the drive center spurs.
7. Mount the workpiece on center A and turn the diameter. Operate the lathe at roughing rpm.
8. Reduce the lathe speed 25% to 35% for turning on centers B and C because these are out-of-balance turning operations.
9. Remount the workpiece on center B and turn the second diameter. The turning tool touches only a portion of the circumference.
10. Remount the workpiece on center C and repeat the operation.
11. Remove the workpiece from the lathe and smooth it with abrasive paper to remove any ridge lines.

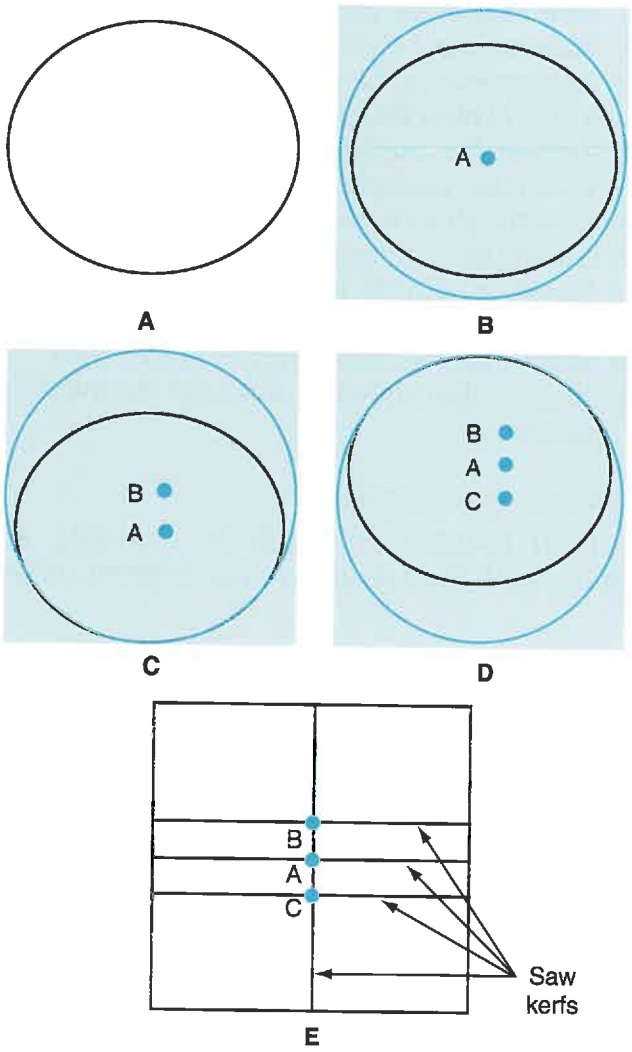


Figure 27-38. Procedure for laying out an oval turning.

Faceplate Turning

Faceplate turning may be done on a bowl lathe and the inboard or outboard side of a standard lathe. Bowls, trays, stool seats, and small round table tops are turned while attached to a faceplate.

Preparing material for faceplate turning

Determine from the product design (working drawings) whether you must laminate several layers of stock together. See **Figure 27-39.** Some products are designed thicker than standard lumber thicknesses.

Mount material for faceplate turning by attaching the faceplate directly into workpiece or attaching it to a backup board. See **Figure 27-40.** Screws can extend through the faceplate directly into the workpiece. However, with this method, you wind up with holes in the bottom of your product. An alternate method is to attach the faceplate to a backup board. Here, the workpiece is glued to the backup block separated with sized paper. See **Figure 27-41.** This practice is the same as that for split turning between centers. Once the

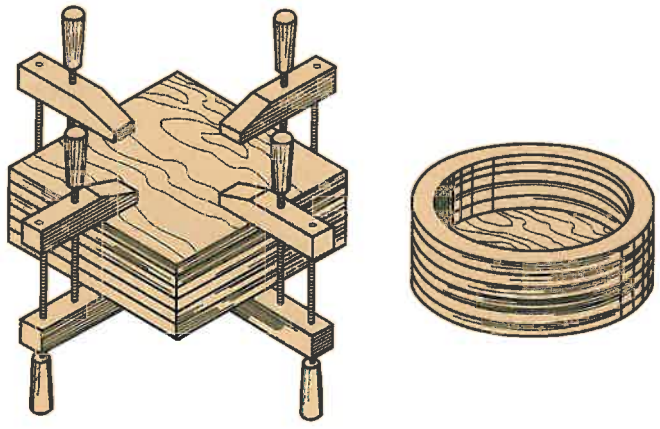


Figure 27-39. Some turnings, such as this deep bowl, may require gluing layers together. *(Shopsmith)*

product is turned, the backup board and product are separated by a chisel.

To attach the faceplate, draw two diagonals on the workpiece. From their intersection, lay out two concentric circles. The inner circle locates the faceplate; the outer circle locates the size of the workpiece. With a band saw, cut the workpiece ¼" to ½" (6 mm to 13 mm) greater than the outer circle.

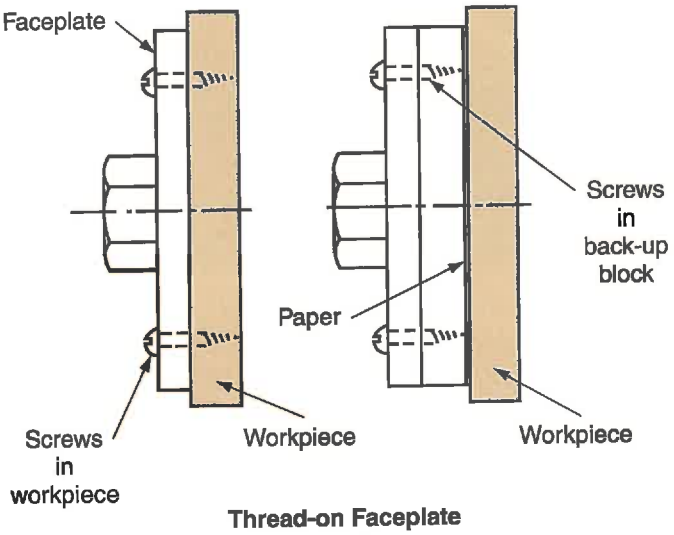
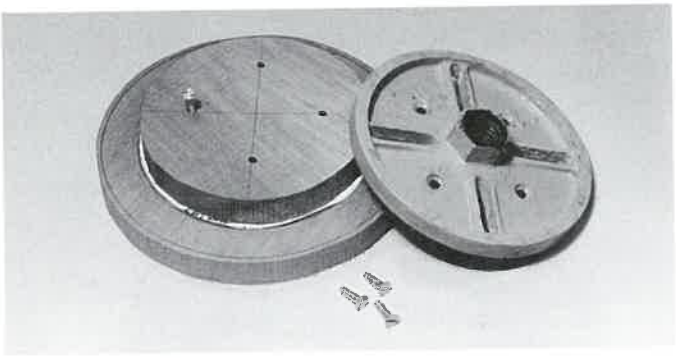


Figure 27-40. Workpieces can be attached to a faceplate with, or without, a backup board.



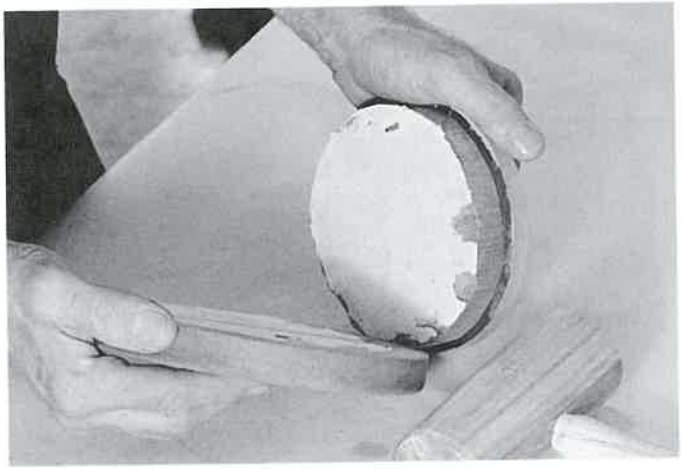


Figure 27-41. Top. Screws enter the backup board but not the workpiece. Bottom. The backup board is separated from the workpiece with a mallet and chisel.

Next, draw layout lines on the face of the workpiece. These mark where the contours will be located. Also consider using a template. Leave one side of the template straight, and mark linear distances from the center. Cut the other side to the shape of half the finished contour. See **Figure 27-42.**

Position and secure the faceplate on the back of the workpiece within the circle drawn earlier. Use screws long enough to hold the material securely, but short enough that they do not interfere with the turning tool. If a backup board is used, cut it the size of the faceplate. Align it within the circle drawn on the workpiece for the faceplate.

Once the faceplate is attached, thread it (and the attached workpiece) onto the spindle. Depending on the size of the workpiece, you will mount the faceplate on either the inboard or outboard side of the headstock.

Inboard faceplate turning

The size of a workpiece mounted on the spindle side of the bed is limited by the lathe's swing. Lathes with a gap bed increase the maximum swing by about 25%. The steps for inboard turning are as follows.

1. Prepare the workpiece as described above.
2. Remove the spur center, clean off the threads, and thread on the faceplate.
3. To prevent the faceplate from being wedged against the spindle shoulder, install a heavy leather washer on the spindle first.
4. Mount the workpiece on the lathe.
5. Adjust the tool rest near to the edge of the workpiece. Set the speed according to the workpiece diameter.

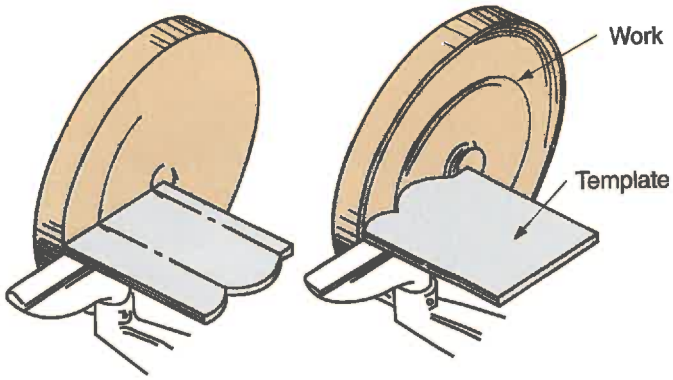


Figure 27-42. Templates help you to turn shapes precisely. *(Shopsmith)*

6. Lower the guard into position.
7. Use a gouge, then spear point tool to smooth the outside edge of the disk. See **Figure 27-43.** This balances the stock.
8. Adjust the tool rest parallel to the face of the workpiece.
9. Use the appropriate tools to create the contour. See **Figure 27-44.** Begin the cut in the center and move the tool outward.
10. Place the template against your work. Check your progress at regular intervals.
11. Stop turning when you come within 1/16" (2 mm) of the desired size.

Some lathe models have a right angle tool rest. See **Figure 27-45.** It prevents having to reposition the tool rest from edge to face turning.

Outboard faceplate turning

Stock too large for inboard turning is mounted on the outboard side of the lathe, **Figure 27-46.** A tripod supports the tool rest. Set the lathe accordingly. Prepare and mount the workpiece as you did for inboard turning. Attach a large faceplate on the inboard spindle so you can stop the lathe from coasting. Use a scraping action when turning. The size of outboard turnings should be only 25% more than that allowed by the inboard swing. Circular workpieces larger than this should be made by sawing and shaping practices.

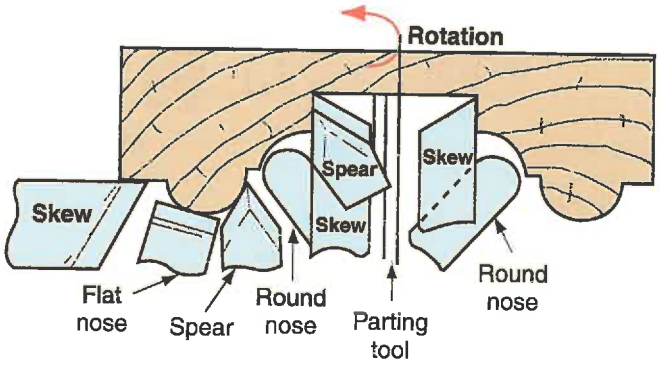


Figure 27-44. Several turning tools are needed to turn the desired contour. The guard was removed to show the operation.

Figure 27-43. A gouge quickly turns the edge to diameter. The guard was removed to show the operation.

Figure 27-45. Both the face and edge can be turned without having to reposition a right angle tool rest.

Screw-thread faceplate

The ***screw-thread faceplate*** is appropriate for small turned parts. Prepare the stock as described earlier. Drill a pilot hole in the wood for the screw thread center. Remove any chips from the spindle hole. Press the tapered shaft of the faceplate into the spindle by hand. Hold the handwheel and screw the workpiece onto the threaded center. Turn the workpiece as though faceplate mounted. Cabinetmakers likely will find limited use for the screw-thread faceplate, except for custom knobs and pulls.

Chuck turning

Dowels and round workpieces are held easily in a lathe chuck. Use care when tightening the chuck as excessive torque could dent the workpiece.

Smoothing Turned Products

A sharp tool, used properly, greatly reduces the need for smoothing the turned part. Yet, there are times when filing or sanding is needed. If the product is made from open grain hardwood or softwood, turning tools may leave the surface rough.

You can use a file instead of turning tools to reach the final diameter. Set the machine at roughing speed. Grip the file at each end and hold it at a 90° angle to your work. See **Figure 27-47.** Apply light pressure and move the file with a slow forward motion. A small flat or triangular file will smooth fine detail.

If abrasives are needed, remember that they will create cross grain scratches that are difficult to remove. Select the finest abrasive that will do the job. You can use an abrasive pad or cord. See *Figure 27-48.* Remove the tool rest. Hold an abrasive

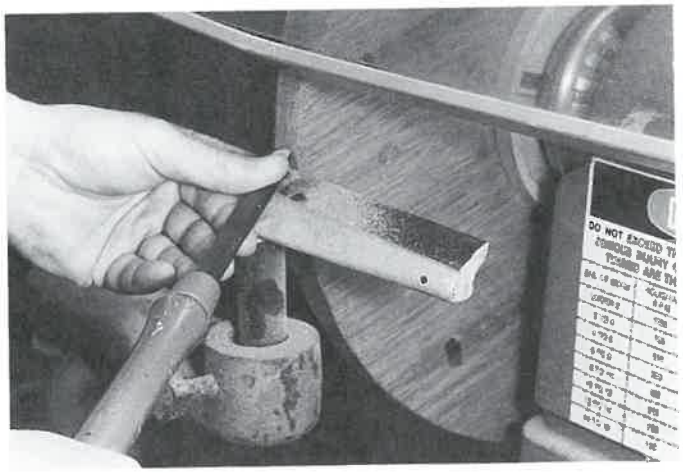


Figure 27-46. Guard slides to the outboard side of the headstock.

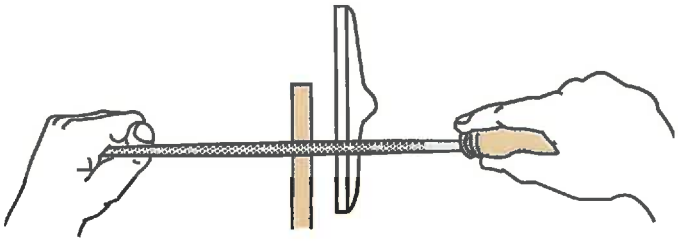
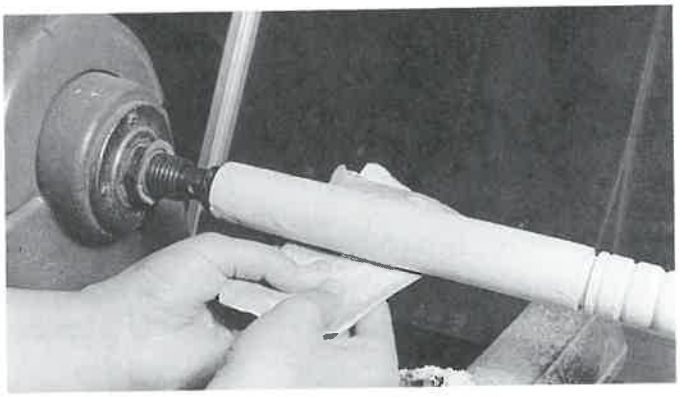
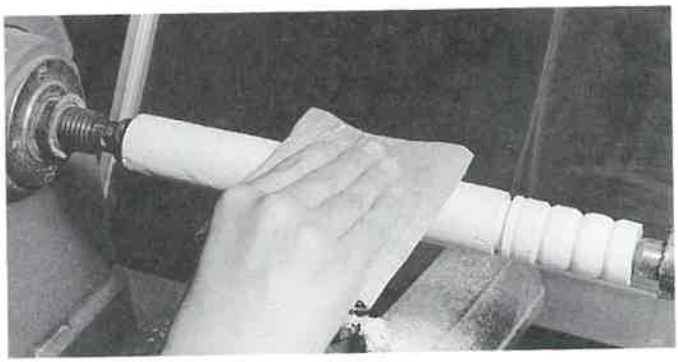


Figure 27-47. A file is handy to smooth the turned part.



A

B



C

Figure 27-48. A—Apply abrasive paper under the rotating workpiece to remove tool marks. The guard was removed to show the operation. B—Abrasive cord for sanding detail. *(Woodworker's Supply)* C—Remove circular scratches by sanding the workpiece along the grain. Do not have the lathe on for this operation.

pad beneath the workpiece while it turns. Keep the lathe speed slow to reduce heat buildup. You are not as likely to burn your fingers while holding the pad. You might loop an abrasive cord or strip of paper around the workpiece to smooth grooves and beads. When only fine scratches left by the abrasive are visible, stop the lathe. Sand with the grain to remove any circular scratches.

Maintaining Lathes and Tools

The condition of tools and equipment directly affects the quality of your work and safety of the operation. Tools must be kept sharp. The lathe needs to be cleaned and lubricated periodically.

Sharpening lathe tools

Turning tools are most often sharpened by honing. Grinding is done only when the edge has been damaged. Frequent honing keeps edges in good condition. Some lathe operators will hone a tool several times during each hour of use.

Tool angles when grinding and honing are important. Angles for the five common turning tools were shown in *Figure 27-6.*

Honing is done with an oil stone. Lightly touch both sides of the cutting edge to remove dull edges or grinding burrs. A flat stone and slip stone will hone the shapes of most turning tools. See **Figure 27-49.**

When grinding tools, set the tool rest or jig on the grinder to position the tool. See **Figure 27-50.** Use only the wheel surface directly in front of the tool rest. This will hollow grind the tool slightly.

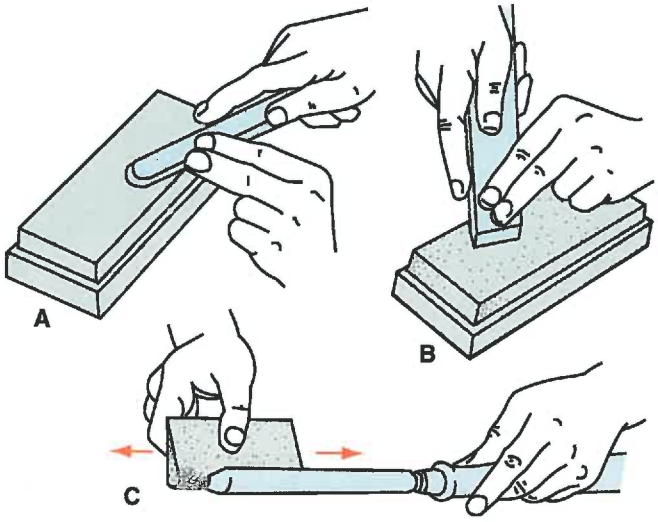


Figure 27-49. Honing turning tools. A—Honing the ground edge of a gouge. B—Honing the inner edge of the gouge. C—Honing flat-ground tools on a stone. *(Disston)*

Flat ground tools can be sharpened on a power sander having an aluminum oxide or emery abrasive. Be sure to maintain the proper tool angle. A jig for sharpening lathe chisels on the disk sander is shown in **Figure 27-51.**

When ground, the tool should have a narrow, reflective, sharpened edge. Do not hone the tool to a thin wire edge because it becomes weaker.

Maintaining the lathe

A wood turning lathe is relatively maintenance free. Prevent an accumulation of wood chips and rust. A limited number of lubricating points exist. Service might be needed for the variable speed mechanism, spindle bearings, or quill threads.

Figure 27-50. A jig allows you to precisely set the tool angle. *(Rockwell International)*

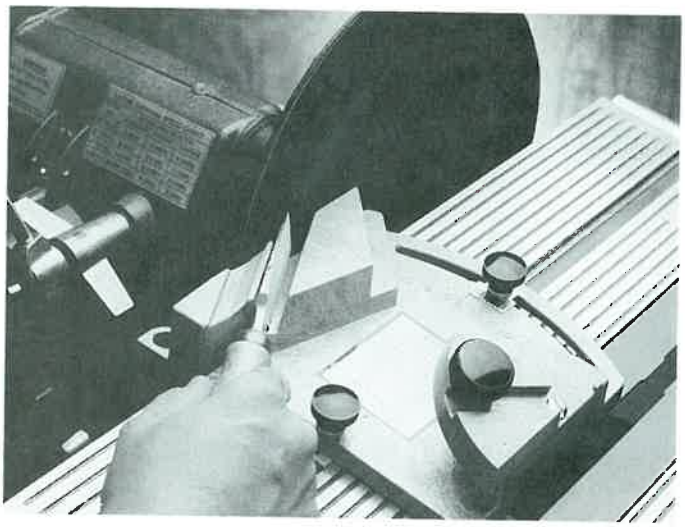


Figure 27-51. Jig designed for sharpening the skew on a disk sander. *(Shopsmith)*

Be sure the centers and chucks fit properly. All have a Morse taper shank. Always use a mallet to set a spur center firmly in the workpiece. A steel hammer can damage the shank. This could prevent an adequate friction fit. Keep the spur center lips from being damaged. File away any burrs.

At the tailstock end of the lathe, centers should be easy to remove when you retract the quill. The center should slip out into your hand. If it does not, the quill will have to be removed and checked. Turn the handwheel the opposite direction until the quill is free. You will then need a knockout rod. Insert it through the quill, and tap the center until it slips out.

Some clamping levers can cause problems. For example, suppose the tool holder cannot be secured with the handle. This indicates that the nut under the bed needs to be tightened slightly.

Summary

Turning is the process of producing round products, such as table legs, bedposts, bowls, and knobs. There are two basic operations used to create turned products: between-center turning and faceplate turning.

Between-center turning is done on a standard lathe. Stock is held between a spur, or drive, center and live or dead tailstock center. The tool rest is positioned within 1/8" (3 mm) of your work. An assortment of turning tools is used to shape the wood. These include the gouge, skew, spear-point tool, parting tool, and round-nose tool. Each is appropriate for creating unique shapes.

Faceplate turning is done on a bowl lathe or on either the inboard or outboard side of a standard lathe. Stock is attached to a faceplate that is then threaded on to the lathe spindle. A backup board may be glued to the workpiece before the faceplate is attached. It prevents the screws from entering the workpiece.

High quality turning is done with properly sharpened tools on a well-maintained lathe. Tools should be honed often and ground rarely. Maintain the lathe by removing wood chips and rust. Check belt-driven lathes for belt wear. Make sure that all tool rest and tailstock clamps tighten properly.

Test Your Knowledge

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

1. Two common types of lathes for small shop and home use are the _____ and _____.
2. List the standard lathe specifications that determine the largest diameter and longest workpiece you can turn.
3. How would you mount the following products to be turned?
   a. Chair leg.
   b. 6" (152 mm) diameter bowl.
   c. 15" (381 mm) diameter stool seat.
   d. 5' (1.52 m) bedpost.
   e. Drawer knob.
   f. 3" (76 mm) long finial.
4. Explain why you might you choose a scraping action over a cutting action.
5. List the five turning tools found in a standard set.
6. The best position for the tool rest is _____" away from your work and _____" above the work center line.
7. Describe why you would choose a ball bearing live center over a dead center for supporting the tailstock end of your work.
8. Lumber should be free of defects, especially _____ and _____.
9. List the steps taken to prepare material for between-center turning.
10. After rough turning, turn to approximate diameter. How do you know when you have reached the approximate diameter?
11. Chatter is usually the result of _____.
    a. using sharp turning tools
    b. using dull turning tools
    c. turning a long, small diameter workpiece
    d. faceplate turning a thin disk
12. List the tools that can be used to turn the following features:
    a. Cylinder.
    b. V-groove.
    c. Bead.
    d. Cove.
    e. Shoulder.
13. Select _____ paper for split turnings.
14. How many times must you mount the workpiece when turning oval spindles?
15. Give steps for mounting a workpiece, including a backup board, for faceplate turning.
16. What additional accessory is needed for outboard turning?
17. Explain two methods to turn duplicate parts.
18. Chatter can be reduced by mounting a(n) _____.
19. _____ turning may be done on a bowl lathe and the inboard or outboard side of a standard lathe.
20. List several lathe maintenance checks you should make.

The turning process was used to create the table and leg supports for this furniture. *(Thomasville)*

28

Accessories, Jigs, and Special Machines

Objectives

After studying this chapter, you will be able to:

- Identify accessories that increase the convenience of a machine.
- Describe several applications of jigs and fixtures.
- Select equipment to cut large or bulky panel products.
- Explain the advantages and disadvantages of multipurpose machinery.

Important Terms

accessory
circle jig
doweling jig
fixture
folding table
frame
framing clamp
gliding table
jig
miter jig
miter trimmer
multipurpose machine
panel saw
portable drill attachment
power feed attachment
ripping guide
roller table
table extension
tapering jig
vise insert

Standard machines discussed in previous chapters will produce almost every product you design. Yet, there are times when add-on equipment makes a standard machine more efficient, more accurate, and often safer. On some occasions a special machine may be even more appropriate. This chapter covers accessories, jigs, and special machines. The coverage is not complete. Hundreds of vendors sell gadgets, attachments, and accessories that may make your work easier. The tools presented in this chapter indicate the wide range of equipment you might choose.

Accessories

Accessories increase the convenience or use of a machine. A number of devices have been described in previous chapters. For example, with a molding cutterhead, you can convert a table saw into a shaper.

Accessories, often called attachments, connect to a basic machine. Some make major changes to machines and tools. Those designed to be permanent usually fit only one model.

Table extensions

Table extensions help support awkward stock. The table saw extensions shown in Figure 28-1 allow the cutting of wider and longer material. A special fence, fence guide, table extension, outfeed rollers, and a gliding table have been added to make use of the full table size. Outfeed rollers support stock to the rear of the table. The extended rip fence guide and shop made table expands rip width to 52" (1.32 m). The power miter saw table extension shown in **Figure 28-2** extends the available workpiece support to 8' (2.44 m).

Figure 28-1. Table attachments make saw operations easier, safer, and more accurate. This table saw has the manufacturer's rip fence accessory. Aftermarket accessories are the sliding table and roller outfeed table.

Gliding table

The *gliding table* is a movable saw table and miter gauge. Some saw manufacturers make a gliding table as standard equipment. See **Figure 28-3.** Saw manufacturers and aftermarket manufacturers offer sliding table accessories. See **Figure 28-4.** With a standard miter gauge, the workpiece size is limited without support for the weight. The table glides along with the material. Holding the workpiece and maintaining the cutting angle is easy.

Ripping and safety hold down guides

A *ripping guide* holds stock against the saw table and fence as you feed it past the blade. See

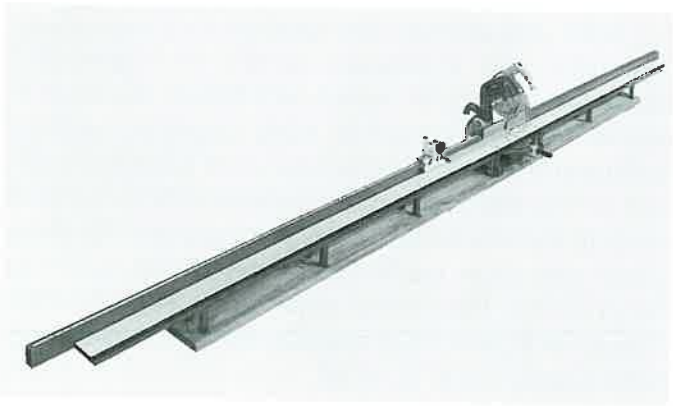


Figure 28-2. Longer stock can be cut on the power miter saw with table attachments. *(Biesemeyer)*

Figure 28-5. A locking device to hinder kickback prevents the wheels from rotating backwards. The device is attached to the fence by screws or clamps. The wheels are spring loaded to adjust to any stock thickness. Because of the uplifting pressure of the springs, the device cannot be attached to all fences.

Figure 28-4. A gliding table supports longer and heavier stock for cross and miter cuts. The miter gauge features a stop and scale to 72" (1.83 m). The stop was rotated up and out of the way for this trimming operation. *(Chuck Davis Cabinets)*

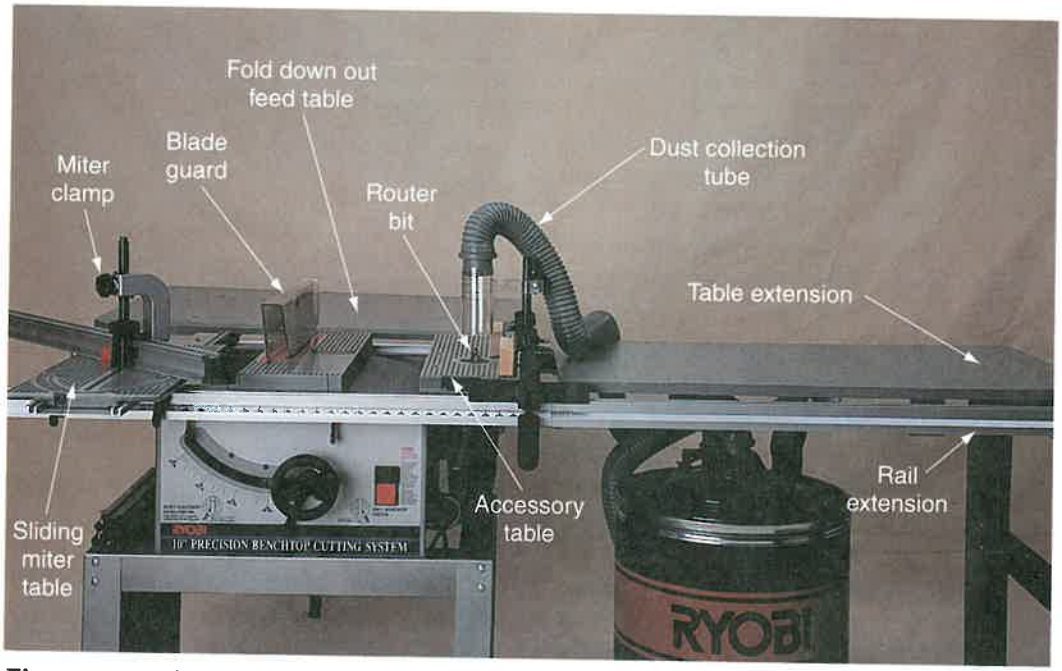


Figure 28-3. This table saw has a sliding miter table as standard equipment. The miter fence is longer than a miter gauge. The miter clamp, outfeed table, table extension, dust collector, and router attachment are accessories. *(Ryobi America Corp.)*

The ***safety hold down*** is a similar device that is much like the ripping guide. See **Figure 28-6.** Yellow wheels rotate clockwise. Orange wheels rotate counter clockwise. Green wheels are free wheeling. It fits the saw, shaper and other equipment with fences.

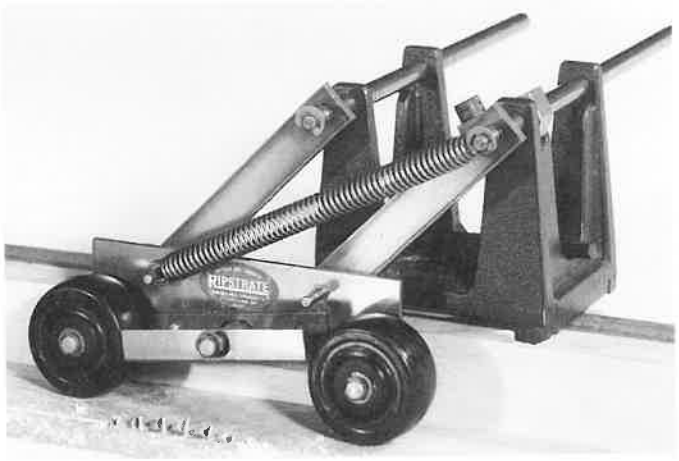
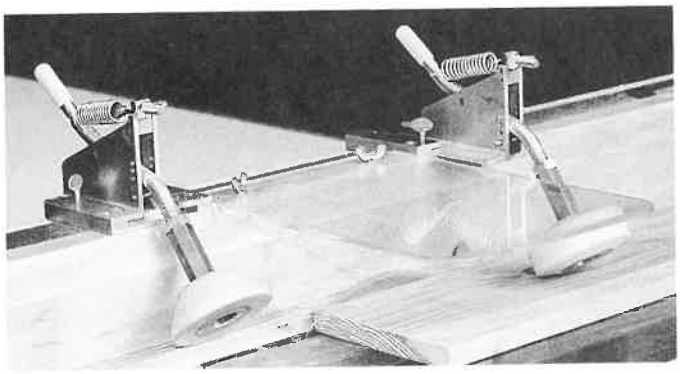


Figure 28-5. Ripping guides keep material against the table and fence, and prevent kickback. The guard was removed to show the operation. *(Fisher Hill Products)*



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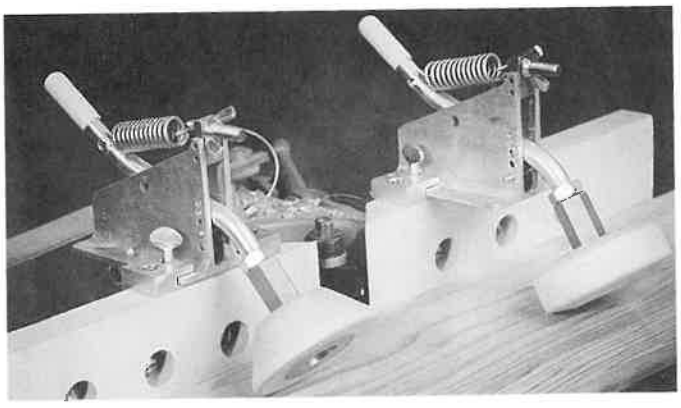


B

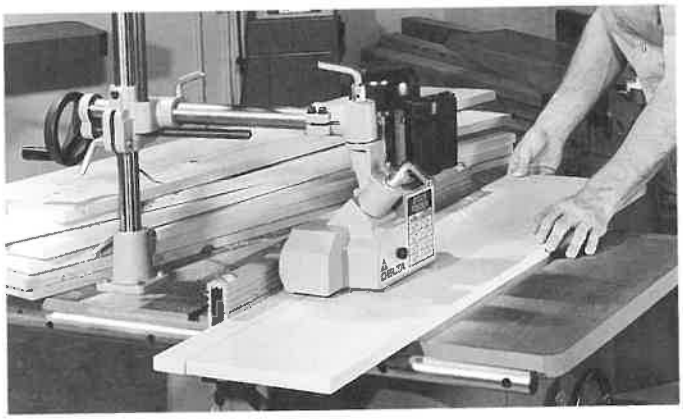
Figure 28-6. Guides hold material against the table and fence and prevent kickback. A—Mounted on the table saw. B—Mounted on the shaper. *(Western Commercial Products)*

Power feed

Power feed attachments allow automatic feed control and keep the user's hands away from the point of operation. See **Figure 28-7.** A power feed attachment can be installed on table saws and shapers. A column crank adjusts the height according to the workpiece thickness. Powered rollers move the workpiece at a set feed rate past the blade or cutter. Start the material under the rollers just as you would feed material into a planer. Move to the outfeed side of the machine to receive and support the material.

Roller tables

Roller tables make feeding long or bulky stock much easier. They are used for both infeed and outfeed sides of the machine. See **Figure 28-8A.** When not in use, the table can be stored upright by folding the legs. A stand with one roller often is adequate. See **Figure 28-8B.** Locate it on the infeed or outfeed side of saws, shapers, planers, and jointers.



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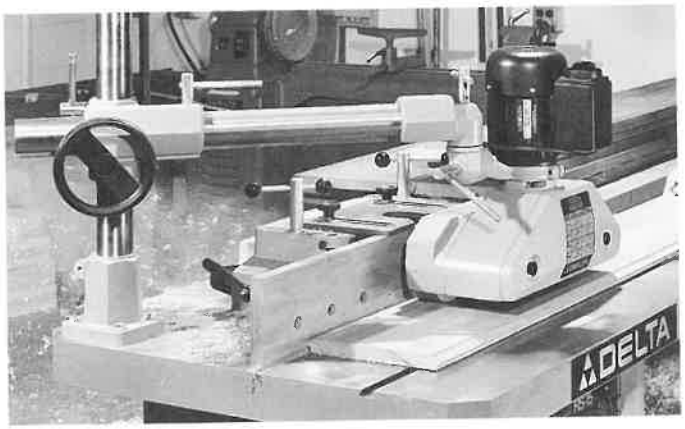

B

Figure 28-7. Power feed attachments help one operator control long stock. A—Mounted on table saw. B—Mounted on shaper. *(Delta International Machinery Corp.)*

Portable drill attachment

Attachments are not limited to stationary machines. The flexibility of a portable electric drill can be increased greatly. A typical ***portable drill attachment*** consists of a spindle adapter, two guides, and a ring base. Some applications of this accessory are shown in **Figure 28-9.**

Portable tool frame

Frames expand the applications of portable tools. The tool glides on tubes or rails. The frame shown in **Figure 28-10** increases the accuracy of square and miter cuts. It also positions a router for making dadoes or grooves. The frame shown in **Figure 28-11** allows you to rout letters.

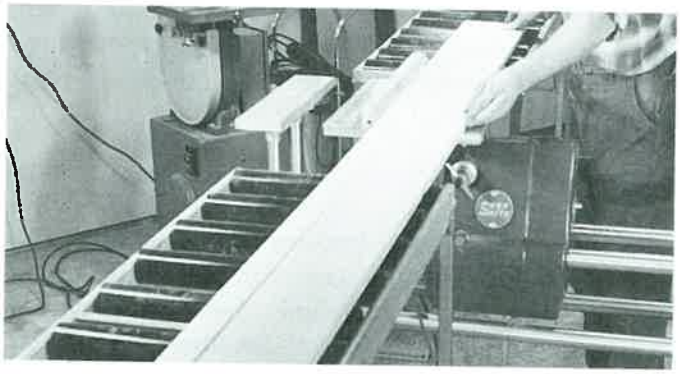

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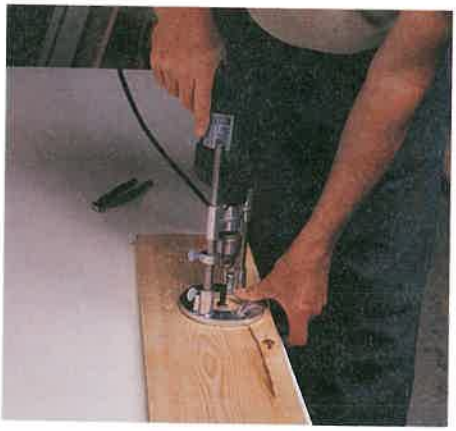
Figure 28-8. Roller tables help one person support and feed stock. The guard was removed to show the operation. *(Turning Point)*



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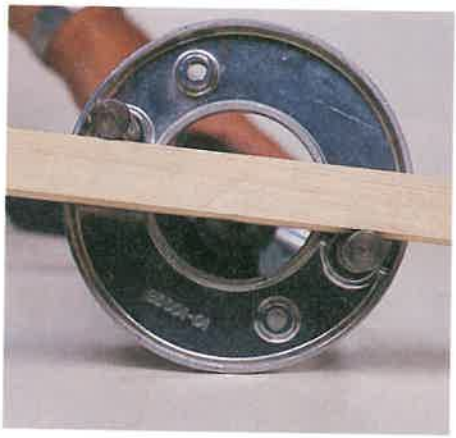
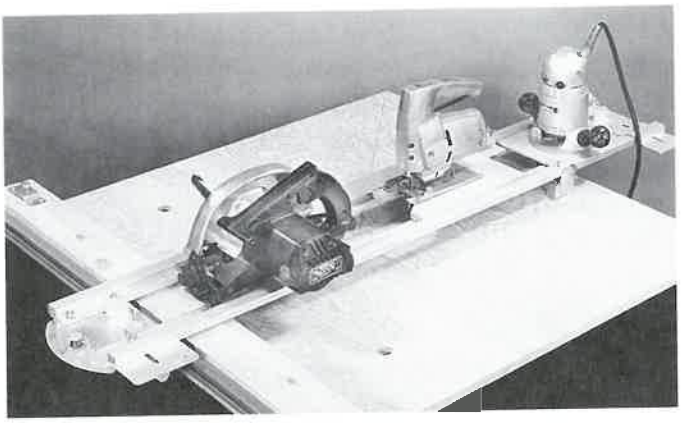


D

E

F

Figure 28-9. A drilling attachment increases the use and accuracy of a portable drill. A—90° drilling on a flat surface. B—Centering on round stock. C—Attached under a table as a drum sander. D—Centering on a narrow edge as seen from below. E—Centering on a narrow edge as seen from above. F—Angle drilling on a flat surface. *(Chuck Davis Cabinets)*



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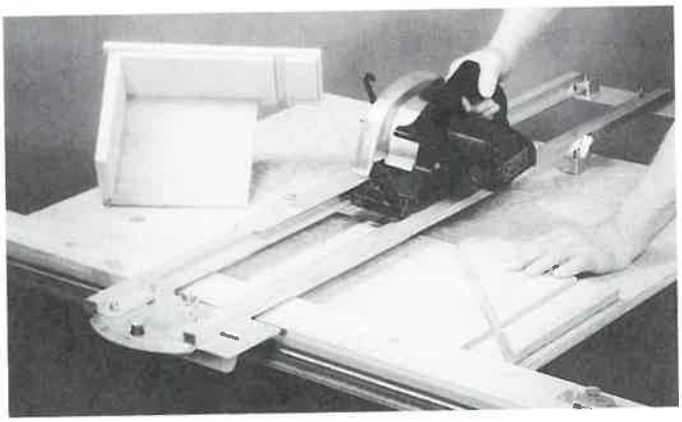


B

Figure 28-10. A—Frames make portable tools more accurate. B—Crosscutting with a portable saw. *(Brett-Hauer Co.)*

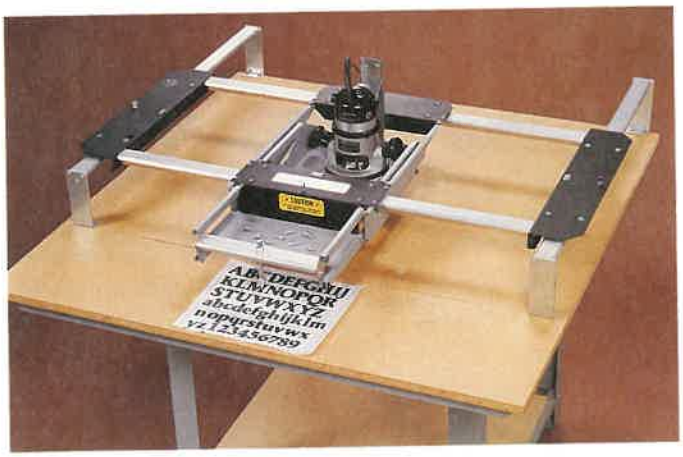


Figure 28-11. Frame guide to rout letters. *(Woodworker's Supply of New Mexico)*

Folding table

Folding tables are appropriate when space in the shop is limited. The table shown in **Figure 28-12** consists of metal folding legs attached to a 7/8" (22 mm) sheet of particleboard. A guide placed on top of the table allows paneling to be cut with a circular saw.

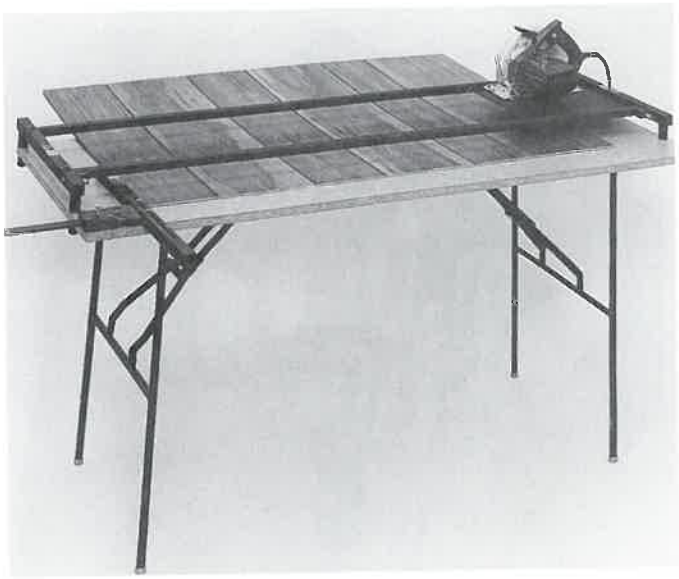


Figure 28-12. Folding tables support bulky material and can be stored easily. *(Saw-Mate Corp.)*

Portable tool tables

Tables can convert a portable tool into a stationary machine. For example, the table in **Figure 28-13A** converts a router into a shaper. You can also attach a saber saw for scroll saw operations. Portable power miter saws are used with a variety of stands. They are available with and without wheels, and may fold up for easy storage or transport.

Jigs and Fixtures

Jigs and fixtures increase the accuracy of a machine or stability of a workpiece. They may be bought or designed and built. Jigs hold a workpiece in position and guide the tool or workpiece. Jigs are a great asset to cabinetmakers. Some jigs, such as the dovetail jig, allow you to perform cuts that are difficult to do freehand. Fixtures are holding devices that do not guide the tool. Clamps, as discussed in *Chapter 33*, are one type of fixture.

A jig or fixture is recommended when making a number of duplicate parts. When it aligns the stock and guides the tool, there is less chance for error. Most often you will set up or build jigs and fixtures for mass-producing products. For the most part, purchased devices are safe and self-explanatory. Those you create must be safe. You must account for the tool, workpiece, and chips created by the operation. The failure of a jig or fixture typically is not its ability to hold the workpiece or guide the tool. The failure occurs when the designer forgets that chips will accumulate in the device. This prevents the device from performing properly.

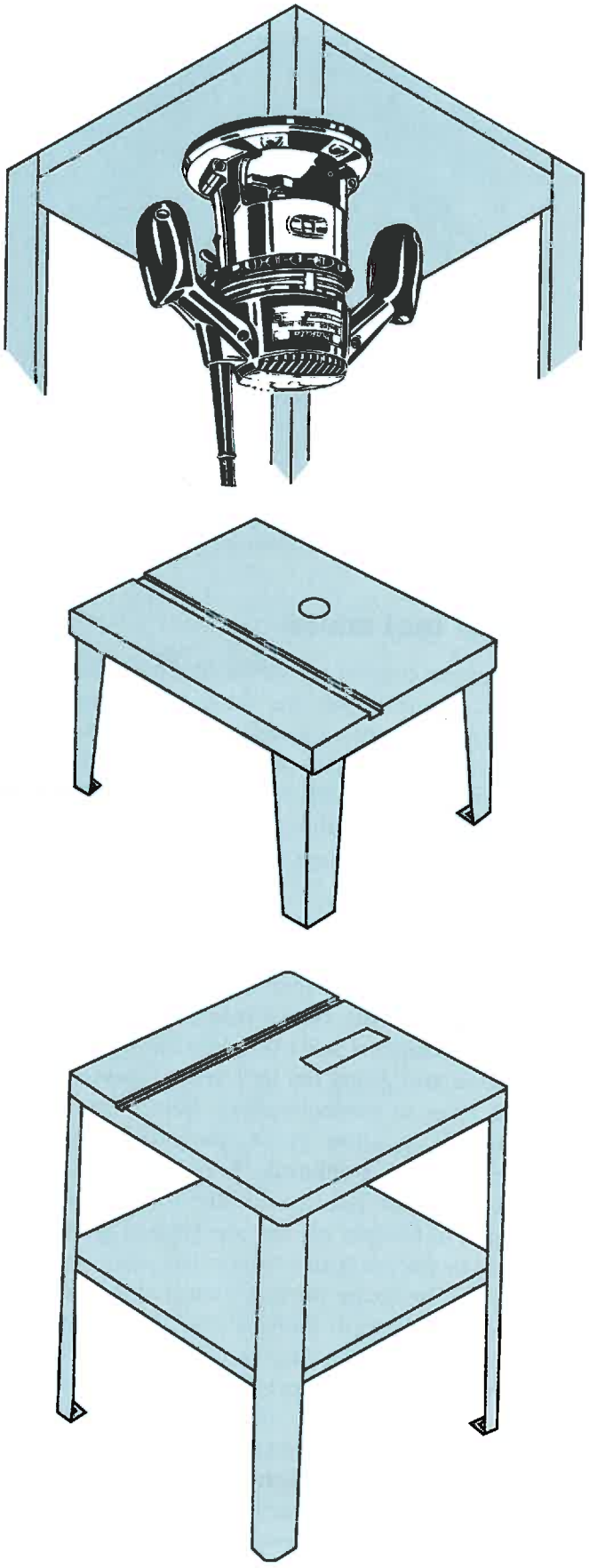


Figure 28-13. Tables convert portable tools into stationary equipment. *(Makita U.S.A., Inc.)*

Doweling jig

The ***doweling jig*** allows you to drill holes precisely in the center of an edge or end of a board. See **Figure 28-14.** As you turn the clamp handle, both jaws move equally toward the center. Holes and hole inserts in the jig permit several drill bit sizes. This jig is discussed further in *Chapter 29.*

Dovetail jig

The ***dovetail jig*** guides a portable router for making dovetail joints. See **Figure 28-15.** It is one of the most valuable joint making jigs. Dovetailing by hand is a very tedious process. This jig, discussed further in *Chapter 29,* is widely used when making drawers.

Taper jigs

Jigs for sawing tapers may be a one-piece or adjustable two-piece device. A one-piece taper jig is cut from one piece of material. Lay out the taper and cut a wedge or notches. See **Figure 28-16.** A handle can be added to the jig for safe operation. To

Figure 28-14. Doweling jig centers the drill bit on the edge of material. *(The Fine Tool Shops)*

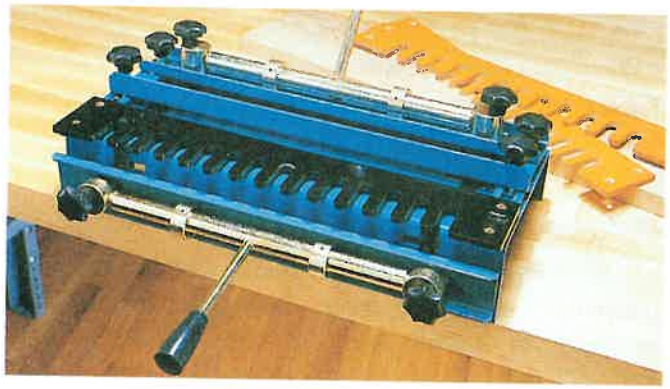


Figure 28-15. A dovetail jig allows you to cut dovetail joints with a portable router. *(American Machine and Tool)*

use the jig, set the rip fence, allowing for the jig width and desired taper. Then complete the cut.

Adjustable taper jigs can meet many needs. See **Figure 28-17.** Tapers may be cut on one or more surfaces. The adjustable taper jig and other taper cut operations are discussed in *Chapter 40* since most tapers are cut for making tapered square legs and bases.

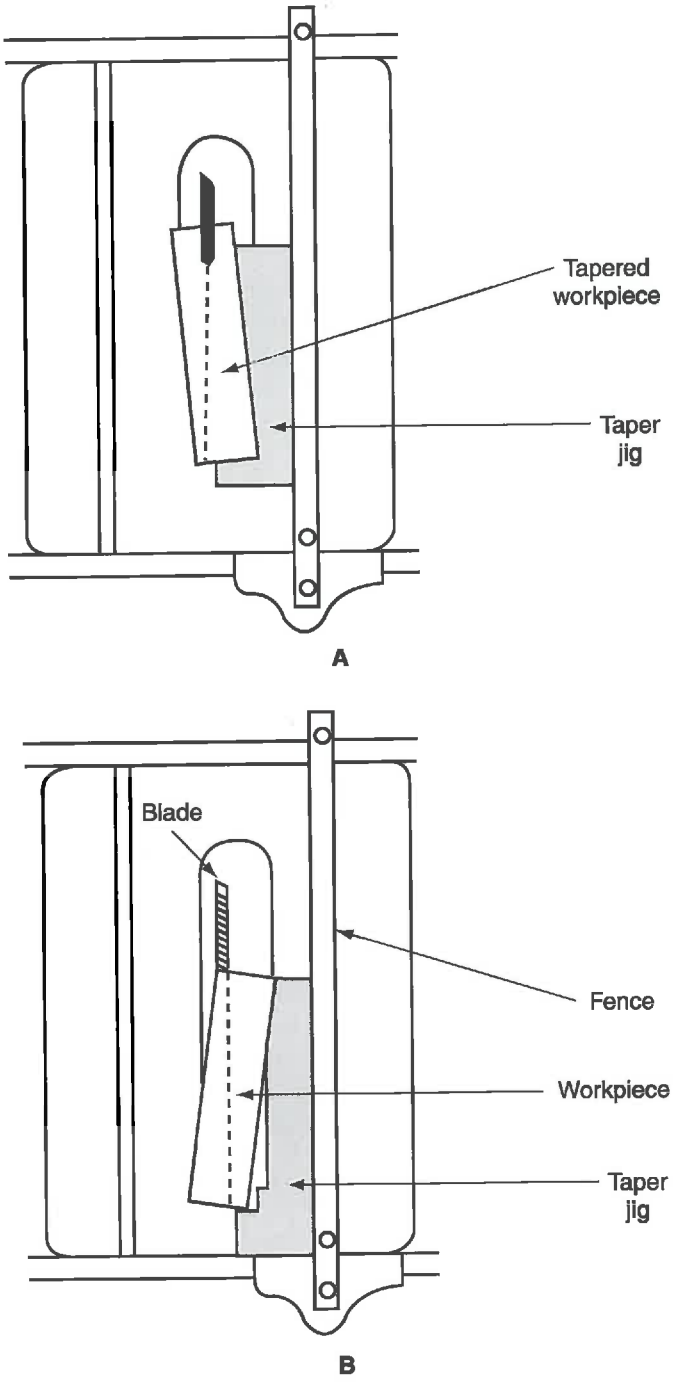


Figure 28-16. One-piece taper jigs align stock at the proper angle. A—Single taper. B—Adjustable taper.

Circle cutting jig

Sawing an accurate circle on the band saw is best done with a ***circle jig.*** The jig may be bought or custom made and can be located above or below the saw table. One type is clamped to the guide post

Figure 28-17. A—This manufactured two-piece taper jig can be set for angles up to 15° or tapers up to 1 in./ft. *(The Fine Tool Shops)* B—Jig you might build.

above the table. See **Figure 28-18.** The one you might make slides in the saw table slot. See **Figure 28-19.** The steps to set up and use this jig are as follows:

1. Position the jig on the table with the jig guide. See **Figure 28-20.**
2. Push it forward until the pivot pin is even with the blade's teeth. Remember, the blade width determines the minimum radius for the circle.
3. Secure the jig stop against the machine table edge.
4. Measure the circle radius from the pivot to the blade.
5. Drill a pivot size hole in the workpiece.
6. Place the workpiece on the pivot. Slide the jig forward making a straight cut until the jig stop touches the table.

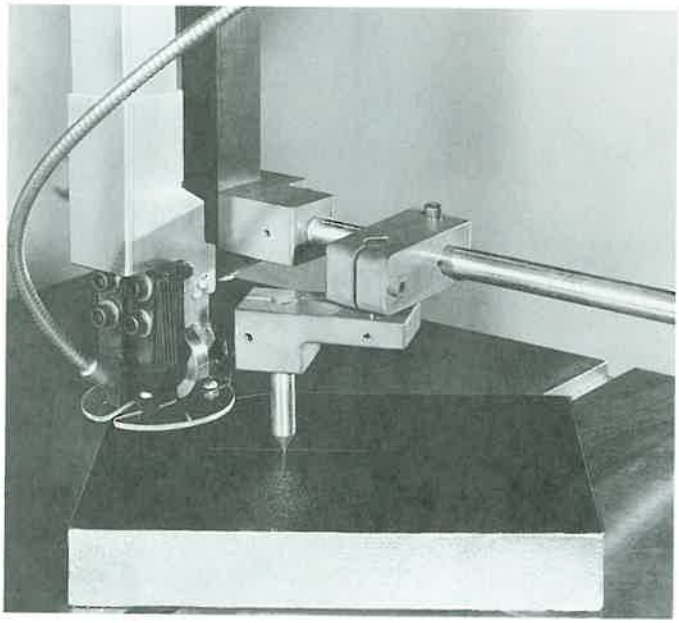


Figure 28-18. Circle cutting jig attached to the guide post of the band saw. *(Delta International Machinery Corp.)*

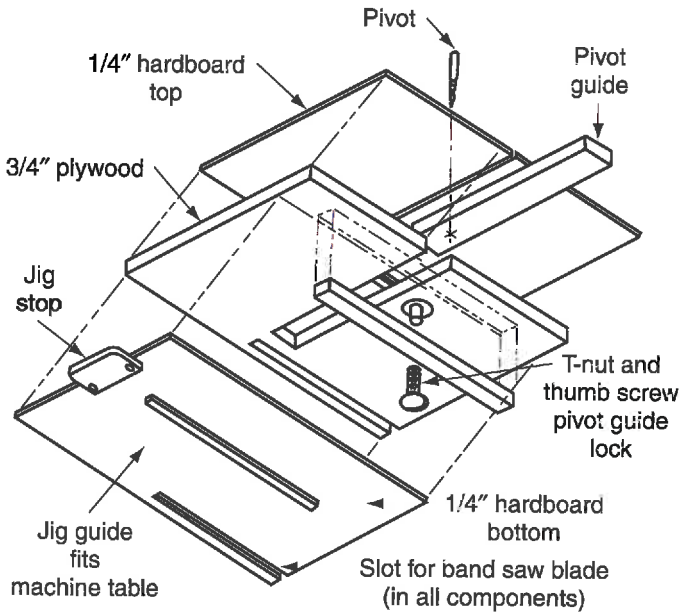


Figure 28-19. Circle cutting jig construction.

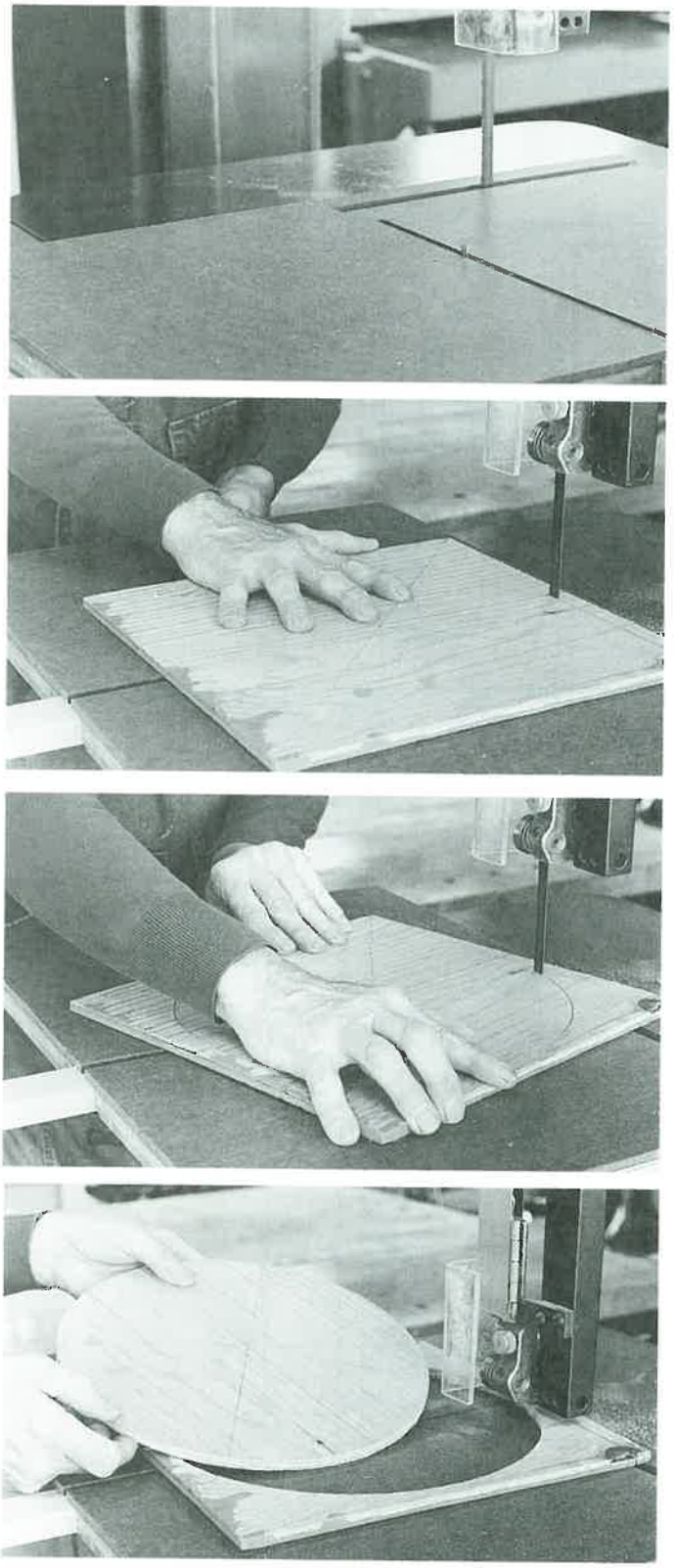


Figure 28-20. Procedure for using a shop-made circle cutting jig. The guard was raised to show the operation.

7. Turn the workpiece and cut the circle.
8. When the circle is cut, pull the jig toward you. The blade should pull from the kerf.

Miter jig

A *miter jig* can be used instead of a miter gauge for 45° cuts. The jig slides in the table slots found on each side of the blade. See **Figure 28-21.** The two angle fences provide for left- and right-hand miters. This jig holds and guides molding or framing strips of various shapes.

Drilling fixtures

Hole drilling fixtures position a workpiece on the drill press. Clamped to the drill table, most fixtures are very simple. Typically, they include an auxiliary table, two fences, or a fence and stop block. A solid fence is not recommended because chips accumulate. See **Figure 28-22A.** Chips prevent the stock from seating properly unless they are brushed away after each cut. A better fence uses three dowels. See **Figure 28-22B.** When you load new stock, the chips are pushed aside. The locating hole in the center of the fixture allows you to align the jig on the drill press table. Insert a bit the same diameter as the hole. Lower the bit and move the jig until the bit enters the locating hole. Then clamp the fixture.

Vise insert

A *vise insert* helps you clamp odd-shaped parts in a woodworking vise. This fixture consists of a wedge and pivot dowel. See **Figure 28-23.** Blocks attached to the vise jaws have half-round grooves cut in them. The wedge pivots to conform to the workpiece being held.

Framing clamp

As you will learn in *Chapter 33,* there are many types of clamps for holding glued and assembled components. Frame assembly poses a special problem. Clamping a miter joint frame could involve four clamps. With the framing fixture, one handscrew meets all needs. See **Figure 28-24.** Clamping pressure is equal at all joints. Make sure the handscrew jaws are kept parallel when applying pressure.

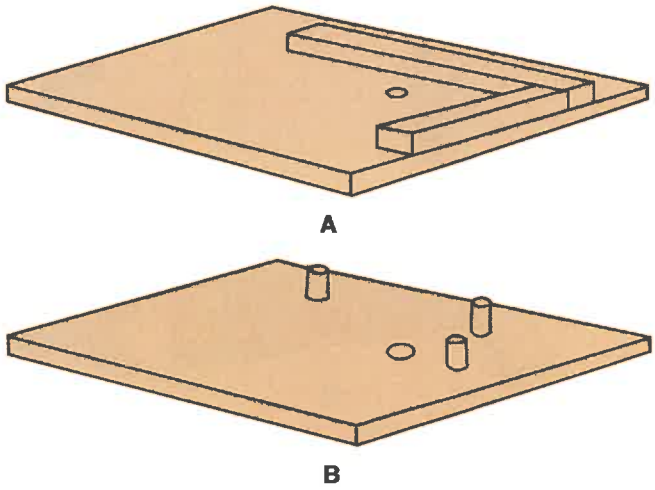


Figure 28-22. A—Chips accumulate against a solid fence. B—Chips can be pushed past a dowel fence.

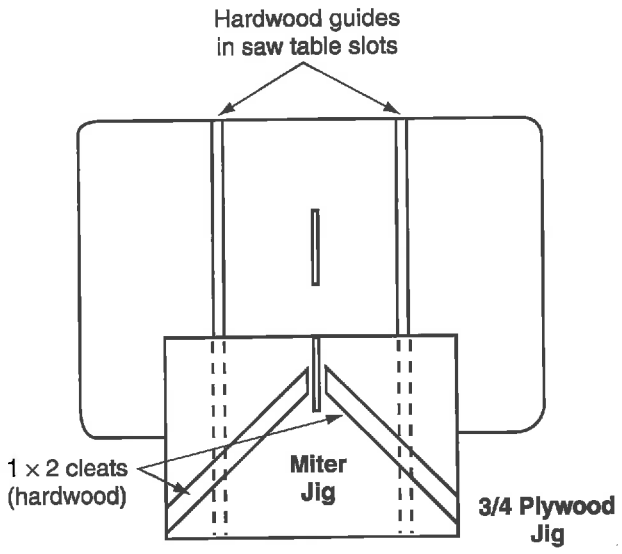


Figure 28-21. A miter jig is an alternative to a miter gauge.

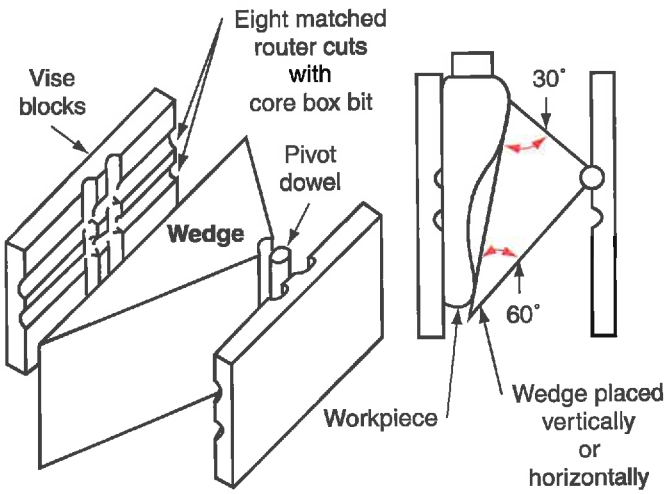
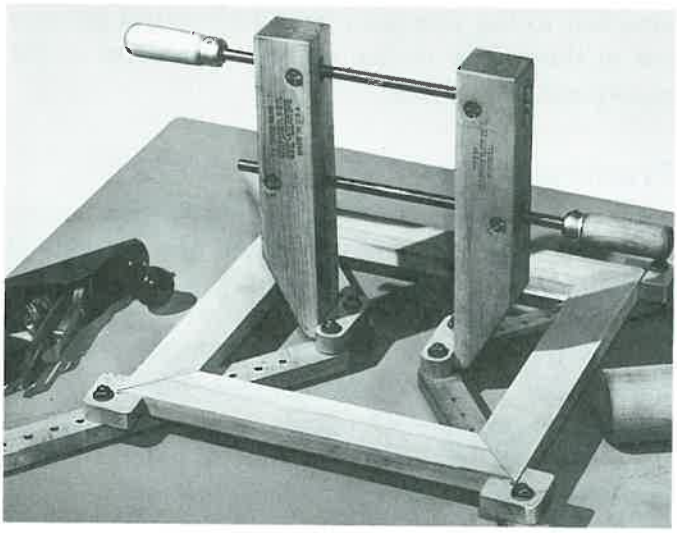


Figure 28-23. Routed vise blocks with a wedge and dowel hold irregular workpieces.



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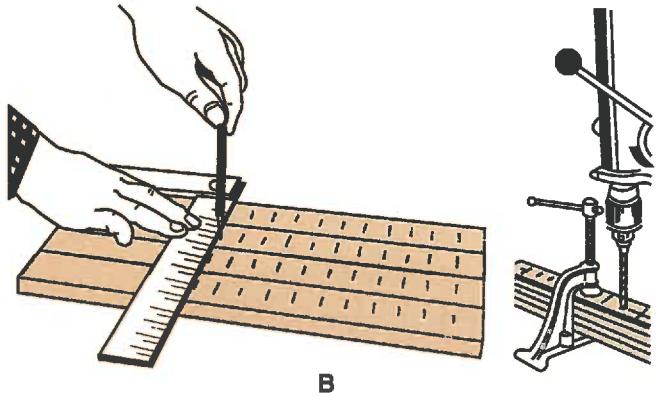

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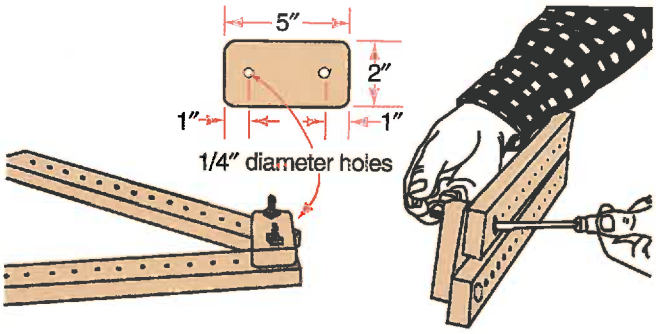

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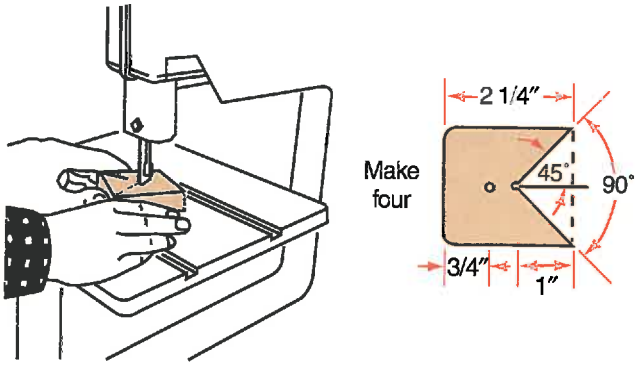


D

Figure 28-24. A—Frame clamping fixture applies equal pressure to all four miter joints. B—Instructions for building the framing fixture. *(Adjustable Clamp Co.)*

Vertical clamp

A special clamp holds stock vertical. See **Figure 28-25.** Stock clamped vertically in a woodworking vise may not be secure enough. Clamps that rotate to almost any position are also available.

Special Machinery

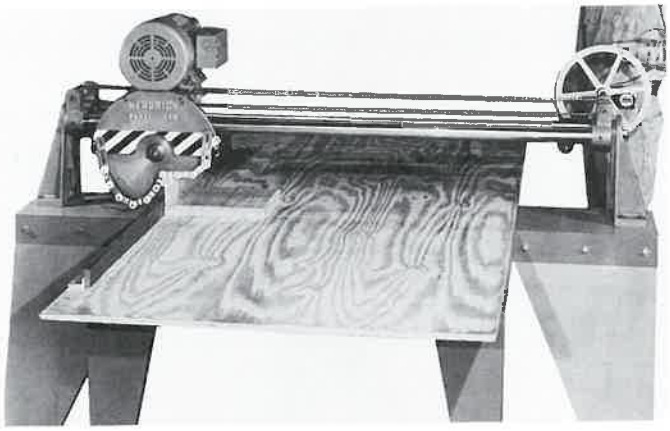
Standard stationary and portable equipment has been discussed in previous chapters. Many of the machines were described as being adaptable to meet special needs. In addition, there are special machines designed for one purpose and those designed to perform most all processing operations. A few of these are discussed in this section.

Sawing manufactured panel products

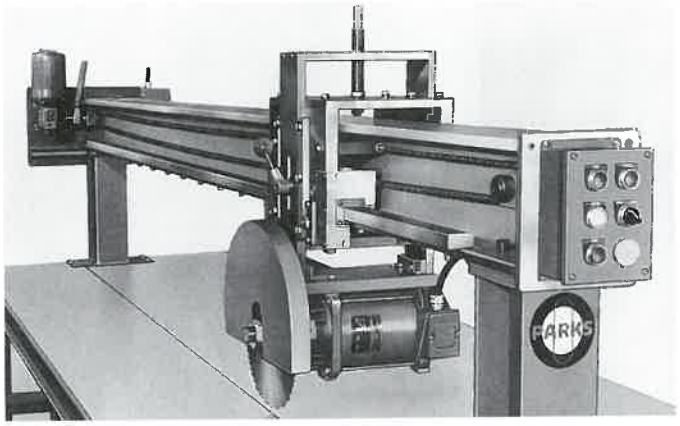
Handling large and bulky materials is often a problem in the cabinetmaking shop. Panel products are one example. They may be large, thin, and flexible, or thick and heavy. Handling these materials may require two people. To cut full-size sheets of paneling, use a panel saw rather than a table saw.

Figure 28-25. This vise holds stock in a vertical position. *(The Fine Tool Shops)*

Horizontal and vertical panel saws are available. See **Figure 28-26.** The horizontal machine functions much like the radial arm saw. The panel is well supported on the table. The saw moves completely across it. This may be controlled manually or automatically.



A



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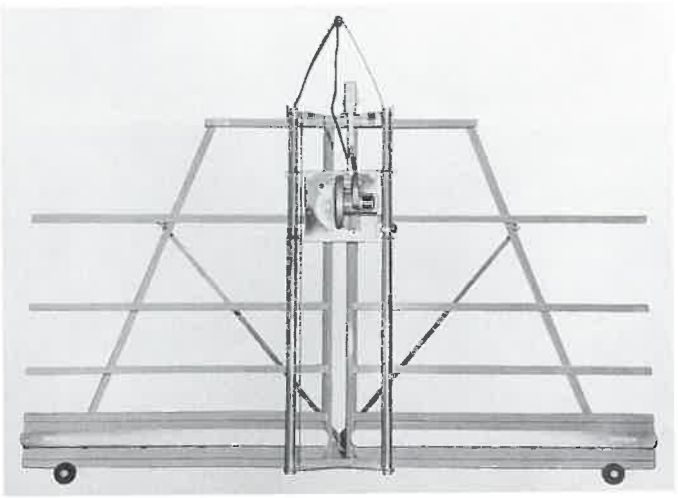

C

Figure 28-26. Panel saws. A—Manual horizontal. *(Henrick)* B—Automatic horizontal. *(Parks)* C—Vertical. *(Safety Speed Cut)*

The horizontal panel saw occupies much space. You may not saw paneling often enough to justify space for this machine. A vertical panel saw may be a better use of space. Place the panel on the frame. Most machines saw in both a vertical and horizontal direction.

Several panel saws can be fitted with a router. This allows you to groove paneling as well as cut it. Select a *V*-shaped or straight bit.

You can saw paneling and conserve space using a folding table like that shown in **Figure 28-12.** When not in use, it is folded and stored conveniently. An added advantage is that you can take the machine and table on location.

Miter trimmer

The ***miter trimmer*** fits precise 45° miter joints for molding. See **Figure 28-27.** Some trimmers also cut other angles. To use the tool, saw the material 1/8" to ¼" (3 to 6 mm) longer than needed. You can use a less precise portable saw for this cut. Then position the material against the fence of the trimmer and pull back on the handle. This tool is excellent for on-site architectural woodwork where a stationary saw might not be available.

Multipurpose machine

Up to now you have studied machines that have a single purpose but can be adapted for other operations. You can retrofit a table saw for shaping. A radial arm saw can be set up for shaping, sanding, and drilling. In addition, there are machines designed to perform many operations.

Figure 28-27. The miter trimmer shears perfect miters on molding. *(The Fine Tool Shops)*

The ***multipurpose machine*** is a versatile machine for small workspaces. See **Figure 28-28.** The machine consists of a motor, frame, table, fence, and accessories. It performs a number of operations: circular sawing, band sawing, scroll sawing, jointing, planing, drilling, mortising, shaping, pin routing, faceplate or between-center turning, as well as belt sanding, disk sanding, and drum sanding. The motor and frame can be positioned horizontally and vertically. Some tooling connected directly to the spindle operates the accessory. For other operations, a flexible coupling is required.

Using this machine requires much planning. You should decide all steps required to complete a project. Group similar operations. Otherwise, too much time is spent changing setups. Some of the setups are very different from standard machines. To set blade height for sawing, you must raise and

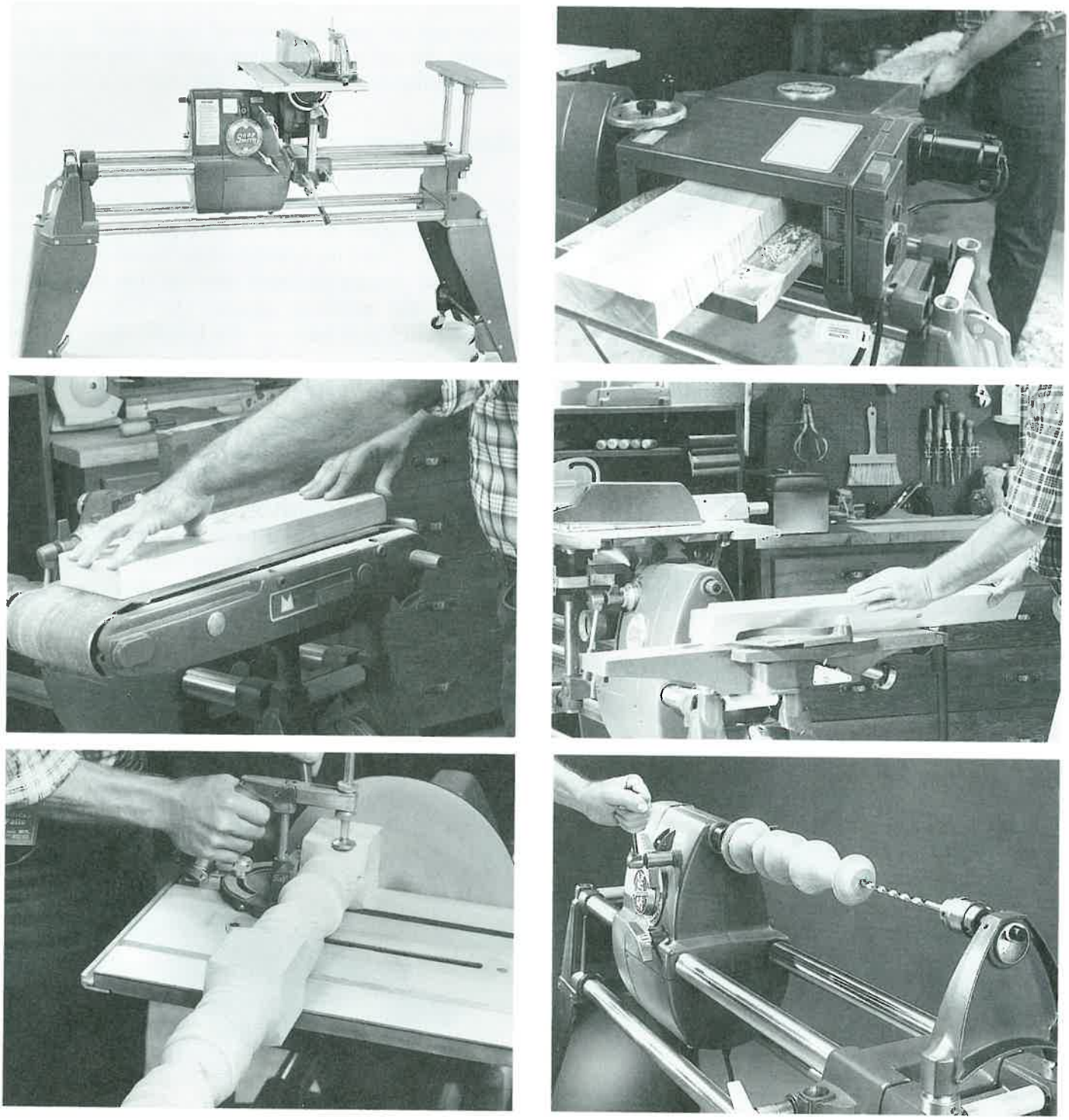

Figure 28-28. A multipurpose machine performs numerous operations. *(Shopsmith)*

lower the table rather than the arbor. When turning, the dead center is attached to the rip fence, rather than to a tailstock.

Summary

Accessories, jigs, and special machines often accompany standard cabinetmaking equipment. Accessories increase the convenience of a machine. Some examples are table extensions, gliding tables, power feed attachments, roller tables, and folding tables. Jigs hold a workpiece and guide the tool or workpiece. Some examples are the doweling jig, dovetail jig, tapering jig, and miter jig. Fixtures secure a part for processing or assembly. Clamps, discussed in *Chapter* 33, are one type of fixture. Others include vises and shop designed fixtures for drilling. Special machines include those engineered for only one purpose and those made for numerous operations. Panel saws easily cut large and bulky panel products. This is primarily a single purpose machine. On the other hand, the multipurpose machine performs a number of tasks. It saws, joints, planes, drills, shapes, routs, turns, and sands.

Test Your Knowledge

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

1. An accessory that supports wide or long stock when sawing is a(n) _____ _____.
2. A movable saw table and miter gauge accessory is the _____ _____.
3. List the three functions of a ripping guide.
4. Identify two accessories that make feeding long or bulky stock much easier.
5. Describe the difference between a jig and a fixture.
6. The failure of a fixture to align a workpiece accurately is often due to _____.
7. Name three jigs you might buy.
8. What accessory can you name that is needed to convert a portable router, drill, or saw into a stationary tool?
9. A woodworking vise can be adapted to hold irregular shaped workpieces. True or False?
10. Since supporting bulky panel products can cause injury, what machine could you choose to cut these?

This vertical panel saw is designed to let one person cut full-sized sheets quickly, safely, and accurately. *(Panel Pro)*