CHAPTER 3

WOODWORKING TOOLS, MATERIALS, AND METHODS

As a Builder, hand and power woodworking tools are essential parts of your trade. To be a proficient woodworking craftsman, you must be able to use and maintain a large variety of field and shop tools effectively. To perform your work quickly, accurately, and safely, you must select and use the correct tool for the job at hand. Without the proper tools and the knowledge to use them, you waste time, reduce efficiency, and may injure yourself or others.

Power tools not only are essential in performing specific jobs, but also play an important role in your daily work activities. Keep in mind that you are responsible for knowing and observing all safety precautions applicable to the tools and equipment you operate. For additional information on the topics discussed in this chapter, you are encouraged to study *Tools and Their Uses,* NAVEDTRA 10085-B2. Because that publication contains a detailed discussion of common tools used by Builders, we will not repeat that information in this chapter.

In this chapter, several of the most common power tools used by Builders are briefly described. Their uses, general characteristics, attachments, and safety and operating features are outlined. To become skilled with these power tools and hand tools, you must use them. You should also study the manufacturer's operator and maintenance guides for each tool you use for additional guidance. We will also be covering materials and methods of woodworking.

POWER TOOLS

LEARNING OBJECTIVE: Upon completing this section, you should be able to determine the proper use and maintenance requirements of portable power tools.

Your duties as a Builder include developing and improving your skills and techniques when working with different power tools. In this section, we'll identify and discuss the most common power tools that are in the Builder's workshop or used on the jobsite. We'll also discuss safety precautions as they relate to the particular power tool under discussion. You must keep in mind and continually stress to your crew that woodworking power tools can be dangerous, and that safety is everyone's responsibility.

SHOP TOOLS

As a Builder, you might be assigned to a shop. Therefore, you will need to know some of the common power tools and equipment found there.

Shop Radial Arm Saw

Figure 3-1 illustrates a typical shop radial arm saw. The procedures used in the operation, maintenance, and lubrication of any shop radial arm saw are found in the manufacturers' operator and maintenance manuals. The safety precautions to be observed for this saw are found in these same manuals. The primary difference between this saw and other saws of this type (field saws) is the location of controls.

Tilt-Arbor Table Bench Saw

A tilt-arbor table bench saw (figure 3-2) is so named because the saw blade can be tilted for cutting bevels by tilting the arbor. The arbor, located beneath the table, is controlled by the tilt handwheel. In earlier types of bench saws, the saw blade remained stationary and the table was tilted. A canted (tilted) saw table is hazardous in many ways; most modern table saws are of the tilt-arbor type.

To rip stock, remove the cutoff gauges and set the rip fence away from the saw by a distance equal to the desired width of the piece to be ripped off. The piece is placed with one edge against the fence and fed through with the fence as a guide.

To cut stock square, set the cutoff gauge at 90° to the line of the saw and set the ripping fence to the outside edge of the table, away from the stock to be cut. The piece is then placed with one edge against

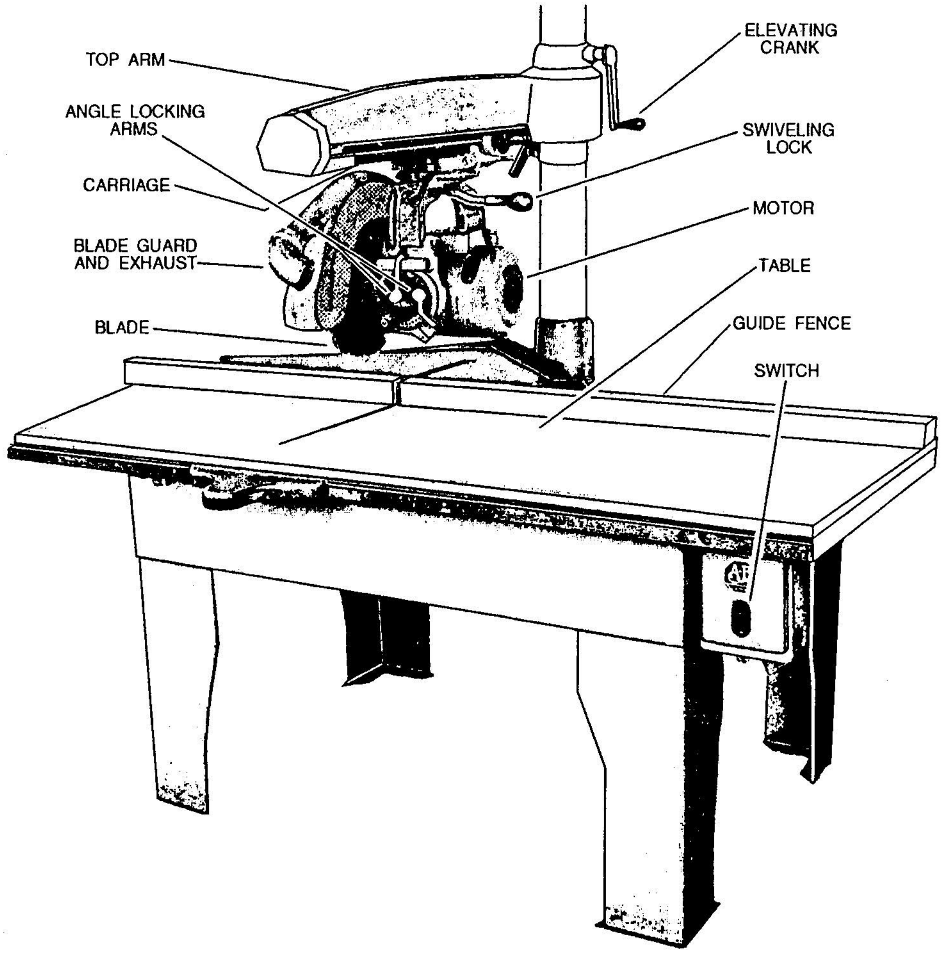

Figure 3-1.—A shop radial arm saw.

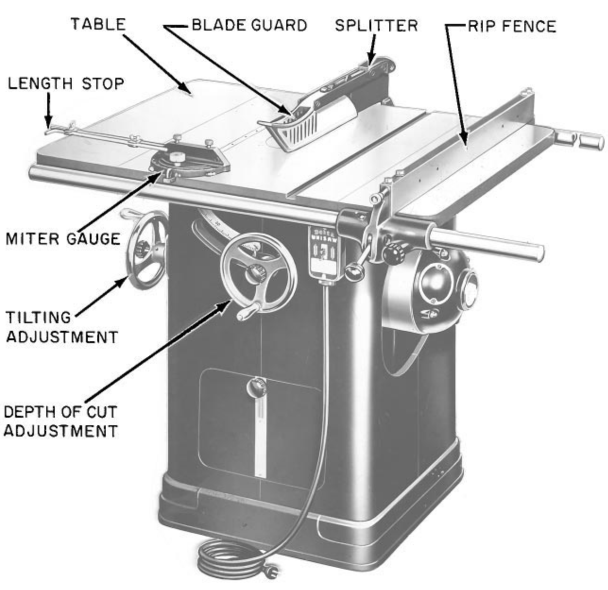

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Figure 3-2.—Tilt-arbor bench saw.

the cutoff gauge, held firmly, and fed through by pushing the gauge along its slot.

The procedure for cutting stock at an angle other than 90° (called miter cutting) is similar, except that the cutoff gauge is set to bring the piece to the desired angle with the line of the saw.

For ordinary ripping or cutting, the saw blade should extend above the table top 1/8 to 1/4 inch plus the thickness of the piece to be sawed. The vertical position of the saw is controlled by the depth of cut handwheel, shown in figure 3-2. The angle of the saw blade is controlled by the tilt handwheel. Except when its removal is absolutely unavoidable, the guard must be kept in place.

The slot in the table through which the saw blade extends is called the throat. The throat is contained in a small, removable section of the table called the throat plate. The throat plate is removed when it is necessary to insert a wrench to remove the saw blade.

The blade is held on the arbor by the arbor nut. A saw is usually equipped with several throat plates, containing throats of various widths. A wider throat is required when a dado head is used on the saw. A dado head consists of two outside grooving saws (which are much like combination saws) and as many intermediate chisel-type cutters (called chippers) as are required to make up the designated width of the groove or dado. Grooving saws are usually I/S-inch thick; consequently, one grooving saw will cut a 1/8-inch groove, and the two, used together, will cut a 1/4-inch groove. Intermediate cutters come in various thicknesses.

Observe the following safety precautions when operating the tilt-arbor table bench saw:

- Do not use a ripsaw blade for crosscutting or a crosscut saw blade for ripping. When ripping and crosscutting frequently, you should install a combination blade to eliminate constantly changing the blade. Make sure the saw blade is sharp, unbroken, and free from cracks before using. The blade should be changed if it becomes dull, cracked, chipped, or warped.
- Be sure the saw blade is set at proper height above the table to cut through the wood.
- Avoid the hazard of being hit by materials caused by kickbacks by standing to one side of the saw.
- Always use a push stick to push short, narrow pieces between the saw blade and the gauge.
- Keep stock and scraps from accumulating on the saw table and in the immediate working area.
- Never reach over the saw to obtain material from the other side.
- When cutting, do not feed wood into the saw blade faster than it will cut freely and cleanly.
- Never leave the saw unattended with the power on.

Band Saw

Although the band saw (figure 3-3) is designed primarily for making curved cuts, it can also be used for straight cutting. Unlike the circular saw, the band saw is frequently used for freehand cutting.

The band saw has two large wheels on which a continuous narrow saw blade, or band, turns, just as a belt is turned on pulleys. The lower wheel, located below the working table, is connected to the motor directly or by means of pulleys or gears and serves as the driver pulley. The upper wheel is the driven pulley.

The saw blade is guided and kept in line by two sets of blade guides, one fixed set below the table and one set above with a vertical sliding adjustment. The alignment of the blade is adjusted by a mechanism on the backside of the upper wheel. Tensioning of the blade—tightening and loosening-is provided by another adjustment located just back of the upper wheel.

Cutoff gauges and ripping fences are sometimes provided for use with band saws, but you'll do most of your work freehand with the table clear. With this type of saw, it is difficult to make accurate cuts when gauges or fences are used.

The size of a band saw is designated by the diameter of the wheels. Common sizes are 14-, 16-, 18-, 20-, 30-, 36-, 42-, and 48-inch-diameter wheel machines. The 14-inch size is the smallest practical band saw. With the exception of capacity, all band

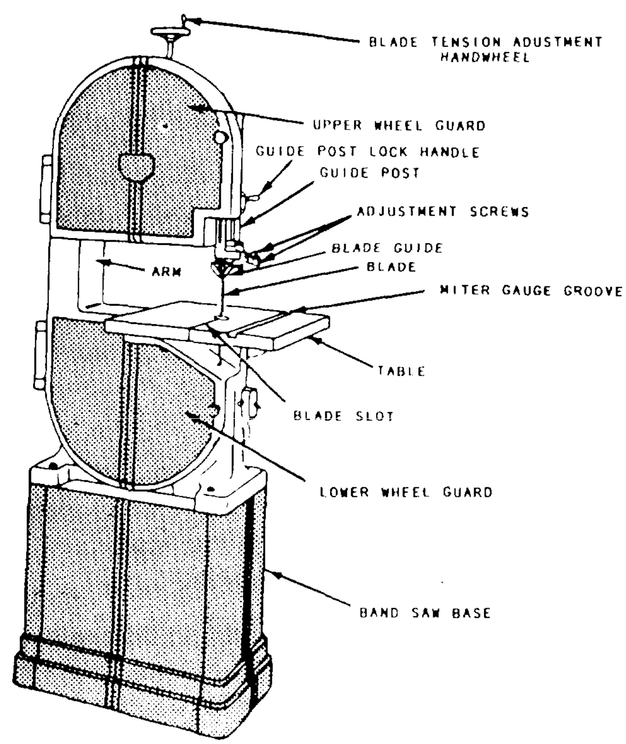

Figure 3-3.—Band saw.

saws are much the same with regard to maintenance, operation, and adjustment.

A rule of thumb used by many Seabees is that the width of the blade should be one-eighth the minimum radius to be cut. Therefore, if the piece on hand has a 4-inch radius, the operator should select a 1/2-inch blade. Don't construe this to mean that the minimum radius that can be cut is eight times the width of the blade; rather, the ratio indicates the practical limit for high-speed band saw work.

Blades, or bands, for band saws are designated by points (tooth points per inch), thickness (gauge), and width. The required length of a blade is found by adding the circumference of one wheel to twice the distance between the wheel centers. Length can vary within a limit of twice the tension adjustment range.

Band saw teeth are shaped like the teeth in a hand ripsaw blade, which means that their fronts are filed at 90° to the line of the saw. Reconditioning procedures are the same as those for a hand ripsaw, except that very narrow band saws with very small teeth must usually be set and sharpened by special machines.

Observe the following safety precautions when operating a band saw:

- Keep your fingers away from the moving blade.
- Keep the table clear of stock and scraps so your work will not catch as you push it along.
- Keep the upper guide just above the work, not excessively high.
- Don't use cracked blades. If a blade develops a click as it passes through the work, the operator should shut off the power because the click is a danger signal that the blade is cracked and may be ready to break. After the saw blade has stopped moving, it should be replaced with one in proper condition.
- If the saw blade breaks, the operator should shut off the power immediately and not attempt to remove any part of the saw blade until the machine is completely stopped.
- If the work binds or pinches on the blade, the operator should never attempt to back the work away from the blade while the saw is in motion since this may break the blade. The operator should always see that the blade is working freely through the cut.

  A band saw should not be operated in a location where the temperature is below 45°F. The blade may break from the coldness.

- Using a small saw blade for large work or forcing a wide saw on a small radius is bad practice. The saw blade should, in all cases, be as wide as the nature of the work will permit.
- Band saws should not be stopped by thrusting a piece of wood against the cutting edge or side of the band saw blade immediately after the power has been shut off; doing so may cause the blade to break. Band saws with 36-inch-wheel diameters and larger should have a hand or foot brake.
- Particular care should be taken when sharpening or brazing a band saw blade to ensure the blade is not overheated and the brazed joints are thoroughly united and finished to the same thickness as the rest of the blade. It is recommended that all band saw blades be butt welded where possible; this method is much superior to the old style of brazing.

Drill Press

Figure 3-4 shows a drill press. (The numbers in the figure correspond to those in the following text.) The drill press is an electrically operated power machine that was originally designed as a metal-working tool; as such, its use would be limited in the average woodworking shop. However, accessories, such as a router bit or shaper heads, jigs, and special techniques, now make it a versatile woodworking tool as well.

The motor (10) is mounted to a bracket at the rear of the head assembly (1) and designed to permit V-belt changing for desired spindle speed without removing the motor from its mounting bracket. Four spindle speeds are obtained by locating the V-belt on any one of the four steps of the spindle-driven and motor-driven pulleys. The belt tensioning rod (16) keeps proper tension on the belt so it doesn't slip.

The controls of all drill presses are similar. The terms "right" and "left" are relative to the operator's position standing in front of and facing the drill press. "Forward" applies to movement toward the operator. "Rearward" applies to movement away from the operator.

The on/off switch (11) is located in the front of the drill press for easy access.

The spindle and quill feed handles (2) radiate from the spindle and quill pinion feed (3) hub, which is located on the lower right-front side of the head assembly (1). Pulling forward and down on any one of the three spindle and quill feed handles, which point upward at the time, moves the spindle and quill assembly downward. Release the feed handle (2) and the spindle and quill assembly return to the retracted or upper position by spring action.

The quill lock handle (4) is located at the lower left-front side of the head assembly. Turn the quill lock handle clockwise to lock the quill at a desired operating position. Release the quill by turning the quill lock handle counterclockwise. However, in most cases, the quill lock handle will be in the released position.

The head lock handle (5) is located at the left-rear side of the head assembly. Turn the head leek handle clockwise to lock the head assembly at a desired vertical height on the bench column. Turn the head lock handle counterclockwise to release the head assembly. When operating the drill press, you must ensure that the head lock handle is tight at all times.

The head support collar handle (6) is located at the right side of the head support collar and below the head assembly. The handle locks the head support collar, which secures the head vertically on the bench column, and prevents the head from dropping when the head lock handle is released. Turn the head support collar lock handle clockwise to lock the support to the bench column and counterclockwise to

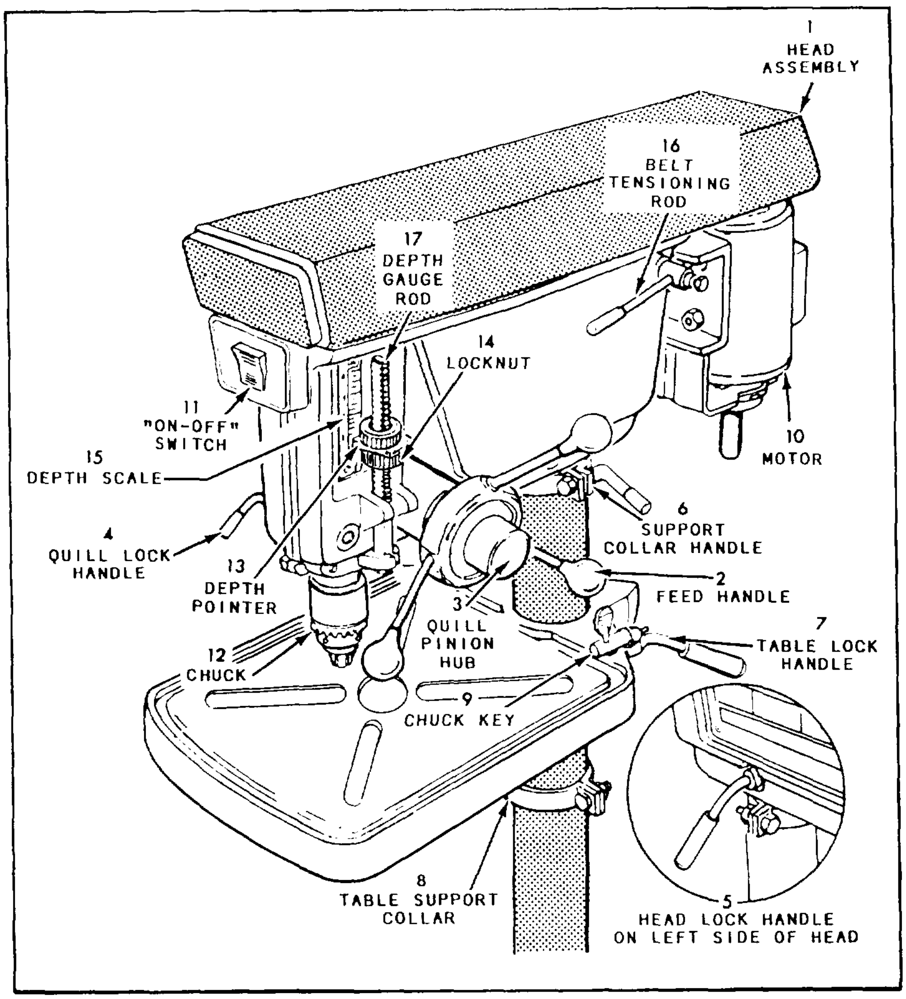

Figure 3-4.—Drill press.

release the support. When operating the drill press, ensure that the head support collar lock handle is tight at all times.

As you face the drill press, the tilting table lock handle is located at the right-rear side of the tilting table bracket. The lockpin secures the table at a horizontal or 45° angle. This allows you to move the table to the side, out of the way for long pieces of wood. The table support collar (8) allows you to raise or lower the table. Turn the tilting table lock handle counterclockwise to release the tilting table bracket so it can be moved up and down or around the bench column. Lock the tilting table assembly at the desired height by turning the lock handle clockwise. When operating the drill press, ensure that the tilting table lock handle is tight at all times.

The adjustable locknut (14) is located on the depth gauge rod (17). The purpose of the adjustable locknut is to regulate depth drilling. Turn the adjustable locknut clockwise to decrease the downward travel of the spindle. The locknut must be secured against the depth pointer (13) when operating the drill press. The depth of the hole is shown on the depth scale (15).

Observe the following safety precautions when operating a drill press:

- Make sure that the drill is properly secured in the chuck (12) and that the chuck key (9) is removed before starting the drill press.
- Make sure your material is properly secured.
- Operate the feed handle with a slow, steady pressure to make sure you don't break the drill bit or cause the V-belt to slip.
- Make sure all locking handles are tight and that the V-belt is not slipping.
- Make sure the electric cord is securely connected and in good shape.
- Make sure you are not wearing hanging or loose clothing.
- Listen for any sounds that may be signs of trouble.
- After you have finished operating the drill press, make sure the area is clean.

Woodworking Lathe

The woodworking lathe is, without question, the oldest of all woodworking machines. In its early form, it consisted of two holding centers with the suspended stock being rotated by an endless rope belt. It was operated by having one person pull on the rope hand over hand while the cutting was done by a second person holding crude hand lathe tools on an improvised beam rest.

The actual operations of woodturning performed on a modern lathe are still done to a great degree with woodturner's hand tools. However, machine lathe work is coming more and more into use with the introduction of newly designed lathes for that purpose.

The lathe is used in turning or shaping round drums, disks, and any object that requires a true diameter. The size of a lathe is determined by the maximum diameter of the work it can swing over its bed. There are various sizes and types of wood lathes, ranging from very small sizes for delicate work to large surface or bull lathes that can swing jobs 15 feet in diameter.

Figure 3-5 illustrates a type of lathe that you may find in your shop. It is made in three sizes to swing 16-, 20-, and 24-inch diameter stock. The lathe has four major parts: bed, headstock, tailstock, and tool rest.

The lathe shown in figure 3-5 has an iron bed and comes in assorted lengths. The bed is a broad, flat surface that supports the other parts of the machine.

The headstock is mounted on the left end of the lathe bed. All power for the lathe is transmitted through the headstock. It has a fully enclosed motor that gives variable spindle speed. The spindle is threaded at the front end to receive the faceplates. A faceplate attachment to the motor spindle is furnished to hold or mount small jobs having large diameters. There is also a flange on the rear end of the spindle to receive large faceplates, which are held securely by four stud bolts.

The tailstock is located on the right end of the lathe and is movable along the length of the bed. It supports one end of the work while the other end is being turned by the headstock spur. The tail center can be removed from the stock by simply backing the screw. The shank is tapered to center the point automatically.

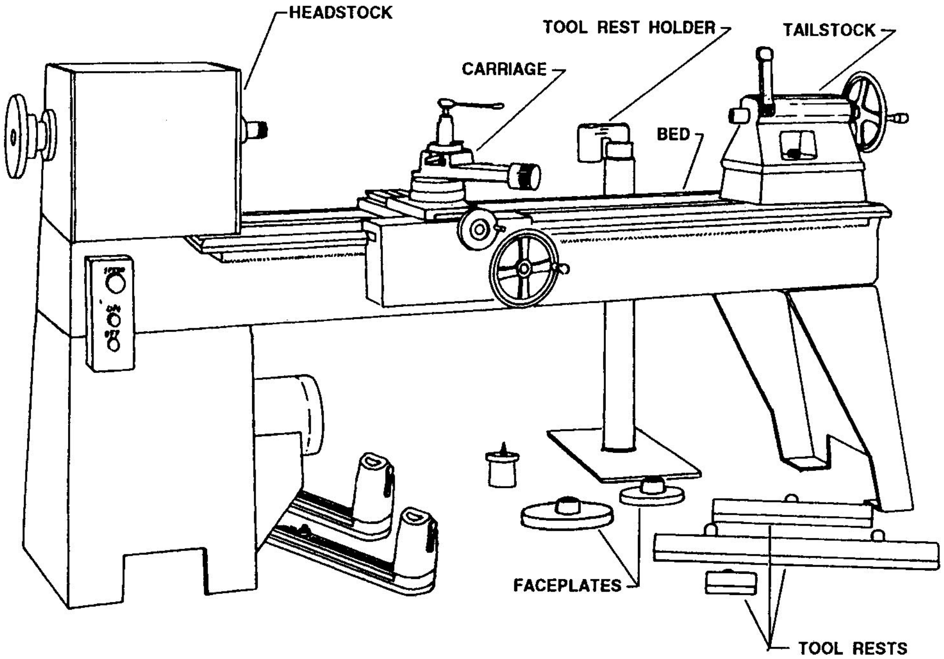

Figure 3-5.—A woodworking lathe with accessories.

Most large sizes of lathes are provided with a power-feeding carriage. A cone-pulley belt arrangement provides power from the motor, and trackways are cast to the inside of the bed for sliding the carriage back and forth. All machines have a metal bar that can be attached to the bed of the lathe between the operator and the work. This serves as a hand tool rest and provides support for the operator in guiding tools along the work. It may be of any size and is adjustable to any desired position.

In lathe work, wood is rotated against the special cutting tools (illustrated in figure 3-6). These tools include turning gouges (view A); skew chisels (view B); parting tools (view C); round-nose (view D); square-nose (view E); and spear-point (view F)

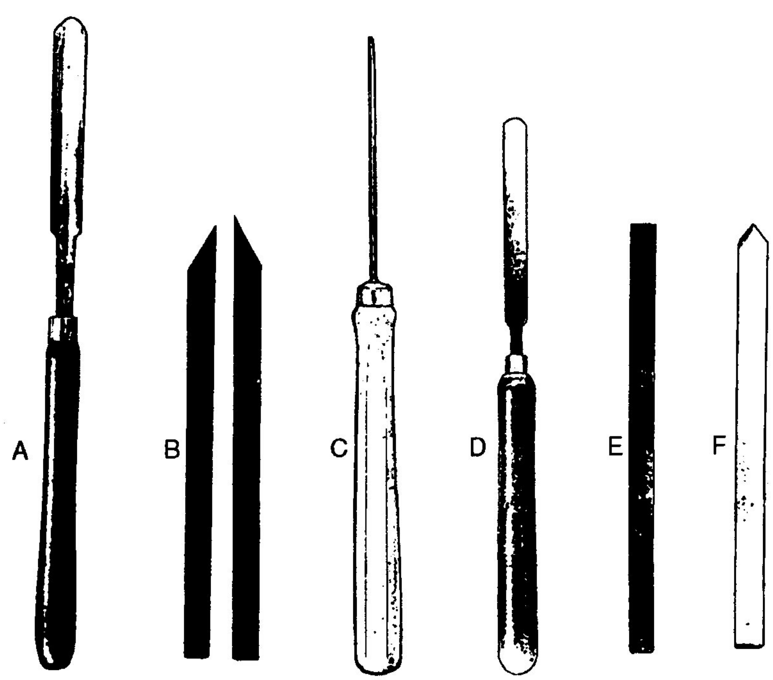

Figure 3-6.—Lathe cutting tools.

chisels. Other cutting tools are toothing irons and auxiliary aids, such as calipers, dividers, and templates.

Turning gouges are used chiefly to rough out nearly all shapes in spindle turning. The gouge sizes vary from 1/8 to 2 or more inches, with 1/4-, 3/4-, and 1-inch sizes being most common.

Skew chisels are used for smoothing cuts to finish a surface, turning beads, trimming ends or shoulders, and for making V-cuts. They are made in sizes from 1/8 to 2 1/2 inches in width and in right-handed and left-handed pairs.

Parting tools are used to cut recesses or grooves with straight sides and a flat bottom, and also to cut off finished work from the faceplate. These tools are available in sizes ranging from 1/8 to 3/4 inch.

Scraping tools of various shapes are used for the most accurate turning work, especially for most faceplate turning. A few of the more common] y used shapes are illustrated in views D, E, and F of figure 3-6. The chisels shown in views B, E, and F are actually old jointer blades that have been ground to the required shape; the wood handles for these homemade chisels are not shown in the illustration.

A toothing iron (figure 3-7) is basically a square-nose turning chisel with a series of parallel grooves cut into the top surface of the iron. These turning tools we used for rough turning of segment work mounted on the face plate. The points of the toothing iron created by the parallel grooves serve as a series of spear point chisels (detail A); therefore, the tool is not likely to catch and dig into the work like a square-nose turning chisel. The toothing iron is made with course, medium, and fine parallel grooves and varies from 1/2 to 2 inches in width.

Lathe turning can be extremely dangerous. You therefore must use particular care in this work. Observe the following safety precautions:

- When starting the lathe motor, stand to one side. This helps you avoid the hazard of flying debris in the event of defective material.

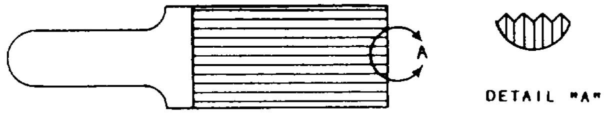

Figure 3-7.—Toothing iron lathe tool.

- The tool rest must be used when milling stock.
- Adjust and set the compound or tool rest for the start of the cut before turning the switch on.
- Take very light cuts, especially when using hand tools.
- Never attempt to use calipers on interrupted surfaces while the work is in motion.

Jointer

The jointer is a machine for power planing stock on faces, edges, and ends. The planing is done by a revolving butterhead equipped with two or more knives, as shown in figure 3-8. Tightening the set screws forces the throat piece against the knife for holding the knife in position. Loosening the set screws releases the knife for removal. The size of a jointer is designated by the width, in inches, of the butterhead; sizes range from 4 to 36 inches. A 6-inch jointer is shown in figure 3-9.

The principle on which the jointer functions is illustrated in figure 3-10. The table consists of two parts on either side of the butterhead. The stock is started on the infeed table and fed past the butterhead onto the outfeed table. The surface of the outfeed table must be exactly level with the highest point reached by the knife edges. The surface of the infeed table is depressed below the surface of the outfeed

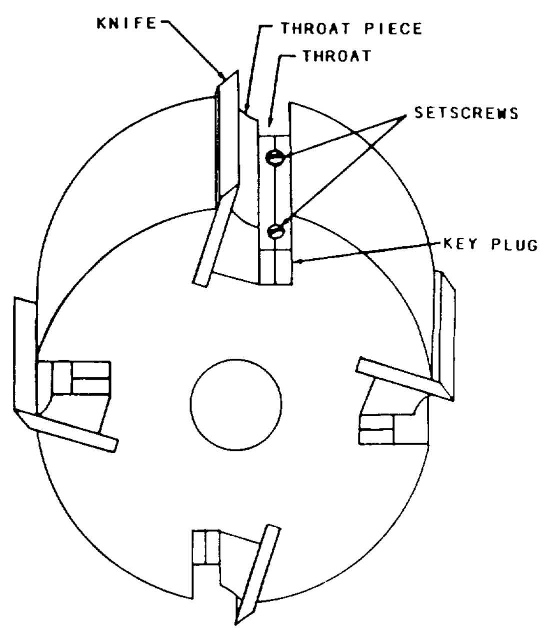

Figure 3-8.—Four-knife butterhead for a jointer.

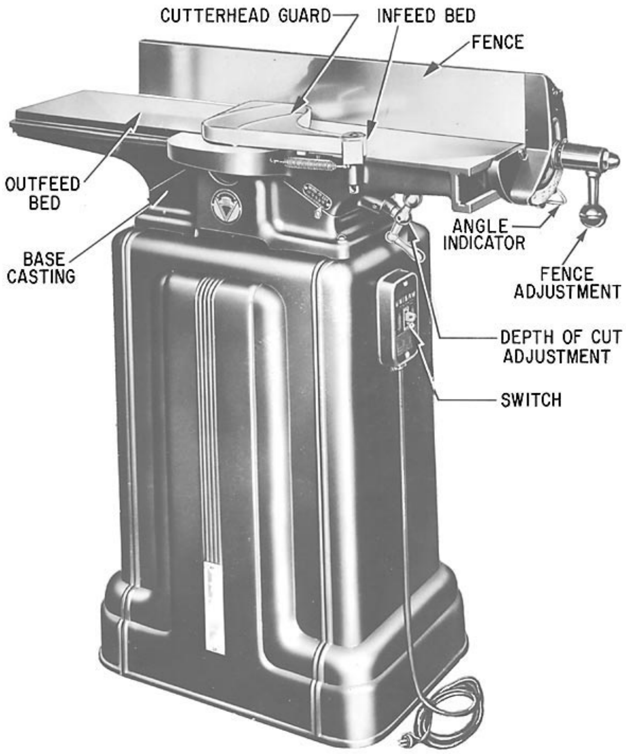

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Figure 3-9.—Six-inch jointer.

table an amount equal to the desired depth of cut. The usual depth of cut is about 1/16 to 1/8 inch.

The level of the outfeed table must be frequently checked to ensure the surface is exactly even with the highest point reached by the knife edges. If the outfeed table is too high, the cut will become progressively more shallow as the piece is fed through. If the outfeed table is too low, the piece will drop downward as its end leaves the infeed table, and the cut for the last inch or so will be too deep.

To set the outfeed table to the correct height, first feed a piece of waste stock past the cutterhead until a few inches of it lie on the outfeed table. Then, stop the machine and look under the outfeed end of the piece. If the outfeed table is too low, there will be a space between the surface of the table and the lower face of the piece. Raise the outfeed table until this space is eliminated. If no space appears, lower the outfeed table until a space does appear. Now, run the stock back through the machine. If there is still a space, raise the table just enough to eliminate it.

Note that the cutterhead cuts toward the infeed table; therefore, to cut with the grain, you must place the piece with the grain running toward the infeed table. A piece is edged by feeding it through on edge with one of the faces held against the fence. A piece is surfaced by feeding it through flat with one of the edges against the fence. However, this operation should, if possible, be limited to straightening the face of the stock. The fence can be set at 90° to produce squared faces and edges, or at any desired angle to produce beveled edges or ends.

Only sharp and evenly balanced knives should be used in a jointer cutting head. The knives must not be set to take too heavy a cut because a kickback is almost certain to result, especially if there is a knot or change of grain in the stock. The knives must be securely refastened after the machine has been standing in a cold building over the weekend.

Each hand-fed jointer should be equipped with a cylindrical cutting head, the throat of which should not exceed 7/1 6 inch in depth or 5/8 inch in width. It is strongly recommended that no cylinder be used in which the throat exceeds 3/8 inch in depth or 1/2 inch in width.
Each hand-fed jointer should have an automatic guard that covers all the sections of the head on the working side of the fence or gauge. The guard should automatically adjust horizontally for edge jointing and vertically for surface work, and it should remain in contact with the material at all times.

When operating the jointer, observe the following safety precautions:

- Always plane with the grain. A piece of wood planed against the grain on a jointer may be kicked back.

- Never place your hands directly over the inner cutterhead. Should the piece of wood kick

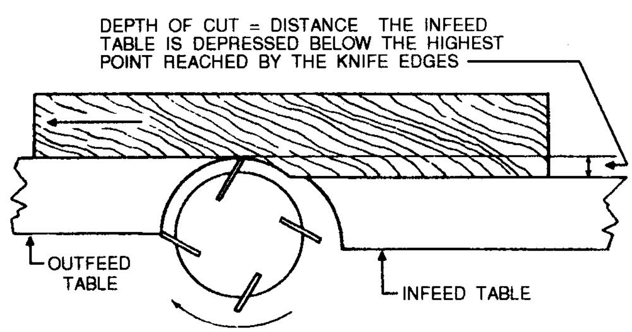

Figure 3-10.—Operating principle of a jointer.

back, your hands will drop on the blades. Start with your hands on the infeed bed. When the piece of wood is halfway through, reach around with your left hand and steady the piece of wood on the outfeed bed. Finish with both your hands on the outfeed bed.

- Never feed a piece of wood with your thumb or finger against the end of the piece of wood being fed into the jointer. Keep your hands on top of the wood at all times.

- Avoid jointing short pieces of wood whenever possible. Joint a longer piece of wood and then cut it to the desired size. If you must joint a piece of wood shorter than 18 inches, use a push stick to feed it through the jointer.

- Never use a jointer with dull cutter blades. Dull blades have a tendency to kick the piece, and a kickback is always dangerous.

- Keep the jointer table and the floor around the jointer clear of scraps, chips, and shavings. Always stop the jointer before brushing off and cleaning up those scraps, chips, and shavings.

- Never joint a piece of wood that contains loose knots.

- Keep your eyes and undivided attention on the jointer as you are working. Do not talk to anyone while operating the jointer.

Remember, the jointer is one of the most dangerous machines in the woodworking shop. Only experienced and responsible personnel should be allowed to operate it using the basic safety precautions provided above.

Surfacer

A single surfacer (also called a single planer) is shown in figure 3-11. This machine surfaces stock on one face (the upper face) only. (Double surfacers, which surface both faces at the same time, are used only in large planing mills.)

The single surfacer cuts with a cutterhead like the one on the jointer, but, on the single surfacer, the cutterhead is located above instead of below the drive rollers. The part adjacent to the cutterhead is pressed down against the feed bed by the chip breakers (just ahead of the cutterhead) and the pressure bar (just behind the cutterhead). The pressure bar temporarily

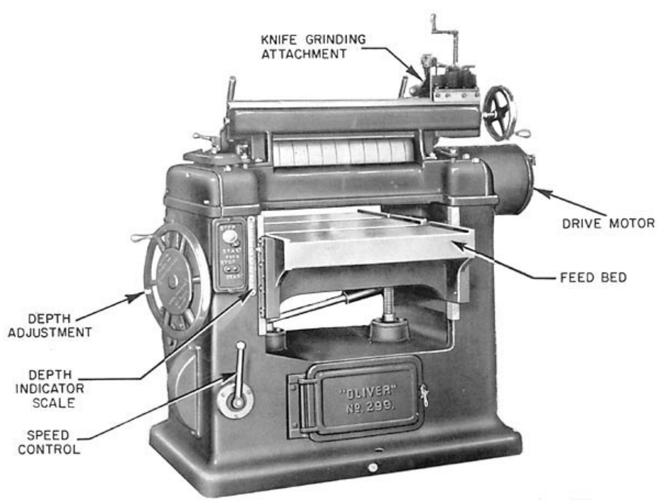

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Figure 3-11.—Single surfacer.

straightens out any warp a piece may have; a piece that goes into the surfacer warped will come out still warped. This is not a defect in the machine; the surfacer is designed for surfacing only, not for truing warped stock. If true plane surfaces are desired, one face of the stock (the face that goes down in the surfacer) must be trued on the jointer before the piece is feed through the surfacer. If the face that goes down in the surfacer is true, the surfacer will plane the other face true.

Observe the following safety precautions when operating a surfacer:

- The cutting head should be covered by metal guards.
- Feed rolls should be guarded by a hood or a semicylindrical guard.
- Never force wood through the machine.
- If a piece of wood gets stuck, turn off the surfacer and lower the feed bed.

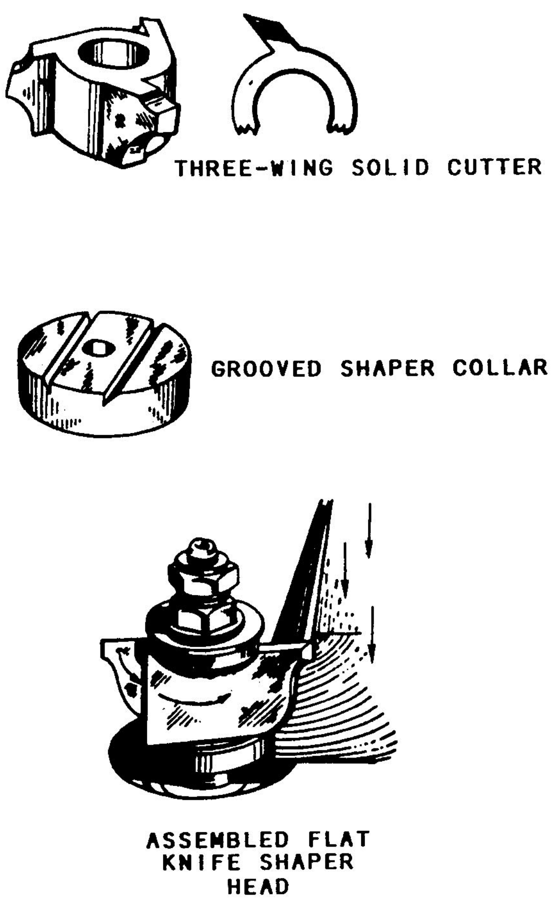

Figure 3-12.—Three-wing cutter for a shaper.

Shaper

The shaper is designed primarily for edging curved stock and for cutting ornamental edges, as on moldings. It can also be used for rabbeting, grooving, fluting, and beading.

The flat cutter on a shaper is mounted on a vertical spindle and held in place by a hexagonal spindle nut. A grooved collar is placed below and above the cutter to receive the edges of the knives. Ball bearing collars are available for use as guides on irregular work where the fence is not used. The part of the edge that is to remain uncut runs against a ball bearing collar underneath the cutter, as shown in the bottom view of figure 3-12. A three-wing cutter (top view of figure 3-12) fits over the spindle. Cutters come with cutting edges in a great variety of shapes.

For shaping the side edges on a rectangular piece, a light-duty shaper has an adjustable fence, like the one shown on the shaper in figure 3-13. For shaping the end edges on a rectangular piece, a machine of this type has a sliding fence similar to the cutoff gauge on a circular saw. The sliding fence slides in the groove shown in the table top.

On larger machines, the fence consists of a board straightedge, clamped to the table with a hand screw,

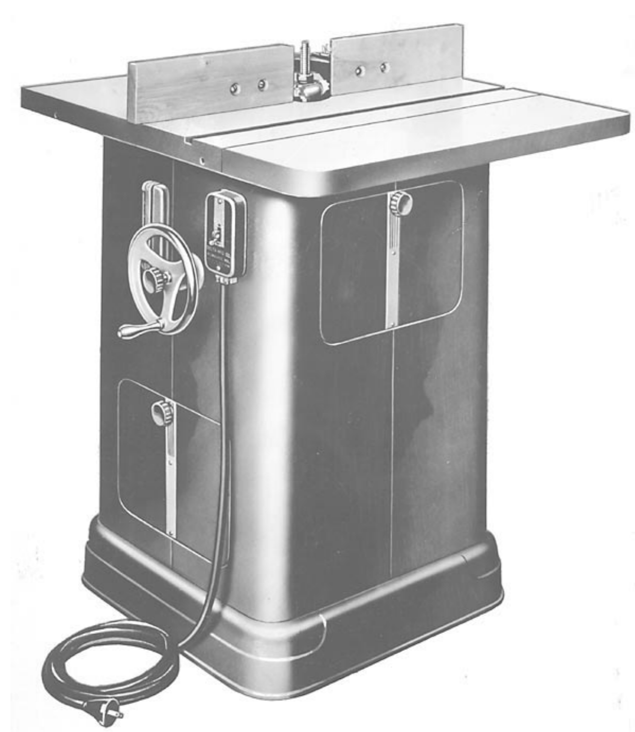

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Figure 3-13.—Light-duty shaper with adjustable fence.

as shown in figure 3-14. A semicircular opening is sawed in the edge of the straightedge to accommodate the spindle and the cutters. Whenever possible, a guard of the type shown in the figure should be placed over the spindle.

For shaping curved edges, there are usually a couple of holes in the table, one on either side of the spindle, in which vertical starter pins can be inserted. When a curved edge is being shaped, the piece is guided by and steadied against the starter pin and the ball bearing collar on the spindle.

When operating a shaper, observe the following safety precautions:

- Like the jointer and surfacer, the shaper cuts toward the infeed side of the spindle, which is against the rotation of the spindle. Therefore, stock should be placed with the grain running toward the infeed side.
- Make sure the cutters are sharp and well secured.
- If curved or irregularly shaped edges are to be shaped, place the stock in position and make sure the collar will rub against the part of the edge, which should not be removed.
- Whenever the straight fence cannot be used, always use a starting pin in the table top.
- Never make extremely deep cuts.
- Make sure the shaper cutters rotate toward the work.
- Whenever possible, always use a guard, pressure bar, hold-down, or holding jig.
- If possible, place the cutter on the shaper spindle so that the cutting will be done on the lower side of the stock.
- Do not attempt to shape small pieces of wood.
- Check all adjustments before turning on the power.

SAFETY NOTE

The spindle shaper is one of the most dangerous machines used in the shop. Use extreme caution at all times.

PORTABLE HAND TOOLS

In addition to using power shop tools, you will be required to operate different types of portable hand tools in the field. You therefore need to understand the safety precautions associated with these.

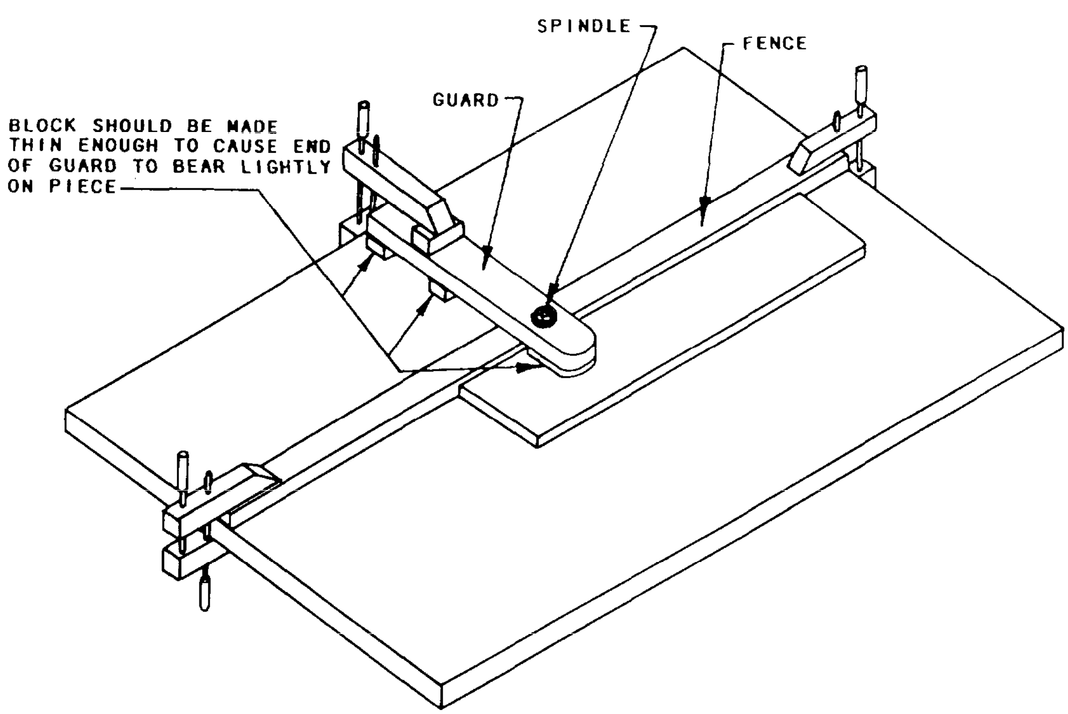


Figure 3-14.—Shaper table showing straightedge fence and guard.

Portable Electric Circular Saw

The portable electric circular saw is used chiefly as a great labor-saving device in sawing wood framing members on the job. The size of a circular saw is determined by the diameter of the largest blade it can use. The most commonly used circular saws are the 7 1/4- and 8 1/4-inch saws. There are two different types of electric saws, as shown in figure 3-15: the side-drive (view A) and the

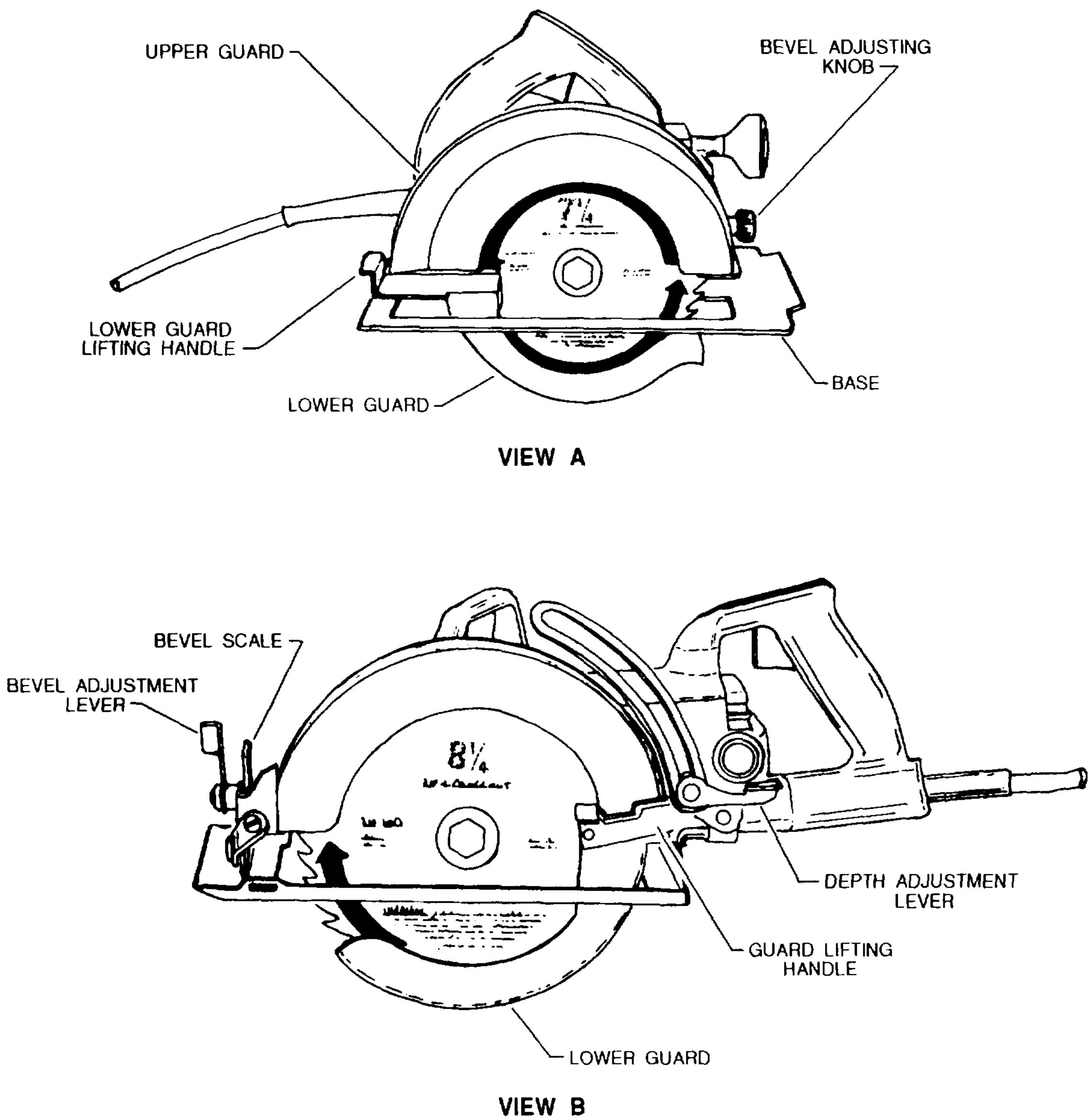


Figure 3-15.-Side-drive (view A) and worm-drive (view B) circular saws

worm-drive (view B). Circular saws can use many different types of cutting blades, some of which are shown in figure 3-16.

COMBINATION CROSSCUT AND RIP BLADES.— Combination blades are all-purpose blades for cutting thick and thin hardwoods and softwoods, both with or across the grain. They can also be used to cut plywood and hardboard.

CROSSCUT BLADES.— Crosscut blades have fine teeth that cut smoothly across the grain of both hardwood and softwood. These blades can be used for plywood, veneers, and hardboard.

RIP BLADES.— Rip blades have bigger teeth than combination blades, and should be used only to cut with the grain. A rip fence or guide will help you make an accurate cut with this type of blade.

HOLLOW-GROUND BLADES.— Hollow-ground blades have no set. They make the smoothest cuts on thick or thin stock. Wood cut with these blades requires little or no sanding.

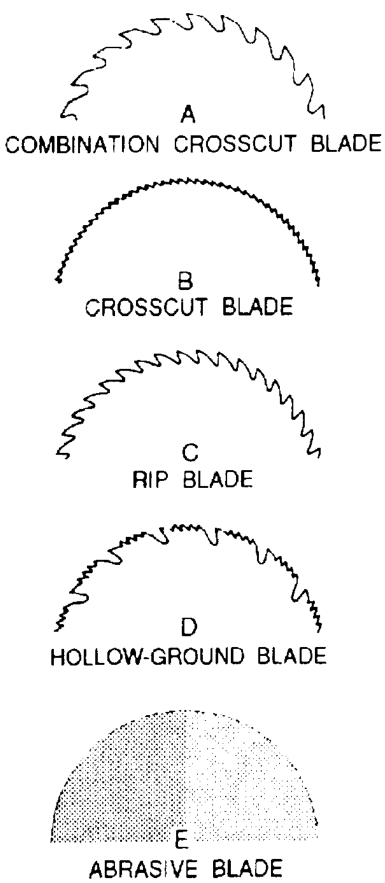


Figure 3-16.-Circular saw blades.

ABRASIVE BLADES.— Abrasive blades are used for cutting metal, masonry, and plastics. These blades are particularly useful for scoring bricks so they can be easily split.

Figure 3-17 shows how versatile the circular saw can be. To make an accurate ripping cut (view A), the

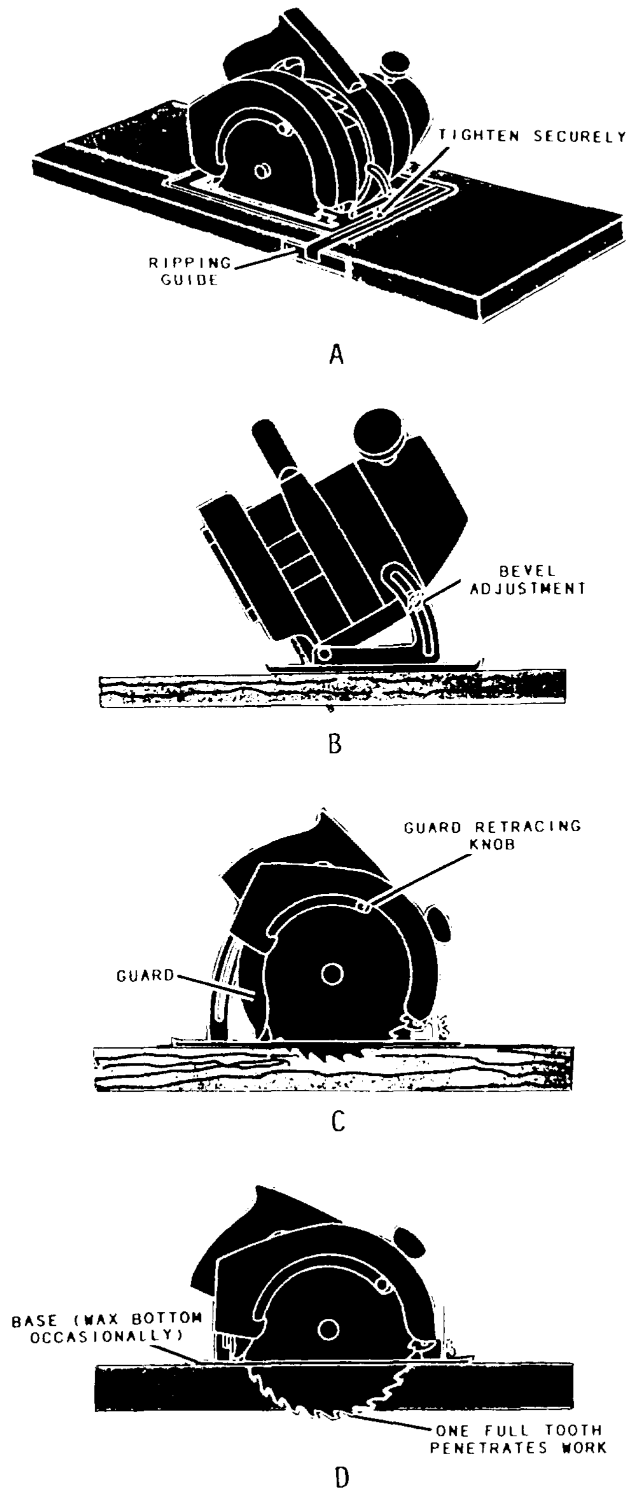


Figure 3-17.-Different ways to use a circular saw.

ripping guide is set a distance away from the saw equal to the width of the strip to be ripped off. It is then placed against the edge of the piece as a guide for the saw. To make a bevel angle cut up to 45° (view B), you just set the bevel adjustment knob to the angle you want and cut down the line. To make a pocket cut (views C and D), a square cut in the middle of a piece of material, you retract the guard back and tilt the saw so that it rests on the front of the base. Then, lowering the rear of the saw into the material, hold it there until it goes all the way through the wood. Then, follow your line.

Observe the following safety precautions when operating a circular saw:

- Don't force the saw through heavy cutting stock. If you do, you may overload the motor and damage it.
- Before using the saw, carefully examine the material to be cut and free it of nails or other metal objects. Cutting into or through knots should be avoided, if possible.
- Disconnect the saw from its power source before making any adjustments or repairs to the saw. This includes changing the blade.
- Make sure all circular saws are equipped with guards that automatically y adjust themselves to the work when in use so that none of the teeth protrude above the work. Adjust the guard over the blade so that it slides out of its recess and covers the blade to the depth of the teeth when you lift the saw off the work.
- Wear goggles or face shields while using the saw and while cleaning up debris afterward.
- Grasp the saw with both hands and hold it firmly against the work. Take care to prevent the saw from breaking away from the work and thereby causing injury.
- Inspect the blade at frequent intervals and always after it has locked, pinched, or burned the work. Disconnect the saw from the power source before performing this inspection.
- Inspect daily the electric cords that you use for cuts or breaks. Before cutting boards, make sure the cord is not in the way of the blade.

Saber Saw

The saber saw (figure 3-18) is a power-driven jigsaw that cuts smooth and decorative curves in wood and light metal. Most saber saws are light-duty machines and not designed for extremely fast cutting.

There are several different, easily interchangeable blades (figure 3-19) designed to operate in the saber saw. Some blades are designed for cutting wood and some for cutting metal.

The best way to learn how to handle this type of tool is to use it. Before trying to do a finished job with the saber saw, clamp down a piece of scrap plywood and draw some curved as well as straight lines to follow. You will develop your own way of

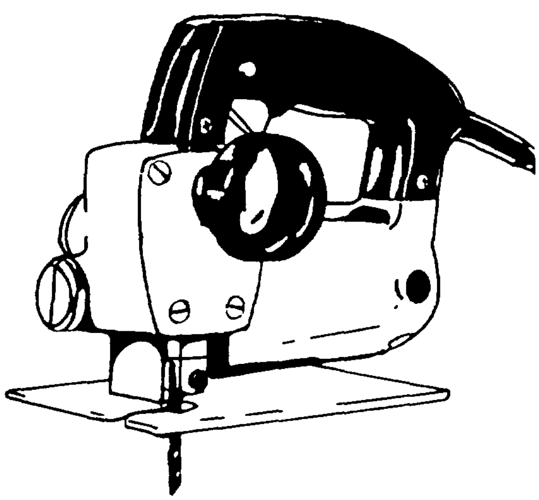


Figure 3-18.-Saber saw.

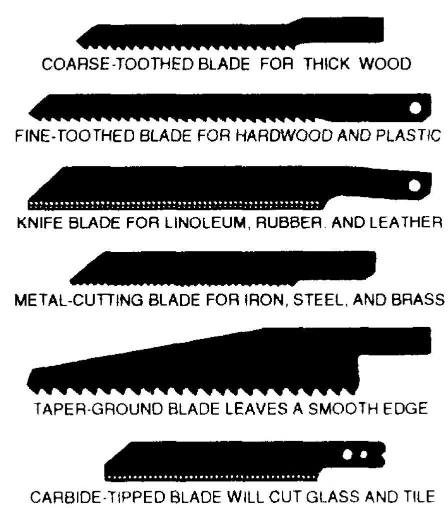


Figure 3-19.-Saber saw blades.

gripping the tool, which will be affected somewhat by the particular tool you are using. On some tools, for example, you will find guiding easier if you apply some downward pressure on the tool as you move it forward. If you don't use a firm grip, the tool will tend to vibrate excessively and roughen the cut. Do not force the cutting faster than the design of the blade allows or you will break the blade.

You can make a pocket cut with a saber saw just like you can with a circular saw, although you need to drill a starter hole to begin work. A saber saw can also make bevel-angle and curve cuts.

Observe the following safety precautions when operating the saber saw:

- Before working with the saber saw, be sure to remove your rings, watches, bracelets, and other jewelry.
- If you are wearing long sleeves, roll them up.
- Be sure the saber saw is properly grounded.
- Use the proper saw blade for the work to be done, and ensure the blade is securely locked in place.
- Be sure the material to be cut is free of any obstructions.
- Keep your full attention focused on the work being performed.
- Grip the handle of the saw firmly. Control the forward and turning movements with your free hand on the front guide.
- To start a cut, place the forward edge of the saw base on the edge of the material being worked, start the motor, and move the blade into the material.

Portable Reciprocating Saw

The portable reciprocating saw (saw-all) (figure 3-20) is a heavy-duty power tool that you can use for a variety of woodworking maintenance work, remodeling, and roughing-in jobs. You can use it to cut rectangular openings, curved openings, along straight or curved lines, and flush.

Blades for reciprocating saws are made in a great variety of sizes and shapes. They vary in length from 2 1/2 to 12 inches and are made of high-speed steel or carbon steel. They have cutting edges similar to those shown in figure 3-19.

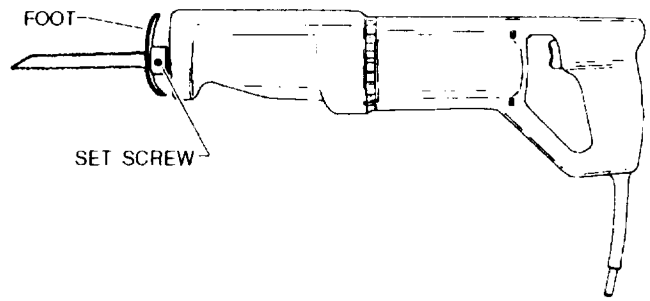


Figure 3-20.-Reciprocating saw.

Before operating this saw, be sure you are using a blade that is right for the job. The manufacturer's instruction manual shows the proper saw blade to use for a particular material. The blade must be pushed securely into the opening provided. Rock it slightly to ensure a correct fit, then tighten the setscrew.

To start a cut, place the saw blade near the material to be cut. Then, start the motor and move the blade into the material. Keep the cutting pressure constant, but do not overload the saw motor. Never reach underneath the material being cut.

Observe the following safety precautions when operating a reciprocating saw:

- Disconnect the saw when changing blades or making adjustments.

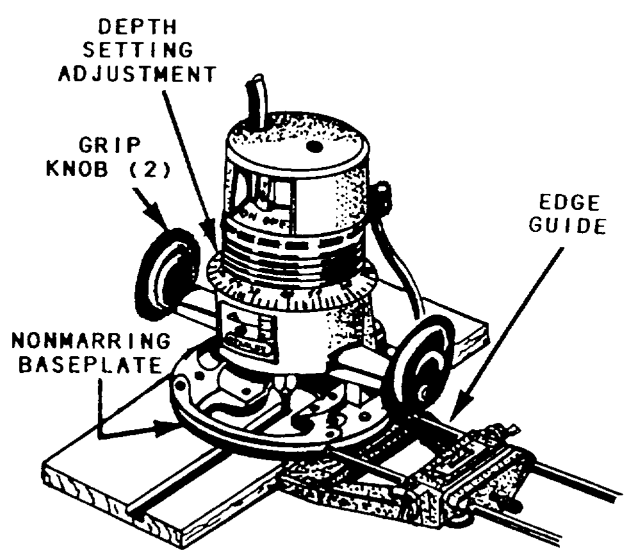


Figure 3-21.-Portable router with edge guide.

- Place the foot of the saw firmly on the stock before starting to cut.

- Don't cut curves shaper than the blade can handle.

- When cutting through a wall, make sure you don't cut electrical wires.

Router

The router is a versatile portable power tool that can be used free hand or with jigs and attachments. Figure 3-21 shows a router typical of most models. It consists of a motor containing a chuck into which the router bits are attached. The motor slides into the base in a vertical position. By means of the depth adjustment ring, easy regulation of the depth of a cut is possible. Routers vary in size from 1/4 to 2 1/2 horsepower, and the motor speed varies from 18,000 to 27,000 rpm.

One of the most practical accessories for the router is the edge guide. It is used to guide the router in a straight line along the edge of the board. The edge guide is particularly useful for cutting grooves on long pieces of lumber. The two rods on the edge guide slip into the two holes provided on the router base. The edge guide can be adjusted to move in or out along the two rods to obtain the desired lateral depth cut.

There are two classifications of router bits. Built-in, shank-type bits fit into the chuck of the router. Screw-type bits have a threaded hole through the center of the cutting head, which allows the cutting head to be screwed to the shank. Figure 3-22 shows a few of the most common router bits.

Observe the following safety precautions when operating a router:

- Before operating a router, be sure the work piece is well secured and free of obstruction.

- Make sure the router is disconnected from the power source before making any adjustment or changing bits.

- Don't overload the router when cutting the material.

- Use both hands to hold the router when cutting material.

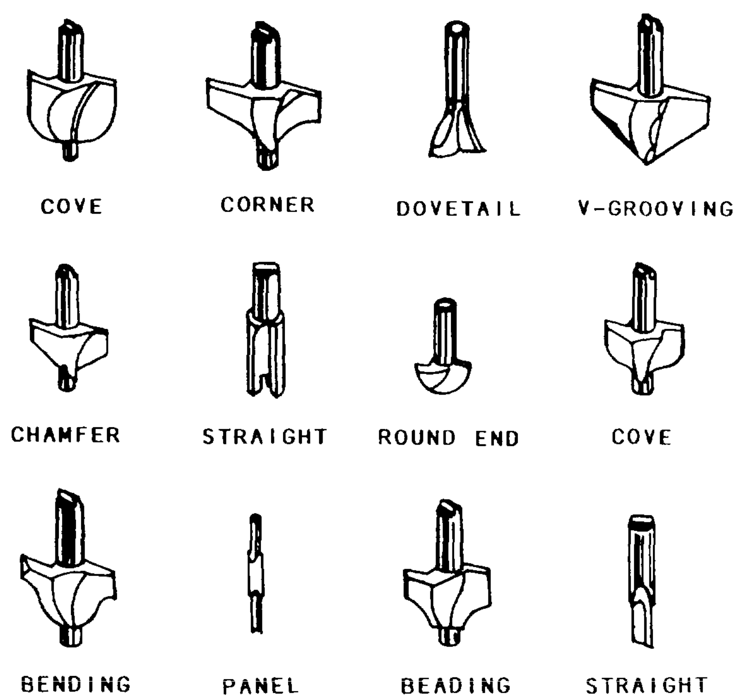


Figure 3-22.-Router bits.

Portable Power Plane

The portable electric power plane (figure 3-23) is widely used for trimming panels, doors, frames, and so forth. It is a precision tool capable of exact depth of cut up to 3/16 inch on some of the heavier models. However, the maximum safe depth of cut on any model is 3/32 inch in any one pass.

The power plane is essentially a high-speed motor that drives a cutter bar, containing either straight or spiral blades, at high speed.

Operating the power plane is simply a matter of setting the depth of cut and passing the plane over the work. First, make careful measurements of the piece, where it is to fit, and determine how much material has to be removed. Then, the stock being planed should be held in a vise, clamped to the edge of a bench, or otherwise firmly held. Check the smoothness and straightness of all the edges.

If a smoothing cut is desired, make that cut first and then recheck the dimensions. Make as many passes as necessary with the plane to reach the desired dimensions, checking frequently so as not to remove too much material. The greater the depth of the cut, the slower you must feed the tool into the work. Feed pressure should be enough to keep the tool cutting, but not so much as to slow it down excessively. Keep wood chips off the work because they can mar the surface of the stock as the tool passes over them. Keep your hands away from the butterhead or blades when a cut is finished.

The L-shaped base, or fence, of the plane should be pressed snugly against the work when planing, assuring that the edge will be cut square. For bevel cuts, loosen the setscrew on the base, set the base at the desired bevel, and then retighten the setscrew.

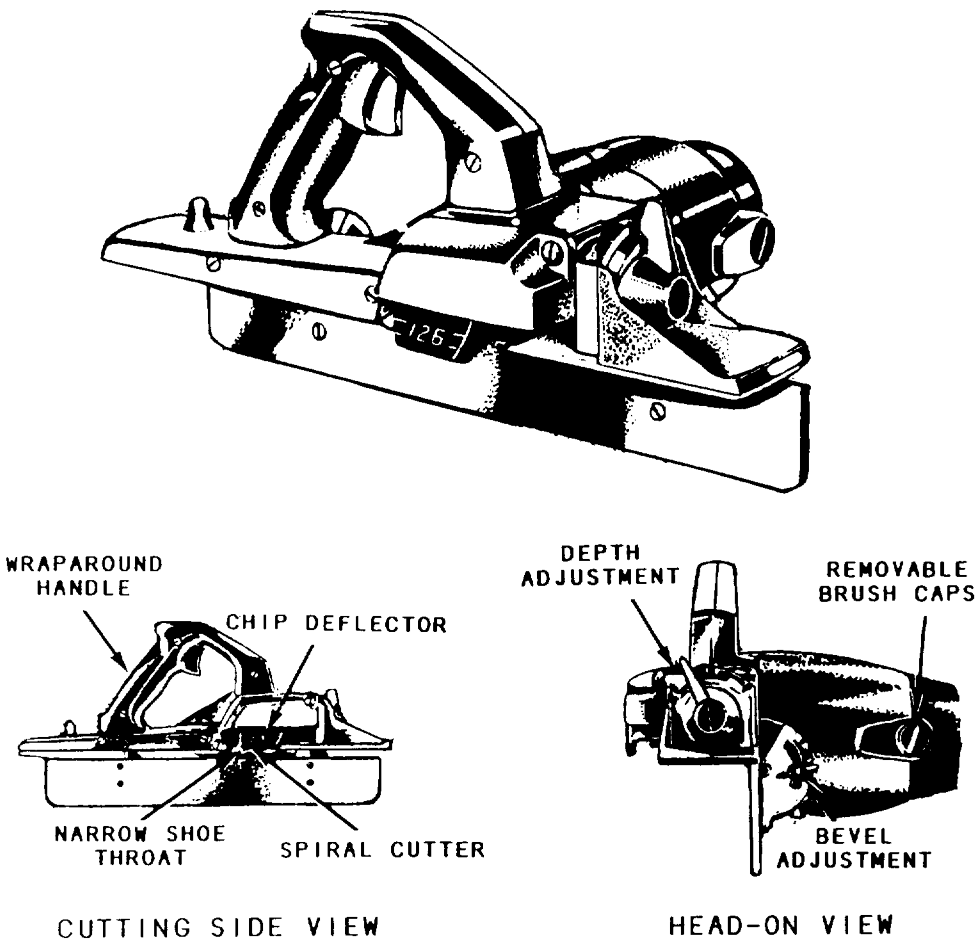


Figure 3-23.-Portable electric power plane.

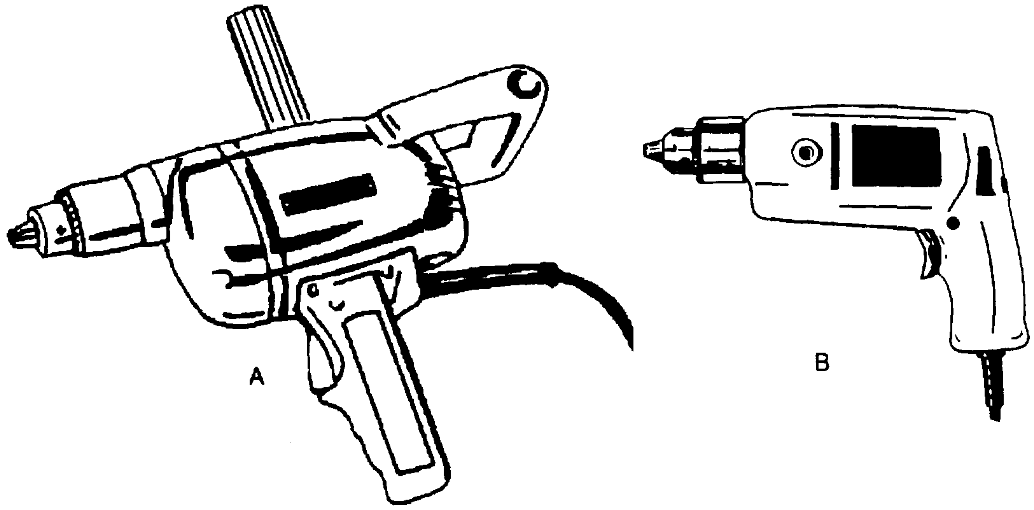


Figure 3-24.-Heavyduty 1/2-inch portable drill (view A) and light-duty 1/2-inch portable drill (view B).

Observe the following safety precautions when operating a portable power plane:

- Make sure that the plane is turned off before plugging it in.
- Make sure you disconnect the plug before making any adjustment.
- Don't attempt to power plane with one hand—you need two.
- Always clamp your work securely in the best position to perform the planing.
- When finished planing, make sure you disconnect the power cord.

Portable Power Drills

Portable power drills have generally replaced hand tools for drilling holes because they are faster and more accurate. With variable-speed controls and special clutch-drive chucks, they can also be used as electric screwdrivers. More specialized power-driven screwdrivers are also available; these have greatly increased the efficiency of many fastening operations in construction work.

The two basic designs for portable electric drills (figure 3-24) are the spade design for heavy-duty construction (view A) and the pistol-grip design for lighter work (view B). Sizes of power drills are based on the diameter of the largest drill shank that will fit into the chuck of the drill.

The right-angle drill is a specialty drill used in plumbing and electrical work. It allows you to drill holes at a right angle to the drill body.

Observe the following safety precautions when operating a portable drill:

- Make sure that the drill or bit is securely mounted in the chuck.
- Hold the drill firmly as prescribed by the manufacturer of the drill.
- When feeding the drill into the material, vary the pressure you apply to accommodate the different kinds of stock. Be careful not to bind the drill or bit.
- When drilling a deep hole, withdraw the drill several times to clean the drill bit.

Portable Sanders

There are three types of portable sanders: belt, disk, and finish sanders. When using a belt sander (figure 3-25), be careful not to gouge the wood. The size of a belt sander is usually identified by the width of its sanding belt. Belt widths on heavier duty

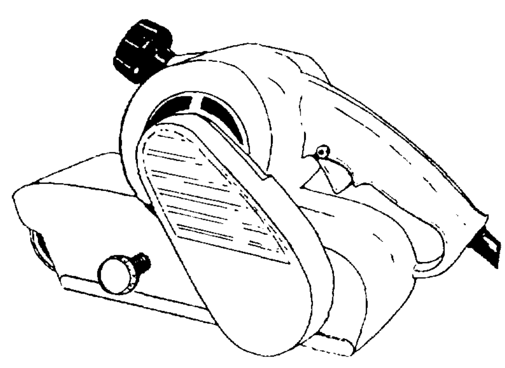


Figure 3-25.-Belt sander.

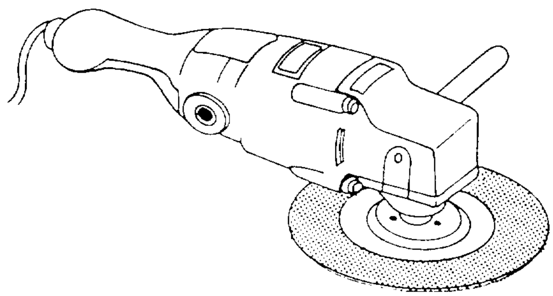


Figure 3-26.-Portable disk sander.

models are usually 3 or 4 inches. Depending on the make and model, belt lengths vary from 21 to 27 inches. Different grades of-abrasives are available.

The disk sander (figure 3-26) is a useful tool for removing old finish, paint, and varnish from siding, wood flooring, and concrete. For best results with a disk sander, tip the machine lightly with just enough pressure to bend the disk. Use a long, sweeping motion, back and forth, advancing along the surface. When using a disk sander, always operate it with both hands.

The finish sander (figure 3-27) is used for light and fine sanding. Two kinds of finish sanders are available. One operates with an orbital (circular) motion (view A), and the other has an oscillating (back and forth) movement (view B). Finish sanders use regular abrasive paper (sandpaper) cut to size from full sheets.

Observe the following safety tips when operating portable sanders:

- Make sure the sander is off before plugging it in.
- Make sure that you use two hands if using the belt sander.
- Don't press down on the sander. The weight of the sander is enough to sand the material.
- Make sure the sander is disconnected when changing sandpaper.
- Keep the electrical cord away from the area being sanded.

Power Nailers and Staplers

There is a wide variety of power nailers and staplers available. A typical example of each is shown in figure 3-28. A heavy-duty nailer is used for

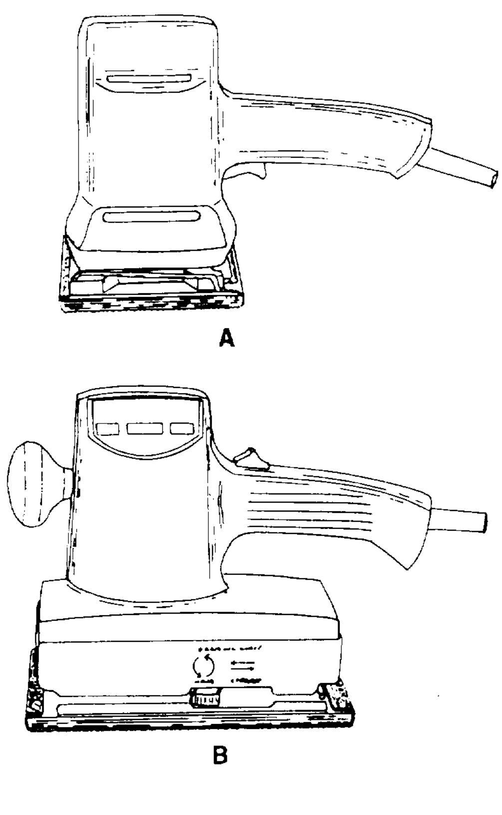


Figure 3-27.-Two types of finish sanders: orbital (view A) and oscillating (view B).

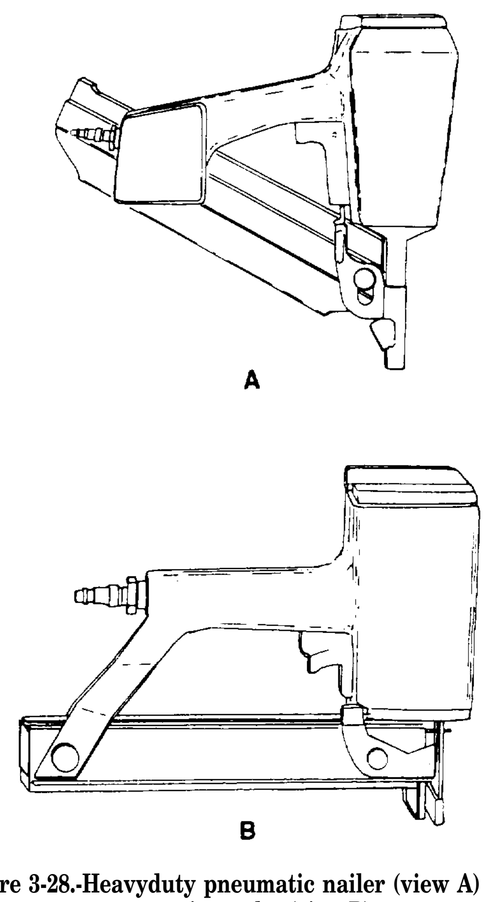


Figure 3-28.-Heavyduty pneumatic nailer (view A) and pneumatic stapler (view B).

framing or sheathing work; finish nailers are used for paneling or trimming. There is also a wide variety of staplers that you can use for jobs, such as fastening sheeting, decking, or roofing. These tools are often driven by compressed air. The amount of pneumatic, or air, pressure required to operate the tool depends on the size of the tool and the type of operation you are performing. Check the manufacturer's manual for the proper air pressure to operate the tool.

The power nailer and power stapler are great timesaving tools, but they are also **very dangerous** tools. Observe the following safety precautions when using them:

- Use the correct air pressure for the particular tool and job.
- Use the right nailer or stapler for the job and also the correct nails and staples.
- Keep the nose of the tool pointed away from your body.
- When you are not using a nailer or stapler or if you are loading one, **disconnect the air supply.**

MATERIALS

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the types, sources, uses, and characteristics of the common woods used on various construction projects.

Of all the different construction materials, wood is probably the most often used and perhaps the most important. The variety of uses of wood is practically unlimited. Few Seabee construction projects are accomplished without using some type of wood. It is used for permanent structures as well as concrete forms, scaffolding, shoring, and bracing, which may be used again and again. The types, sources, uses, and characteristics of common woods are given in table 3-1. The types of classifications of wood for a large project are usual] y designated in the project specifications and included in the project drawings.

Table 3-1.-Common Woods

TYPES	SOURCES	USES	CHARACTERISTICS
ASH	East of Rockies	Oars, boat thwarts, benches, gratings, hammer handles, cabinets, ball bats, wagon construction, farm implements	Strong, heavy, hard, tough, elastic, close straight grain, shrinks very little, takes excellent finish, lasts well
BEECH	East of Mississippi and southeastern Canada	Cabinetwork, imitation mahogany furniture, wood dowels, capping, boat trim, interior finish, tool handles, turnery, shoe lasts, carving, flooring	Similar to birch but not so durable when exposed to weather, shrinks and checks considerably, close grain, light or dark red color
BIRCH	East of Mississippi River and north of gulf coast states, southeast Canada, and Newfoundland	Cabinetwork, imitation mahogany furniture, wood dowels, capping, boat trim, interior finish, tool handles, turnery, carving	Hard, durable, fine grain, even texture, heavy, stiff, strong, tough, takes high polish, works easily, forms excellent base for white enamel finish, but not durable when exposed. Heartwood is light to dark reddish brown in color

TYPES	SOURCES	USES	CHARACTERISTICS
BUTTERNUT	Southern Canada, Minnesota, eastern U.S. as far south as Alabama and Florida	Toys, altars, woodenware, millwork, interior trim, furniture, boats, scientific instruments	Very much like walnut in color but softer, not so soft as white pine and basswood, easy to work, coarse grained, fairly strong
DOUGLAS FIR	Pacific coast and British Columbia	Deck planking on large ships, shores, strongbacks, plugs, filling pieces and bulkheads of small boats, building construction, dimension timber, plywood	Excellent structural lumber, strong, easy to work, clear straight grained, soft but brittle. Heartwood is durable in contact with ground, best structural timber of northwest
ELM	States east of Colorado	Agricultural implements, wheel-stock, boats, furniture, crossties, posts, poles	Slippery, heavy, hard, tough, durable, difficult to split, not resistant to decay
HICKORY	Arkansas, Tennessee, Ohio, and Kentucky	Tools, handles, wagon stock, hoops, baskets, vehicles, wagon spokes	Very heavy, hard, stronger and tougher than other native woods, but checks, shrinks, difficult to work, subject to decay and insect attack
MAPLE	All states east of Colorado and Southern Canada	Excellent furniture, high-grade floors, tool handles, ship construction, crossties, counter tops, bowling pins	Fine grained, grain often curly or "Birds's Eyes," heavy, tough, hard, strong, rather easy to work, but not durable. Heartwood is light brown, sap wood is nearly white
LIVE OAK	Southern Atlantic and gulf coasts of U. S., Oregon, and California	Implements, wagons, shipbuilding	Very heavy, hard, tough, strong, durable, difficult to work, light brown or yellow sap wood nearly white
MAHOGANY	Honduras, Mexico, Central America, Florida, West Indies, Central Africa, and other tropical sections	Furniture, boats, decks, fixtures, interior trim in expensive homes, musical instruments	Brown to red color, one of most useful of cabinet woods, hard, durable, does not split badly, open grained, takes beautiful finish when grain is filled but checks, swells, shrinks, warps slightly
NORWAY PINE	States bordering Great Lakes	Dimension timber, masts, spars, piling, interior trim	Light, fairly hard, strong, not durable in contact with ground

Table 3-1.-Common Woods–Continued

TYPES	SOURCES	USES	CHARACTERISTICS
PHILIPPINE MAHOGANY	Philippine Islands	Pleasure boats, medium-grade furniture, interior trim	Not a true mahogany, shrinks, expands, splits, warps, but available in long, wide, clear boards
POPLAR	Virginias, Tennessee, Kentucky, and Mississippi Valley	Low-grade furniture, cheaply constructed buildings, interior finish, shelving drawers, boxes	Soft, cheap, obtainable in wide boards, warps, shrinks, rots easily, light, brittle, weak, but works easily and holds nails well, fine-textured
RED CEDAR	East of Colorado and north of Florida	Mothproof chests, lining for linen closets, sills, and other uses similar to white cedar	Very light; soft, weak, brittle, low shrinkage, great durability, fragrant scent, generally knotty, beautiful when finished in natural color, easily worked
RED OAK	Virginias, Tennessee, Arkansas, Kentucky, Ohio, Missouri, Maryland	Interior finish, furniture, cabinets, millwork, crossties when preserved	Tends to warp, coarse grain, does not last well when exposed to weather, porous, easily impregnated with preservative, heavy, tough, strong
REDWOOD	California	General construction, tanks, paneling	Inferior to yellow pine and fir in strength, shrinks and splits little, extremely soft, light, straight grained, very durable, exceptional y resistant to decay
SPRUCE	New York, New England, West Virginia, central Canada, Great Lakes states, Idaho, Washington, Oregon	Railway ties, resonance wood, piles, airplanes, oars, masts, spars, baskets	Light, soft, low strength, fair durability, close grain, yellowish, sap wood indistinct
SUGAR PINE	California and Oregon	Same as white pine	Very light, soft, resembles white pine
TEAK	India, Burma, Thailand, and Java	Deck planking, shaft logs for small boats	Light brown color, strong, easily worked, durable, resistant to moisture damage

Table 3-1.-Common Woods–Continued

TYPES	SOURCES	USES	CHARACTERISTICS
WALNUT	Eastern half of U.S. except southern Atlantic and gulf coasts, some in New Mexico, Arizona, California	Expensive furniture, cabinets, interior woodwork, gun stocks, tool handles, airplane propellers, fine boats, musical instruments	Fine cabinet wood, coarse grained but takes beautiful finish when pores closed with wood filler, medium weight, hard, strong, easily worked, dark chocolate color, does not warp or check brittle
WHITE CEDAR	Eastern coast of U. S., and around Great Lakes	Boat planking, railroad ties, shingles, siding, posts, poles	Soft, lightweight, close grained, exceptionally durable when exposed to water, not strong enough for building construction, brittle, low shrinkage, fragment, generally knotty
WHITE OAK	The Virginias, Tennessee, Arkansas, Kentucky, Ohio, Missouri, Maryland, and Indiana	Boat and ship stems, stern-posts, knees, sheer strakes, fenders, capping, transoms, shaft logs, framing for buildings, strong furniture, tool handles, crossties, agricultural implements, fence posts	Heavy, hard, strong, medium coarse grain, tough, dense, most durable of hardwoods, elastic, rather easy to work, but shrinks and likely to check. Light brownish grey in color with reddish tinge, medullary rays are large and outstanding and present beautiful figures when quarter sawed, receives high polish
WHITE PINE	Minnesota, Wisconsin, Maine, Michigan, Idaho, Montana, Washington, Oregon, and California	Patterns, any interior job or exterior job that doesn't require maximum strength, window sash, interior trim, millwork, cabinets, cornices	Easy to work, fine grain, free of knots, takes excellent finish, durable when exposed to water, expands when wet, shrinks when dry, soft, white, nails without splitting, not very strong, straight grained
YELLOW PINE	Virginia to Texas	Most important lumber for heavy construction and exterior work, keelsons, risings, filling pieces, clamps, floors, bulkheads of small boats, shores, wedges, plugs, strongbacks, staging, joists, posts, piling, ties, paving blocks	Hard, strong, heartwood is durable in the ground, grain varies, heavy, tough, reddish brown in color, resinous, medullary rays well marked

LUMBER

The terms "wood" "lumber," and "timber" are often spoken of or written in ways to suggest that their meanings are alike or nearly so. But in the Builder's language, the terms have distinct, separate meanings. Wood is the hard, fibrous substance that forms the major part of the trunk and branches of a tree. Lumber is wood that has been cut and surfaced for use in construction work. Timber is lumber that is 5 inches or more in both thickness and width.

SEASONING OF LUMBER

Seasoning of lumber is the result of removing moisture from the small and large cells of wood—drying. The advantages of seasoning lumber are to reduce its weight; increase its strength and resistance to decay; and decrease shrinkage, which tends to avoid checking and warping after lumber is placed. A seldom used and rather slow method of seasoning lumber is air-drying in a shed or stacking in the open until dry. A faster method, known as kiln drying, has lumber placed in a large oven or kiln and dried with heat, supplied by gas- or oil-fired burners. Lumber is considered dry enough for most uses when its moisture content has been reduced to about 12 or 15 percent. As a Builder, you will learn to judge the dryness of lumber by its color, weight, smell, and feel. Also, after the lumber is cut, you will be able to judge the moisture content by looking at the shavings and chips.

DEFECTS AND BLEMISHES

A defect in lumber is any flaw that tends to affect the strength, durability, or utility value of the lumber. A blemish is a flaw that mars only the appearance of lumber. However, a blemish that affects the utility value of lumber is also considered to be a defect; for example, a tight knot that mars the appearance of lumber intended for fine cabinet work.

Various flaws apparent in lumber are listed in table 3-2.

Table 3-2.—Wood Defects and Blemishes

COMMON NAME	DESCRIPTION
Bark Pocket	Patch of bark over which the tree has grown, and has entirely or almost entirely enclosed
Check	Separation along the lengthwise grain, caused by too rapid or nonuniform drying
Cross Grain	Grain does not run parallel to or spiral around the lengthwise axis
Decay	Deterioration caused by various fungi
Knot	Root section of a branch that may appear on a surface in cross section or lengthwise. A cross-sectional knot maybe loose or tight. A lengthwise knot is called a spike knot
Pitch Pocket	Deposit of solid or liquid pitch enclosed in the wood
Shake	Separation along the lengthwise grain that exists before the tree is cut. A heart shake moves outward from the center of the tree and is caused by decay at the center of the trunk. A wind shake follows the circular lines of the annual rings; its cause is not definitely known
Wane	Flaw in an edge or corner of a board or timber. It is caused by the presence of bark or lack of wood in that part
Warp	Twist or curve caused by shrinkage that develops in a once flat or straight board
Blue Stain	A blemish caused by a mold fungus; it does not weaken the wood

CLASSIFICATION OF LUMBER

Trees are classified as either softwood or hardwood (table 3-3). Therefore, all lumber is referred to as either "softwood" or "hardwood." The terms "softwood" and "hardwood" can be confusing since some softwood lumber is harder than some hardwood lumber. Generally, however, hardwoods are more dense and harder than softwoods. In addition, lumber can be further classified by the name of the tree from which it comes. For example, Douglas fir lumber comes from a Douglas fir tree; walnut lumber comes from a walnut tree, and so forth.

The quality of softwood lumber is classified according to its intended use as being yard, structural, factory, or shop lumber. Yard lumber consists of those grades, sizes, and patterns generally intended for ordinary building purposes. Structural lumber is 2 or more inches in nominal thickness and width and is used where strength is required. Factory and shop lumber are used primarily for building cabinets and interior finish work.

Lumber manufacturing classifications consist of rough dressed (surfaced) and worked lumber. Rough lumber has not been dressed but has been sawed, edged, and trimmed. Dressed lumber is rough lumber that has been planed on one or more sides to attain smoothness and uniformity. Worked lumber, in addition to being dressed, has also been matched, shiplapped, or patterned. Matched lumber is tongue and groove, either sides or ends or both. Shiplapped lumber has been rabbeted on both edges to provide a close-lapped joint. Patterned lumber is designed to a pattern or molded form.

Softwood Grading

The grade of a piece of lumber is based on its strength, stiffness, and appearance. A high grade of lumber has very few knots or other blemishes. A low grade of lumber may have knotholes and many loose knots. The lowest grades are apt to have splits, checks, honeycombs, and some warpage. The grade of lumber to be used on any construction job is usually stated in the specifications for a set of blueprints. Basic classifications of softwood grading include boards, dimension, and timbers. The grades within these classifications are shown in table 3-4.

Lumber is graded for quality in accordance with American Lumber Standards set by the National Bureau of Standards for the U.S. Department of Commerce. The major quality grades, in descending order of quality, are select lumber and common

Table 3-3.-Different Types of Softwoods and Hardwoods

SOFTWOODS	HARDWOODS
Douglas fir Southern pine Western larch	Basswood Willow American elm
Hemlock White fir Spruce	Mahogany* Sweet gum White ash*
Ponderosa pine Western red cedar Redwood	Beech Birch Cherry
Cypress White pine Sugar pine	Maple Oak* Walnut*

*Open-grained wood

Table 3-4.-Softwood Lumber Grades

BOARDS

APPEARANCE GRADES	SELECTS	B & BETTER (IWP—SUPREME) C SELECT (IWP—CHOICE) D SELECT (IWP—QUALITY)	
APPEARANCE GRADES	FINISH	SUPERIOR PRIME E	
APPEARANCE GRADES	PANELING	CLEAR (ANY SELECT OR FINISH GRADE) NO. 2, 3 COMMON SELECTED FOR KNOTTY PANELING	
APPEARANCE GRADES	SIDING (BEVEL, BUNGALOW)	SUPERIOR PRIME	
			ALTERNATE BOARD GRADES
BOARDS SHEATHING		NO. 1 COMMON (IWP—COLONIAL) NO. 2 COMMON (IWP—STERLING) NO. 3 COMMON (IWP—STANDARD) NO. 4 COMMON (IWP—UTILITY)	SELECT MERCHANTABLE CONSTRUCTION STANDARD UTILITY

DIMENSION

LIGHT FRAMING 2 in. to 4 in. Thick 2 in. to 4 in. Wide	CONSTRUCTION STANDARD UTILITY ECONOMY	This category for use where high strength values are **NOT** required; such as studs, plates, sills, cripples, blocking, etc.
	STUD ECONOMY STUD	An optional all-purpose grade limited to 10 feet and shorter. Characteristics affecting strength and stiffness values are limited so that the Stud grade is suitable for all stud uses, including load bearing walls.
STRUCTURAL LIGHT FRAMING 2 in. to 4 in. Thick 2 in. to 4 in. Wide	SELECT STRUCTURAL NO. 1 NO. 2 NO. 3 ECONOMY	These grades are designed to fit those engineering applications where higher bending strength ratios are needed in light framing sizes. Typical uses would be for trusses, concrete pier wall forms, etc.
STRUCTURAL JOISTS & PLANKS 2 in. to 4 in. Thick 6 in. and Wider	SELECT STRUCTURAL NO. 1 NO. 2 NO. 3 ECONOMY	These grades are designed especially to fit in engineering applications for lumber 6 inches and wider, such as joists, rafters and general-framing uses.

TIMBERS

BEAMS & STRINGERS	SELECT STRUCTURAL NO. 1 NO. 2 (NO. 1 MINING) NO. 3 (NO. 2 MINING)	**POSTS & TIMBERS**	SELECT STRUCTURAL NO. 1 NO. 2 (NO. 1 MINING NO. 3 (NO. 2 MINING)

lumber. Table 3-5 lists the subdivisions for each grade in descending order of quality.

Hardwood Grades

Grades of hardwood lumber are established by the National Hardwood Lumber Association. FAS (firsts and seconds) is the best grade. It specifies that pieces be no less than 6-inches wide by 8-feet long and yield at least 83 1/3 percent clear cuttings. The next lower grade is selects, which permits pieces 4-inches wide by 6-feet long. A still lower grade is No. 1 common. Lumber in this group is expected to yield 6623 percent clear cuttings.

Lumber Sizes

Standard lumber sizes have been established in the United States for uniformity in planning structures and in ordering materials. Lumber is identified by nominal sizes. The nominal size of a piece of lumber is larger than the actual dressed dimensions. Referring to table 3-6, you can determine the common widths and thicknesses of lumber in their nominal and dressed dimensions.

Table 3-5.-Grades and Subdivisions of Lumber

SELECT LUMBER	
Grade A	This lumber is practically free of defects and blemishes
Grade B	This lumber contains a few minor blemishes
Grade C	This lumber contains more numerous and more significant blemishes than grade B. It must be capable of being easily and thoroughly concealed with paint
Grade D	This lumber contains more numerous and more significant blemishes than grade C, but it is still capable of presenting a satisfactory appearance when painted
COMMON LUMBER	
No. 1	Sound, tight-knotted stock containing only a few minor defects. Must be suitable for use as watertight lumber
No. 2	Contains a limited number of significant defects but no knotholes or other serious defects. Must be suitable for use as grain-tight lumber
No. 3	Contains a few defects that are larger and coarser than those in No. 2 common; for example, occasional knotholes
No. 4	Low-quality material containing serious defects like knotholes, checks, shakes, and decay
No. 5	Capable only of holding together under ordinary handling

Table 3-6.-Nominal and Dressed Sizes of Lumber

NOMINAL SIZE (INCHES)	DRESSED SIZE (INCHES)
1 × 3	3/4 × 2 1/2
1 × 4	3/4 × 3 1/2
1 × 6	3/4 × 5 1/2
1 × 8	3/4 × 7 1/4
1 × 10	3/4 × 9 1/4
1 × 12	3/4 × 11 1/4
2 × 4	1 1/2 × 3 1/2
2 × 6	1 1/2 × 5 1/2
2 × 8	1 1/2 × 7 1/4
2 × 10	1 1/2 × 9 1/4
2 × 12	1 1/2 × 11 1/4
3 × 8	2 1/2 × 7 1/4
3 × 12	2 1/2 × 11 1/4
4 × 12	3 1/2 × 11 1/4
4 × 16	3 1/2 × 15 1/4
6 × 12	5 1/2 × 11 1/2
6 × 16	5 1/2 × 15 1/2
6 × 18	5 1/2 × 17 1/2
8 × 16	7 1/2 × 15 1/2
8 × 20	7 1/2 × 19 1/2
8 × 24	7 1/2 × 23 1/2

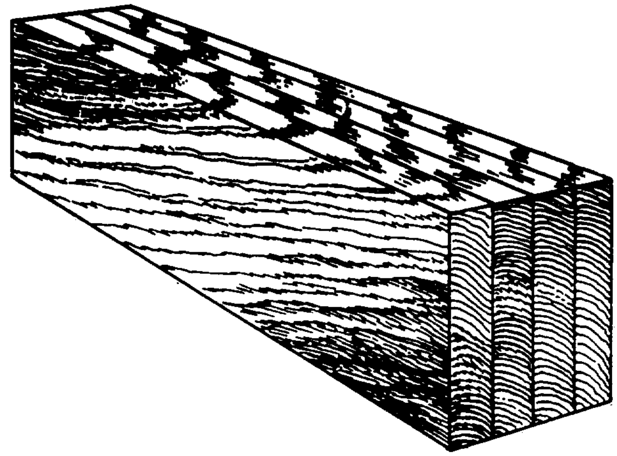


Figure 3-29.-Laminated lumber.

LAMINATED LUMBER

Laminated lumber (figure 3-29) is made of several pieces of lumber held together as a single unit, a process called lamination. Usually 1 1/2-inches thick, the pieces are nailed, bolted, or glued together with the grain of all pieces running parallel. Laminating greatly increases the load-carrying capacity and rigidity of the weed. When extra length is needed, the pieces are spliced—with the splices staggered so that no two adjacent laminations are spliced at the same point. Built-up beams and girders are examples. They are built as shown in figure 3-30, usually nailed or bolted together, and spliced.

Lamination can be used independently or with other materials in the construction of a structural unit. Trusses can be made with lamination for the chords and sawed

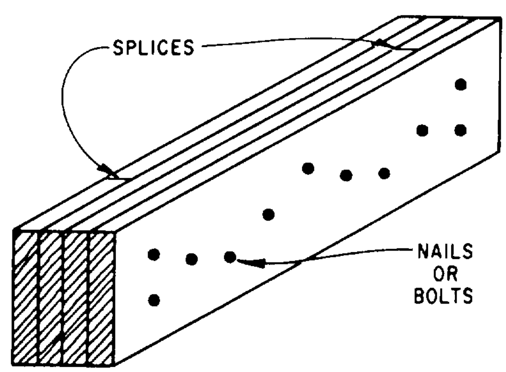


Figure 3-30.-Built-up beam.

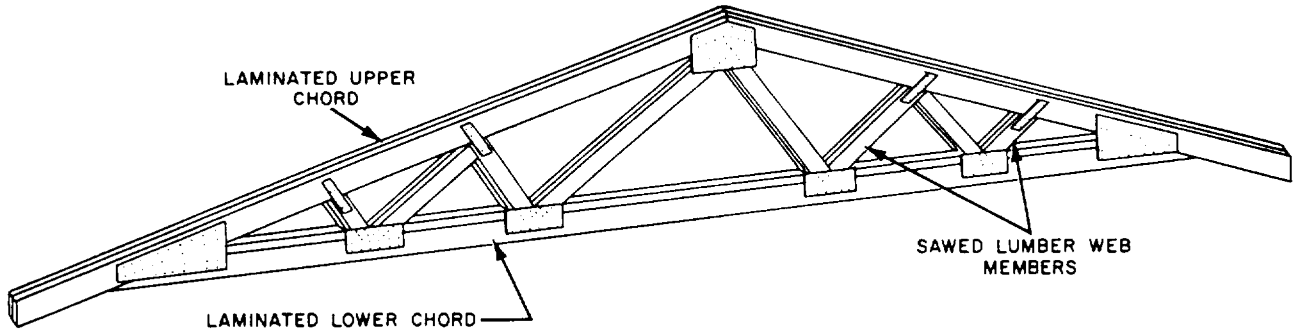


Figure 3-31.-Truss using laminated and sawed lumber.

lumber, or for the web members (figure 3-31). Special beams can be constructed with lamination for the flanges and plywood or sawed lumber, for the web, as shown in figure 3-32. Units, such as plywood box beams and stressed skin panels, can contain both plywood and lamination (figure 3-33).

Probably the greatest use of lamination is in the fabrication of large beams and arches. Beams with spans in excess of 100 feet and depths of 8 1/2 feet have been constructed using 2-inch boards. Laminations this large are factory produced. They are glued together under pressure. Most laminations are spliced using scarf joints (figure 3-34), and the entire piece is dressed to ensure uniform thickness and width. The depth of the lamination is placed in a horizontal position and is usually the full width of the beam (figure 3-35).

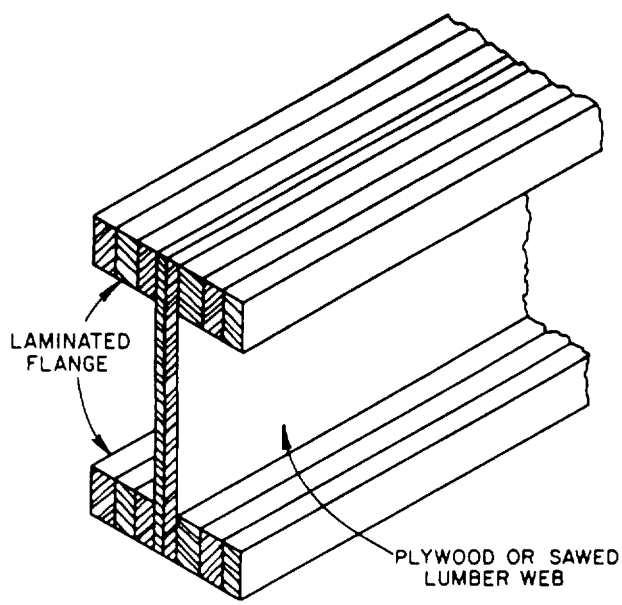


Figure 3-32.-Laminated and sawed lumber or plywood beam.

PLYWOOD

Plywood is constructed by gluing together a number of layers (plies) of wood with the grain direction turned at right angles in each successive layer. This design feature makes plywood highly resistant to splitting. It is one of the strongest building materials available to Seabees. An odd number (3, 5, 7) of plies is used so that they will be balanced on either side of a center core and so that the grain of the outside layers runs in the same direction. The outer plies are called faces or face and back. The next layers under these are called crossbands, and the other inside layer or layers are called the core (figure 3-36). A plywood panel made of three layers would consist of two faces and a core.

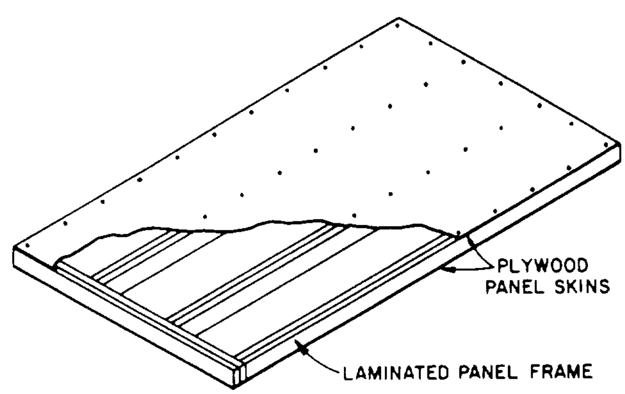


Figure 3-33.-Stressed skin panel.

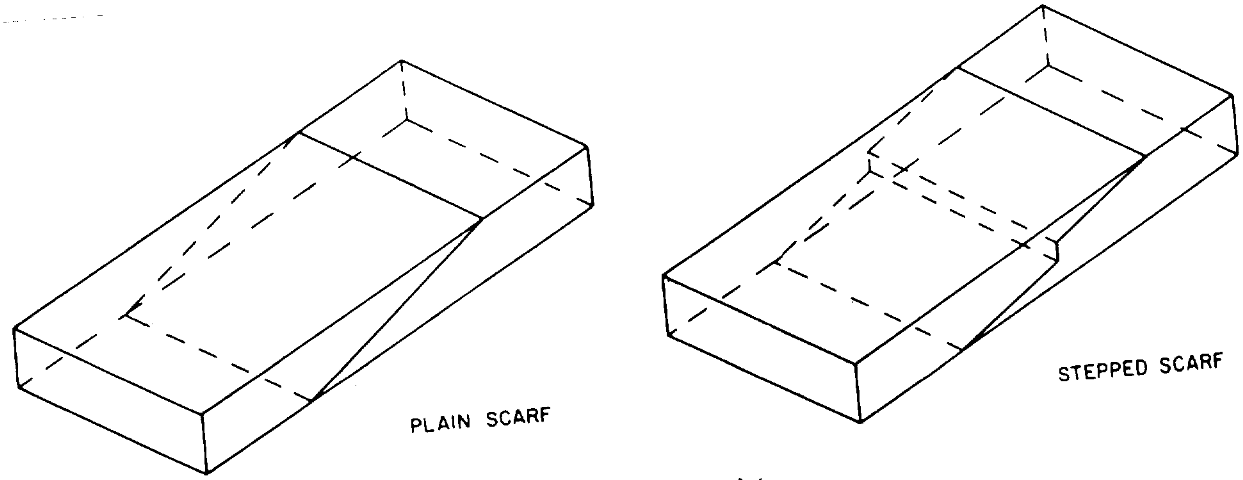


Figure 3-34.-Scarf joints.

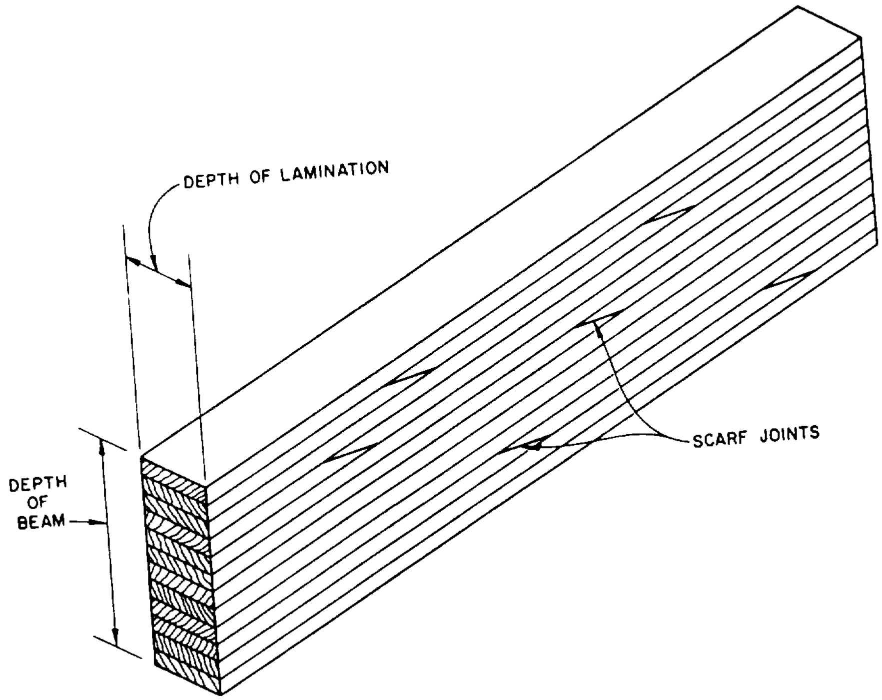


Figure 3-35.-Laminated beam.

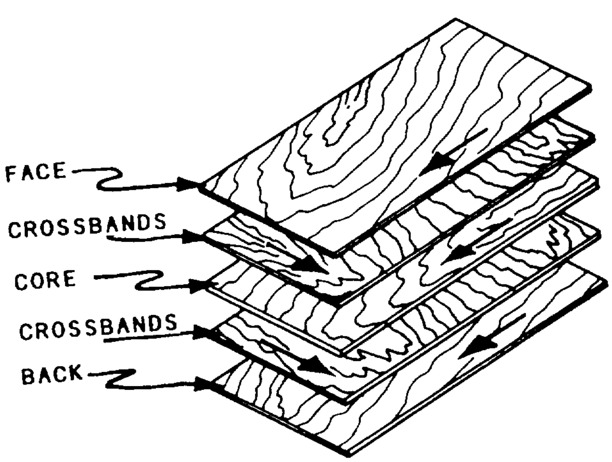


Figure 3-36.-Grain direction in a sheet of plywood.

There are two basic types of plywood: exterior and interior. Exterior plywood is bonded with waterproof glues. It can be used for siding, concrete forms, and other constructions where it will be exposed to the weather or excessive moisture. Interior plywood is bonded with glues that are not waterproof. It is used for cabinets and other inside construction where the moisture content of the panels will not exceed 20 percent.

Plywood is made in thicknesses of 1/8 inch to more than 1 inch, with the common sizes being 1/4, 3/8, 1/2, 5/8, and 3/4 inch. A standard panel size is 4-feet wide by 8-feet long. Smaller size panels are available in the hardwoods.

Table 3-7.-Plywood Veneer Grades

	DESCRIPTION
N	Special order "natural-finish" veneer. Select all heartwood or all sapwood. Free of open defects. Allows some repairs
A	Smooth and paintable. Neatly made repairs permissible. Also used for natural finish in less demanding applications
B	Solid surface veneer. Circular repair plugs and tight knots permitted
C	Knotholes to 1 inch. Occasional knotholes 1/2 inch larger permitted providing total width of all knots and knotholes within a specified section does not exceed certain limits. Limited splits permitted. Minimum veneer permitted in exterior-type plywood
C Plgd	Improved C veneer with splits limited to 1/8 inch in width and knotholes and borer holes limited to 1/4 inch by 1/2 inch
D	Permits knots and knotholes to 2 1/2 inches in width and 1/2 inch larger under certain specified limits. Limited splits permitted

Table 3-8.-Classification of Softwood Plywood Rates Species for Strength and Stiffness

GROUP 1	GROUP 2		GROUP 3	GROUP 4	GROUP 5
Apitong	Cedar,	Maple,	Alder,	Aspen,	Basswood
Beech,	Port	Black	Port	Bigtooth	Fir,
American	Orford	Mengkulang	Birch,	Quaking	Balsam
Birch,	Cypress	Meranti,	Paper	Cativo	Poplar,
Sweet	Douglas fir	Red	Cedar,	Cedar,	Balsam
Yellow	Fir,	Mersawa	Alaska	Incense	
Douglas fir	California	Pine,	Fir,	Western	
Kapur	Red	Pond	Subalpine	Red	
Keruing	Grand	Red	Hemlock,	Cottonwood,	
Larch,	Noble	Virginia	Eastern	Eastern	
Western	Pacific	Western	Maple,	Black	
Maple,	Silver	White	Bigleaf	Western popular	
Sugar	Hemcock,	Sruce,	Pine,	Pine,	
Pine,	White	Red	Jack	Eastern	
Caribbean	Western	Sitka	Lodgepole	White	
Ocote	Lauan,	Sweetgum	Ponderosa	Sugar	
Pine,	Almon	Tamarack	Spruce		
South	Bagtikan	Yellow poplar	Redwood		
Loblolly	Mayapis		Spruce,		
Longleaf	Red lauan		Black		
Shortleaf	Tangile		Engelmann		
Slash	White lauan		White		

Plywood can be worked quickly and easily with common carpentry tools. It holds nails well and normally does not split when nails are driven close to the edges. Finishing plywood presents no unusual problems; it can be sanded or texture coated with a permanent finish or left to weather naturally.

There is probably no other building material as versatile as plywood. It is used for concrete forms, wall and roof sheathing, flooring, box beams, soffits, stressed-skin panels, paneling, shelving, doors, furniture, cabinets, crates, signs, and many other items.

Softwood Plywood Grades

All plywood panels are quality graded based on products standards (currently PS 1/74). The grade of each type of plywood is determined by the kind of veneer (N, A, B, C, or D) used for the face and back of the panel and by the type of glue used in construction. The plywood veneer grades are shown in table 3-7.

Many species of softwood are used in making plywood. There are five separate plywood groups based on stiffness and strength. Group 1 includes the stiffest and strongest; group 5 includes the weakest woods. A listing of groupings and associated woods is shown in table 3-8.

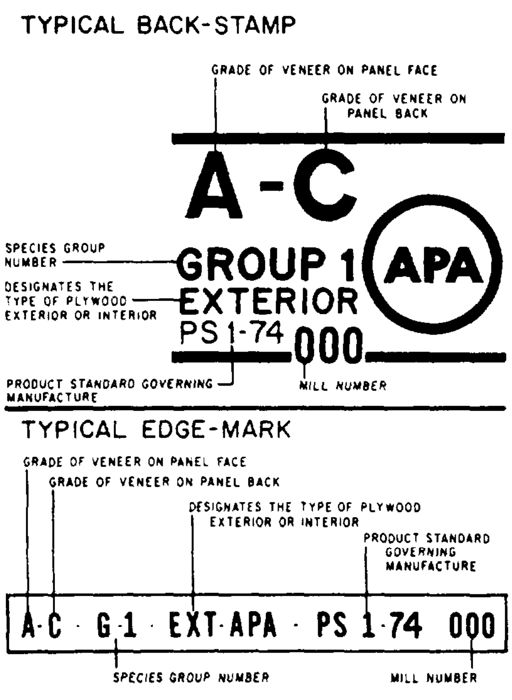


Figure 3-37.-Standard plywood identification symbols.

GRADE/TRADEMARK STAMP.— Construction and industrial plywood panels are marked with different stamps.

Construction Panels.— Grading identification stamps (such as those shown in figure 3-37) indicate the kind and type of plywood. The stamps are placed on the back and sometimes on the edges of each sheet of plywood.

For example, a sheet of plywood having the designation "A-C" would have A-grade veneer on the face and C-grade veneer on the back. Grading is also based on the number of defects, such as knotholes, pitch pockets, splits, discolorations, and patches in the face of each panel. Each panel or sheet of plywood has a stamp on the back that gives all the information you need. Table 3-9 lists some uses for construction-grade plywood.

Industrial Panels.— Structural and sheeting panels have a stamp found on the back. A typical example for an industrial panel grade of plywood is shown in figure 3-38.

The span rating shows a pair of numbers separated by a slash mark (/). The number on the left indicates the maximum recommended span in inches when the plywood is used as roof decking (sheeting). The right-hand number applies to span when the plywood is used as subflooring. The rating applies only when the sheet is placed the long dimension across three or more supports. Generally, the larger the span rating, the greater the stiffness of the panel.

Figure 3-39 lists some typical engineered grades of plywood. Included are descriptions and most common uses.

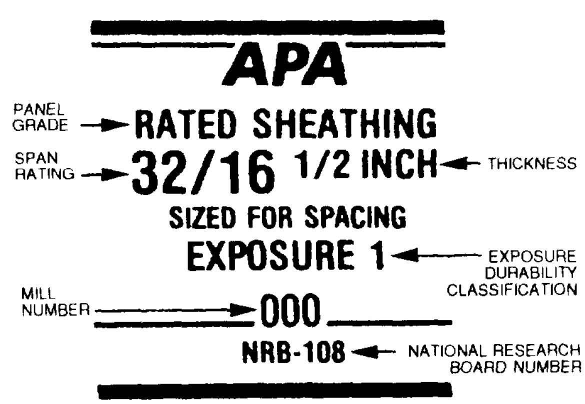


Figure 3-38.-Structural stamp.

Table 3-9.-Plywood Uses

SOFTWOOD PLYWOOD GRADES FOR EXTERIOR USES				
Grade (Exterior)	**Face**	**Back**	**Inner Plies**	**Uses**
A-A	A	A	C	Outdoor where appearance of both sides is important
A-B	A	B	C	Alternate for A-A where appearance of one side is less important
A-C	A	C	C	Siding, soffits, fences. Face is finish grade
B-C	B	C	C	For utility uses, such as farm buildings, some kinds of fences, etc.
C-C (Plugged)	C (Plugged)	C	C	Excellent base for tile and linoleum, backing for wall coverings
C-C	C	C	C	Unsanded, for backing and rough construction exposed to weather
B-B Concrete Forms	B	B	C	Concrete forms. Reuse until wood literally wears out
MDO	B	B or C	C or C-Plugged	Medium density overlay. Ideal base for paint; for siding, built-ins, signs, displays
HDO	A or B	A or B	C-Plugged	High density overlay. Hard surface; no paint needed. For concrete forms, cabinets, counter tops, tanks

SOFTWOOD PLYWOOD GRADES FOR INTERIOR USES				
Grade (Interior)	**Face**	**Back**	**Inner Plies**	**Uses**
A-A	A	A	D	Cabinet doors, built-ins, furniture where both sides will show
A-B	A	B	D	Alternate of A-A. Face is finish grade, back is solid and smooth
A-D	A	D	D	Finish grade face for paneling, built-ins, backing
B-D	B	D	D	Utility grade. One paintable side. For backing, cabinet sides, etc
Standard	C	D	D	Sheathing and structural uses such as temporary enclosures, subfloor. Unsanded

Typical Trademarks	Description and Common Uses	Grade Designation	
APA RATED SHEATHING 48/24 3/4 INCH SIZED FOR SPACING EXTERIOR 000 NRB-108	Exterior sheathing panel for subflooring and wall and roof sheathing, siding on service and farm buildings, crating, pallets, pallet bins, cable reels, etc. Manufactured as conventional veneered plywood. Common thicknesses: 5/16, 3/8, 1/2, 5/8, 3/4.	**APA RATED SHEATHING EXT**	**EXTERIOR USE**
APA RATED SHEATHING STRUCTURAL I 42/20 5/8 INCH SIZED FOR SPACING EXTERIOR 000 PS 1-74 C-C NRB-108	For engineered applications in construction and industry where resistance to permanent exposure to weather or moisture is required. Manufactured only as conventional veneered PS 1 plywood. Unsanded. STRUCTURAL I more commonly available. Common thicknesses: 5/16, 3/8, 1/2, 5/8, 3/4. (3)	**APA STRUCTURAL I & II RATED SHEATHING EXT**	**EXTERIOR USE**
APA RATED STURD-I-FLOOR 20 oc 19/32 INCH SIZED FOR SPACING EXTERIOR 000 NRB-108	For combination subfloor-underlayment under resilient floor coverings where severe moisture conditions may be present, as in balcony decks. Possesses high concentrated and impact load resistance. Manufactured only as conventional veneered plywood. Available square edge or tongue-and-groove. Common thicknesses: 5/8 (19/32), 3/4 (23/32).	**APA RATED STURD-I-FLOOR EXT**	**EXTERIOR USE**
APA RATED SHEATHING 32/16 1/2 INCH SIZED FOR SPACING EXPOSURE 1 000 NRB-108	Specially designed for subflooring and wall and roof sheathing, but can also be used for a broad range of other construction and industrial applications. Can be manufactured as conventional veneered plywood, as a composite, or as a nonveneered panel. For special engineered applications, including high load requirements and certain industrial uses, veneered panels conforming to PS 1 may be required. Specify Exposure 1 when long construction delays are anticipated. Common thicknesses: 5/16, 3/8, 7/16, 1/2, 5/8, 3/4.	**APA RATED SHEATHING EXP 1 or 2**	**PROTECTED OR INTERIOR USE**
APA RATED SHEATHING STRUCTURAL I 24/0 3/8 INCH SIZED FOR SPACING EXPOSURE 1 000 PS 1-74 C-D INT/EXT GLUE NRB-108	Unsanded all-veneer PS 1 plywood grades for use where strength properties are of maximum importance: structural diaphragms, box beams, gusset plates, stressed-skin panels, containers, pallet bins. Made only with exterior glue (Exposure 1). STRUCTURAL I more commonly available. Common thicknesses: 5/16, 3/8, 1/2, 5/8, 3/4. (3)	**APA STRUCTURAL I & II RATED SHEATHING EXP 1**	**PROTECTED OR INTERIOR USE**
APA RATED STURD-I-FLOOR 24 oc 23/32 INCH SIZED FOR SPACING T&G NET WIDTH 47-1/2 EXPOSURE 1 000 NRB-108	For combination subfloor-underlayment. Provides smooth surface for application of resilient floor covering and possesses high concentrated and impact load resistance. Can be manufactured as conventional veneered plywood, as a composite, or as a nonveneered panel. Available square edge or tongue-and-groove. Specify Exposure 1 when long construction delays are anticipated. Common thicknesses: 5/8 (19/32), 3/4 (23/32).	**APA RATED STURD-I-FLOOR EXP 1 or 2**	**PROTECTED OR INTERIOR USE**
APA RATED STURD-I-FLOOR 48 oc 1-1/8 INCH (2-4-1) SIZED FOR SPACING EXPOSURE 1 T&G 000 INT/EXT GLUE NRB-108 FHA-UM-66	For combination subfloor-underlayment on 32- and 48-inch spans and for heavy timber roof construction. Provides smooth surface for application of resilient floor coverings and possesses high concentrated and impact load resistance. Manufactured only as conventional veneered plywood and only with exterior glue (Exposure 1). Available square edge or tongue-and-groove. Thickness: 1-1/8.	**APA RATED STURD-I-FLOOR 48 oc (2-4-1) EXP 1**	**PROTECTED OR INTERIOR USE**

(1) Specific grades, thicknesses, constructions and exposure durability classifications may be in limited supply in some areas. Check with your supplier before specifying.

(2) Specify Performance-Rated Panels by thickness and Span Rating.

(3) All plies in STRUCTURAL I panels are special improved grades and limited to Group 1 species. All plies in STRUCTURAL II panels are special improved grades and limited to Group 1, 2, or 3 species.

Figure 3-39.-List of engineered grade of softwood plywood.

Exposure Ratings.— The grade/trademark stamp lists the exposure durability classification for plywood. There are two basic types or ratings: exterior and interim. The exterior type has a 100-percent waterproof glue line, and the interior type has a highly moisture-resistant glue line. However, panels can be manufactured in three exposure durability classifications: Exterior, Exposure 1, and Exposure 2.

Panels marked "Exterior" can be used where there is continual exposure to weather and moisture. Panels marked "Exposure 1" can withstand moisture during extended periods, but they should be used only indoors. Panels marked "Exposure 2" can be used in protected locations. They may be subjected to some water leakage or high humidity but generally should be protected from weather.

Most plywood is made with waterproof exterior glue. However, interior panels may be made with intermediate or interior glue.

Hardwood Plywood Grades

Hardwood plywood panels are primarily used for door skins, cabinets, and wall paneling. The Hardwood Plywood Manufacturers' Association has established a grading system with the following grades: premium (A), good grade (1), sound grade (2), utility grade (3), and backing grade (4). For example, an A-3 grade hardwood plywood would have a premium face and a utility back. A 1-1 grade would have a good face and a good back.

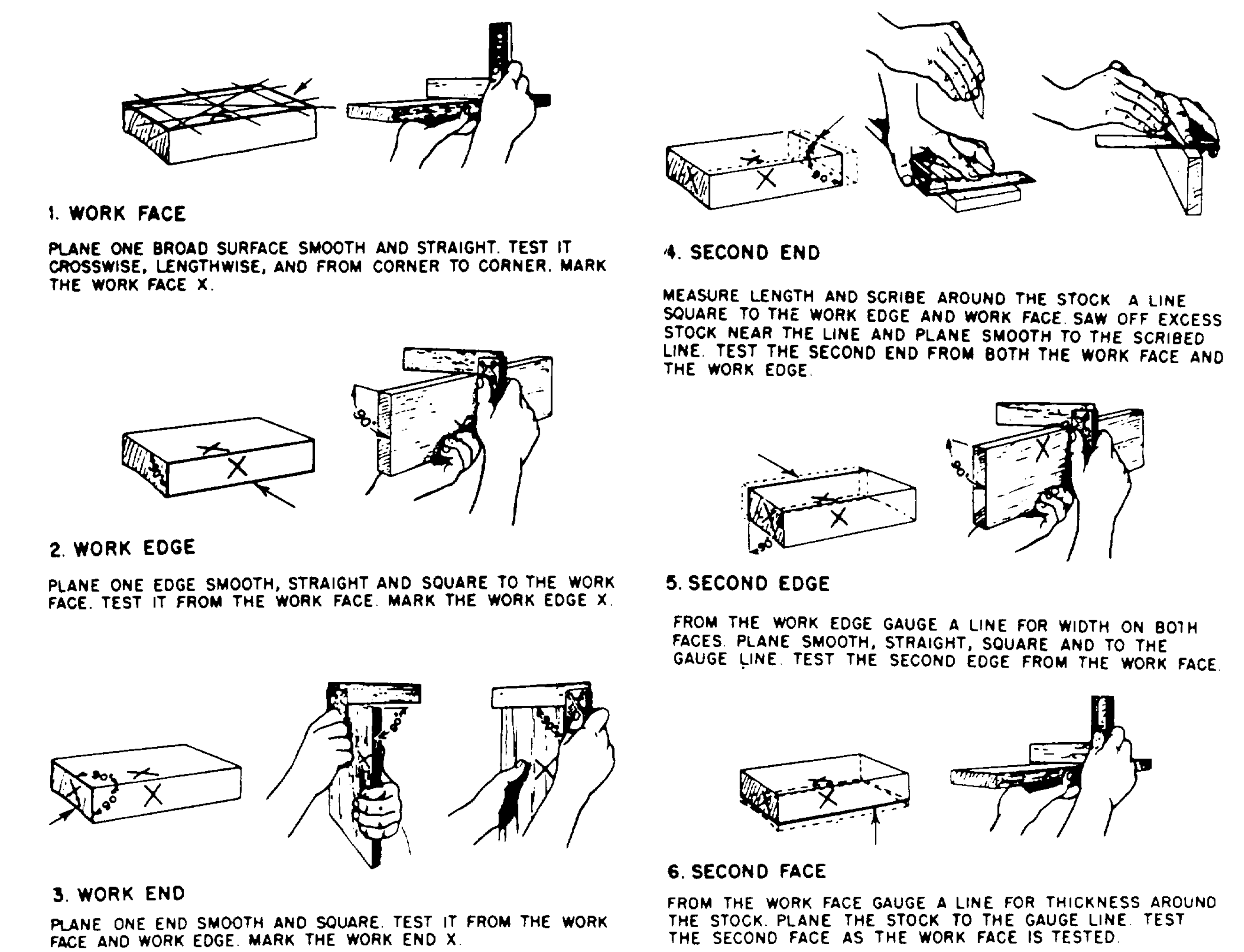


Figure 3-40.-Planing and squaring to dimensions.

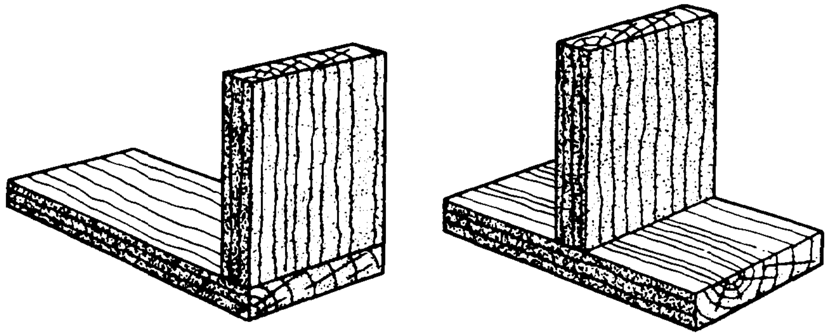


Figure 3-41.-90° plain butt Joints.

WOODWORKING METHODS

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the various methods and joints associated with woodworking.

In the following section, we will cover some of the methods used by Builders in joining wood.

PLANING AND SQUARING TO DIMENSIONS

Planing and squaring a small piece of board to dimensions is what you might call the first lesson in woodworking. Like many other things you may have tried to do, it looks easy until you try it. The six major steps in this process are illustrated and described in figure 3-40. You should practice these steps until you can get a smooth, square board with a minimum of planing.

JOINTS AND JOINING

One basic skill of woodworking is the art of joining pieces of wood to form tight, strong, well-made joints. The two pieces that are to be joined together are called members. The two major steps in making joints are (1) laying out the joint on the ends, edges, or faces and (2) cutting the members to the required shapes for joining.

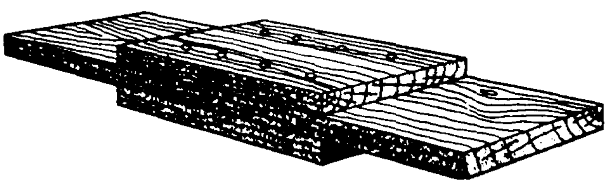


Figure 3-42.-End butt joints with fishplates.

The instruments normally used for laying out joints are the try square, miter square, combination square, the sliding T-bevel, the marking or mortising gauge, a scratch awl, and a sharp pencil or knife for scoring lines. For cutting the more complex joints by hand, the hacksaw dovetail saw and various chisels are essential. The rabbet-and-fillister plane (for rabbet joints) and the router plane (for smoothing the bottoms of dadoes and gains) are also helpful.

Simple joints, like the butt (figures 3-41 and 3-42), the lap (figure 3-43), and the miter joints

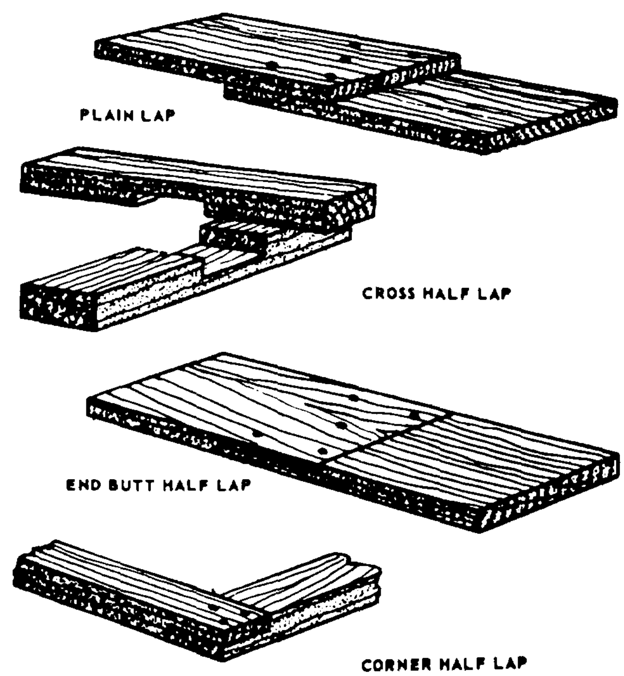


Figure 3-43.-Lap Joints.

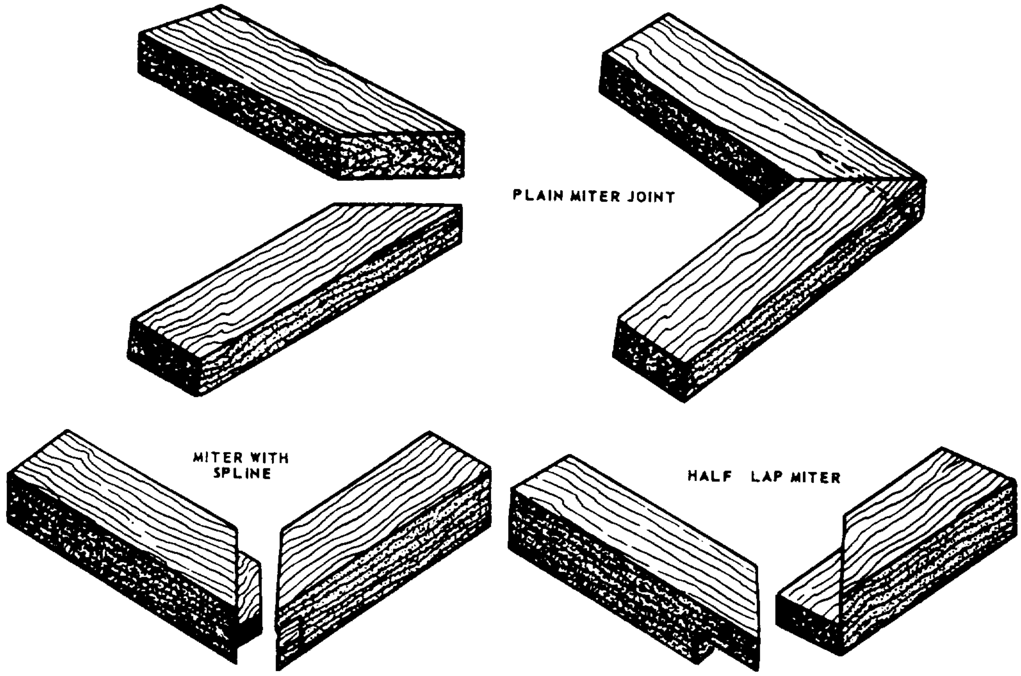


Figure 3-44.-Miter joints.

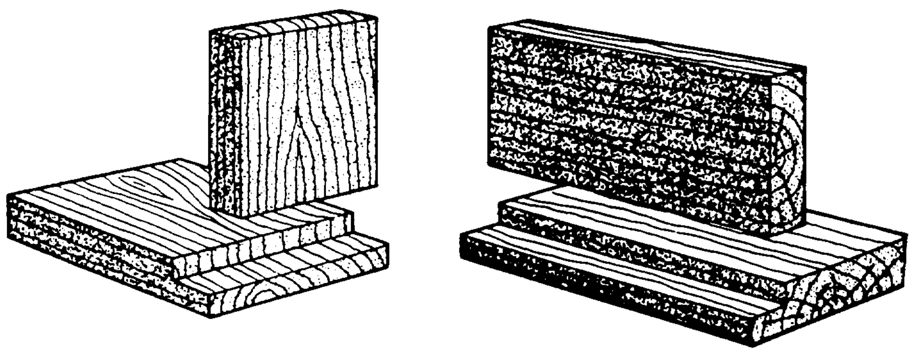


Figure 3-45.-Rabbet joints.

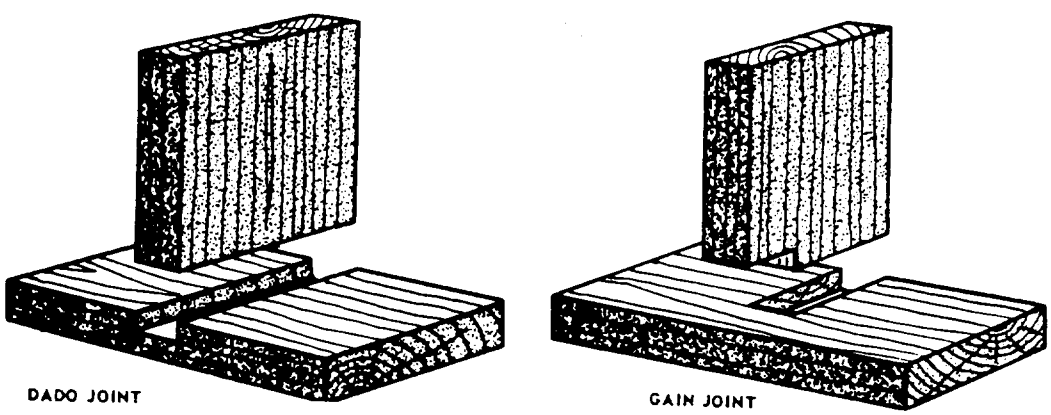


Figure 3-46.-Dado and gain joints.

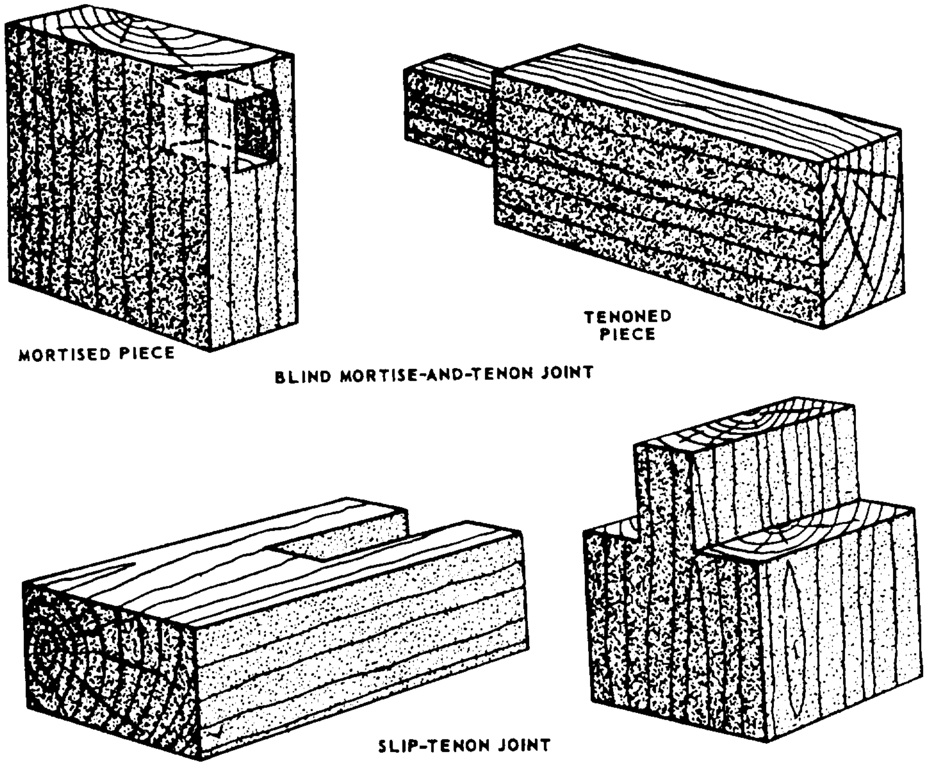


Figure 3-47.-Tenon joints.

(figure 3-44), are used mostly in rough or finish carpentry though they may be used occasionally in millwork and furniture making. More complex joints, like the rabbet joints (figure 3-45), the dado and gain joints (figure 3-46), the blind mortise-and-tenon and slip-tenon joints (figure 3-47), the box corner joint (figure 3-48), and the dovetail joints (figure 3-49), are used mostly in making furniture and cabinets and in

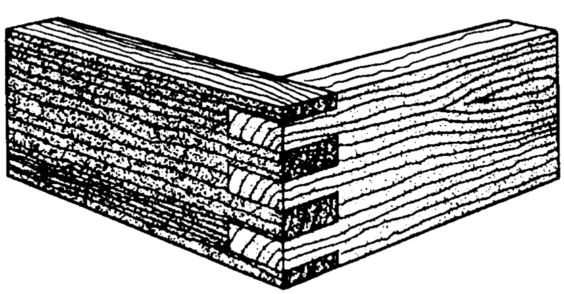


Figure 3-48.-BOX corner joint.

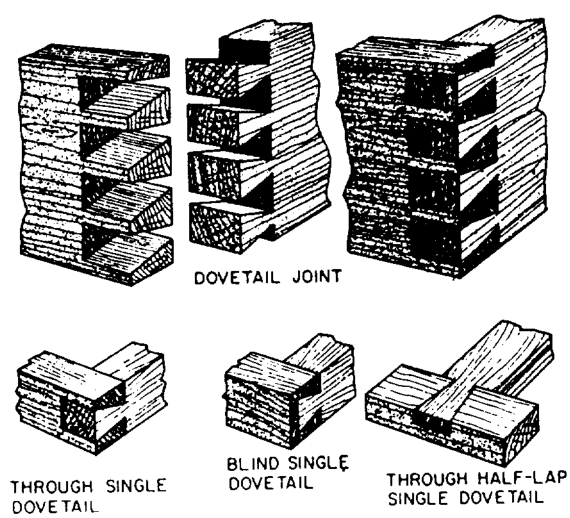


Figure 3-49.-Dovetail joints.

millwork. Of the edge joints shown in figure 3-50, the dowel and spline joints are used mainly in furniture and cabinet work, whereas the plain butt and the tongue-and-groove joints are used in practically all types of woodworking.

The joints used in rough and finished carpentry are, for the most part, simply nailed together. Nails in a 90° plain butt joint can be driven through the member abutted against and into the end of the abutting member. The joints can also be toenailed at an angle through the faces of the abutting member into the face of the member abutted against, as shown in figure 3-51. Studs and joists are usually toenailed to soleplates and sills.

The more complex furniture and cabinet-making joints are usually fastened with glue. Additional strength can be provided by dowels, splines, corrugated fasteners, keys, and other types of joint fasteners. In the dado joint, the gain joint, the mortise-and-tenon joint, the box corner joint, and the dovetail joint, the interlocking character of the joint is an additional factor in fastening.

All the joints we have been mentioned can be cut either by hand or by machine. Whatever the method used and whatever the type of joint, remember: To ensure a tight joint, always cut on the waste side of the line; never on the line itself. Preliminary grooving on the waste side of the line with a knife or chisel will help a backsaw start smoothly.

Half-Lap Joints

For half-lap joints, the members to be jointed are usually of the same thickness, as shown in figure 3-43. The method of laying out and cutting an end butt half lap (figure 3-43) is to measure off the desired amount of lap from each end of each member and square a line all the way around at this point. For a corner half lap (figure 3-43), measure off the width of the member from the end of each member and square a line all the way around. These lines are called shoulder lines.

Next, select the best surface for the face and set a marking gauge to one-half the thickness and score a line (called the cheek line) on the edges and end of each member from the shoulder line on one edge to the shoulder line on the other edge. Be sure to gauge the cheek line from the face of each member. This ensures that the faces of each member will be flush after the joints are cut.

Next, make the shoulder cuts by cutting along the waste side of the shoulder lines down to the waste side of the cheek line. Then, make the cheek cuts along the waste side of the cheek lines. When all cuts have been made, the members should fit together with faces, ends, and edges flush or near enough to be made flush with the slight paring of a wood chisel.

Other half-lap joints are laid out in a similar manner. The main difference is in the method of cutting. A cross half-lap joint may best be cut with a dado head or wood chisel rather than a handsaw. Others may easily be cut on a bandsaw, being certain

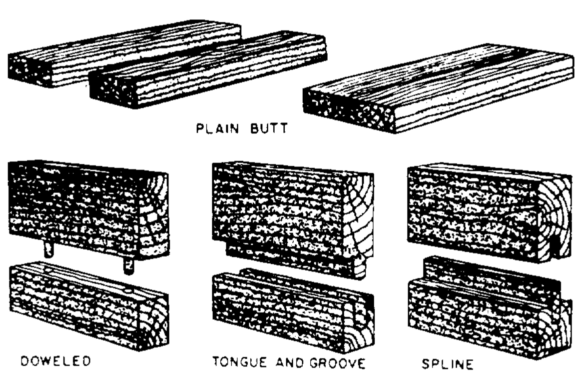


Figure 3-50.-Edge Joints.

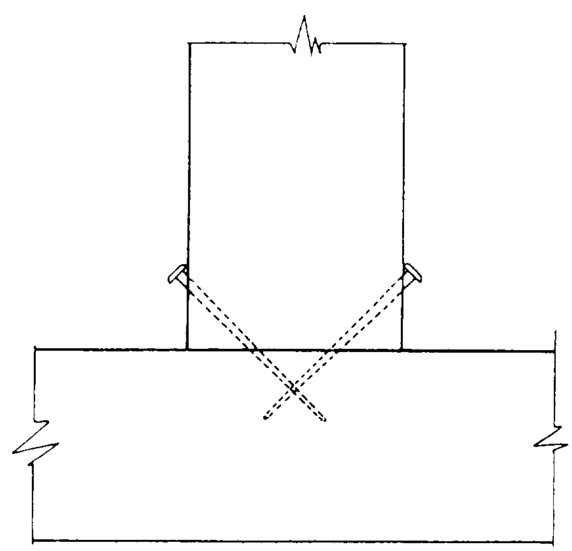


Figure 3-51.—Toenailing.

to cut on the waste side of the lines and making all lines from the face of the material.

Miter Joints

A miter joint is made by mitering (cutting at an angle) the ends or edges of the members that are to be joined together (figure 3-44). The angle of the miter cut is one-half of the angle formed by the joined members. In rectangular mirror frames, windows, door casing boxes, and the like, adjacent members form a 90° angle, and, consequently, the correct angle for mitering is one-half of 90°, or 45°. For members forming an equal-sided figure with other than four sides (such as an octagon or a pentagon), the correct mitering angle can be found by dividing the number of sides the figure will have into 180° and subtracting the result from 90°. For an octagon (an eight-sided figure), determine the mitering angle by subtracting from 90°180° divided by 8 or 90° minus 22.5° equals 67.5°. For a pentagon (a five-sided figure), the angle is

$$90° - (180° \div 5) \text{ or } 90° - 36° = 54°$$

Members can be end mitered to 45° in the wooden miter box and to any angle in the steel miter box by setting the saw to the desired angle, or on the circular saw, by setting the miter gauge to the desired angle. Members can be edge mitered to any angle on the circular saw by tilting the saw to the required angle.

Sawed edges are sometimes unsuitable for gluing. However, if the joint is to be glued, the edges can be mitered on a jointer, as shown in figure 3-52.

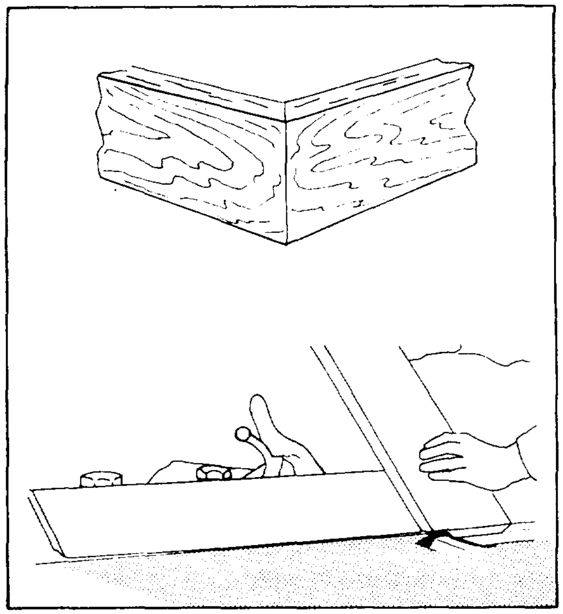


Figure 3-52.-Beveling on a jointer for a mitered edge joint.

SAFETY NOTE

This is a dangerous operation and caution should be taken.

Since abutting surfaces of end-mitered members do not hold well when they are merely glued, they should be reinforced. One type of reinforcement is the corrugated fastener. This is a corrugated strip of metal with one edge sharpened for driving into the joint. The fastener is placed at a right angle to the line between the members, half on one member and half on the other, and driven down flush with the member. The corrugated fastener mars the appearance of the surface into which it is driven; therefore, it is used only on the backs of picture frames and the like.

A more satisfactory type of fastener for a joint between end-mitered members is the slip feather. This is a thin piece of wood or veneer that is glued into a kerf cut in the thickest dimension of the joint. First, saw about halfway through the wood from the outer to the inner corner, then apply glue to both sides of the slip feather, pushing the slip feather into the kerf. Clamp it tightly and allow the glue to dry. After it has dried, remove the clamp and chisel off the protruding portion of the slip feather.

A joint between edge-mitered members can also be reinforced with a spline. This is a thick piece of wood that extends across the joint into grooves cut in the abutting surfaces. A spline for a plain miter joint is shown in figure 3-44. The groove for a spline can be cut either by hand or by a circular saw.

Grooved Joints

A three-sided recess running with the grain is called a groove, and a recess running across the grain is called a dado. A groove or dado that does not extend all the way across the wood is called a stopped groove or a stopped dado. A stopped dado is also known as a gain (figure 3-46). A two-sided recess running along an edge is called a rabbet T (figure 3-45). Dadoes, gains, and rabbets are not, strictly speaking, grooves; but joints that include them are generally called grooved joints.

A groove or dado can be cut with a circular saw as follows: Lay out the groove or dado on the end wood (for a groove) or edge wood (for a dado) that will first come in contact with the saw. Set the saw to the desired depth of the groove above the table, and set the fence at a distance from the saw that will cause the first cut to run on the waste side of the line that indicates the left side of the groove. Start the saw and bring the wood into light contact with it; then stop the saw and examine the layout to ensure the cut will be on the waste side of the line. Readjust the fence, if necessary. When the position of the fence is right, make the cut. Then, reverse the wood and proceed to set and test as before for the cut on the opposite side of the groove. Make as many recuts as necessary to remove the waste stock between the side kerfs.

The procedure for grooving or dadoing with the dado head is about the same, except that, in many cases, the dado head can be built up to take out all the waste in a single cut. The two outside cutters alone will cut a groove 1/4 inch wide. Inside cutters vary in thickness from 1/16 to 1/4 inch.

A stopped groove or stopped dado can be cut on the circular saw, using either a saw blade or a dado head, as follows: If the groove or dado is stopped at only one end, clamp a stop block to the rear of the table in a position that will stop the wood from being fed any farther when the saw has reached the place where the groove or dado is supposed to stop. If the groove or dado is stopped at both ends, clamp a stop block to the rear of the table and a starting block to the front. The starting block should be placed so the saw will contact the place where the groove is supposed to start when the infeed end of the piece is against the block. Start the cut by holding the wood above the saw, with the infeed end against the starting block and the edge against the fence. Then, lower the wood gradually onto the saw, and feed it through to the stop block.

A rabbet can be cut on the circular saw as follows: The cut into the face of the wood is called the shoulder cut, and the cut into the edge or end, the cheek cut. To make the shoulder cut (which should be made first), set the saw to extend above the table a distance equal to the desired depth of the cheek. Be sure to measure this distance from a sawtooth set to the left, or away from the ripping fence. If you measure it from a tooth set to the right or toward the fence, the cheek will be too deep by an amount equal to the width of the saw kerf.

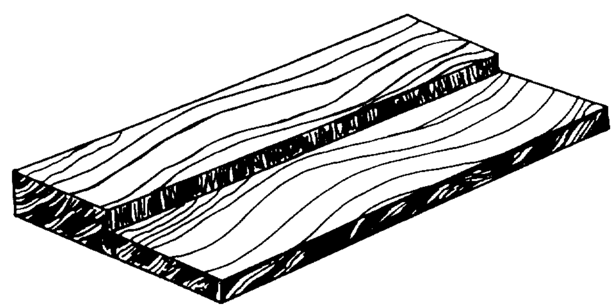
By using the dado head, you can cut most ordinary rabbets in a single cut. First, build up a dado head equal in thickness to the desired width of the cheek. Next, set the head to protrude above the table a distance equal to the desired depth of the should. Clamp a 1-inch board to the fence to serve as a guide for the piece, and set the fence so the edge of the board barely contacts the right side of the dado head. Set the piece against the miter gauge (set at 90°), hold the edge or end to be rabbeted against the l-inch board, and make the cut.

On some jointers, a rabbeting ledge attached to the outer edge of the infeed table can be depressed for rabbeting, as shown in figure 3-53. The ledge is located on the outer end of the butterhead. To rabbet on a jointer of this type, you depress the infeed table and the rabbeting ledge the depth of the rabbet below the outfeed table, and set the fence the width of the rabbet away from the outer end of the butterhead. When the piece is fed through, the unrabbeted part feeds onto the rabbeting ledge. The rabbeted portion feeds onto the outfeed table.

Various combinations of the grooved joints are used in woodworking. The tongue-and-groove joint is a combination of the groove and the rabbet, with the tongued member rabbeted on both faces. In some types of paneling, the tongue is made by rabbeting only one face. A tongue of this kind is called a barefaced tongue. A joint often used in making boxes, drawers, and cabinets is the dado and rabbet joint, shown in figure 3-54. As you can see, one of the members is rabbeted on one face to form a barefaced tongue.

Mortise-and-Tenon Joints

The mortise-and-tenon joint is most frequently used in furniture and cabinet work. In the blind mortise-and-tenon joint, the tenon does not penetrate



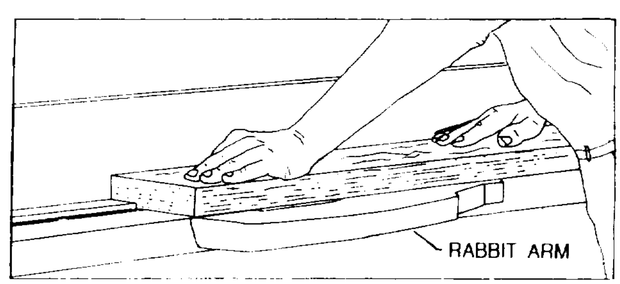


Figure 3-53.-Rabbeting on a jointer with a rabbeting ledge.

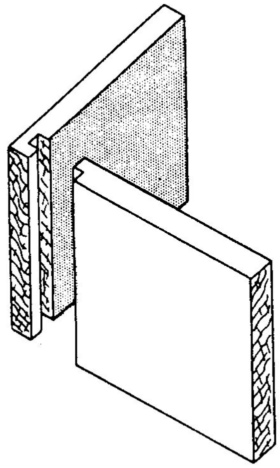


Figure 3-54.-Dado and rabbet joint.

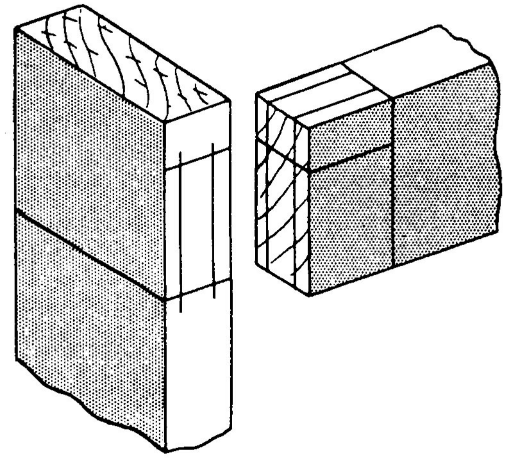


Figure 3-56.-Layout of stub mortise-and-tenon joint.

all the way through the mortised member (figure 3-47).

A joint in which the tenon does penetrate all the way through is a through mortise-and-tenon joint (figure 3-55). Besides the ordinary stub joint (view A), there are haunched joints (view B) and table-haunched joints (view C). Haunching and table-haunching increase the strength and rigidity of the joint.

The layout procedure for an ordinary stub mortise-and-tenon joint is shown in figure 3-56. The shoulder and cheek cuts of the tenon are shown in figures 3-57 and 3-58. To maintain the stock upright while making the cheek cuts, use a push board similar to the one shown in figure 3-58. Tenons can also be cut with a dado head by the same method previously described for cutting end half-lap joints.

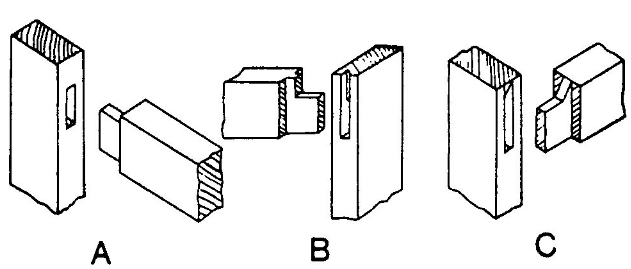


Figure 3-55.-Stub (view A), haunched (view B), and table-haunched (view C) mortise-and-tenon joints.

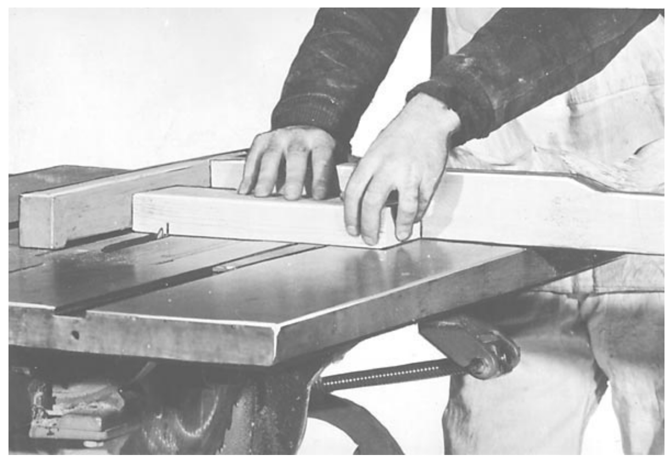


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Figure 3-57.-Making tenon shoulder cut on a table saw.

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Figure 3-58.-Making tenon cheek cut on a table saw using a push board.

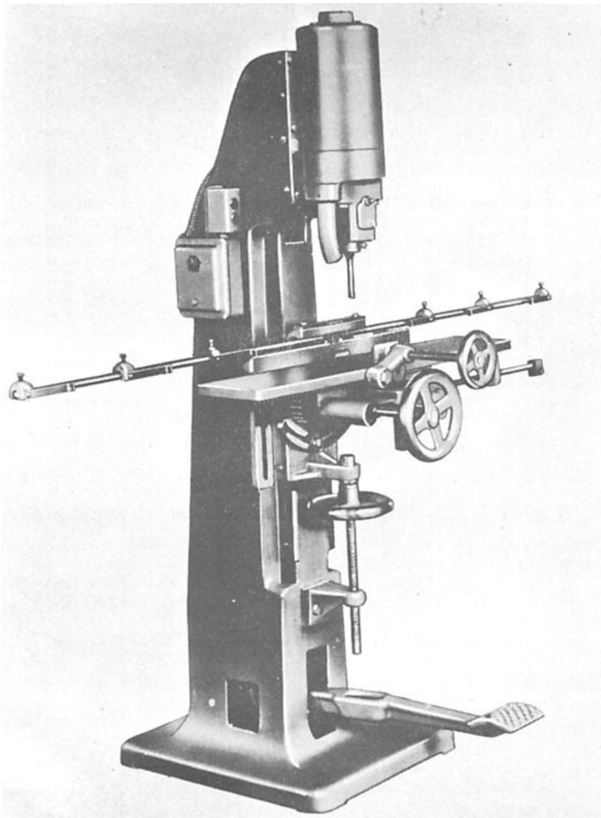

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Figure 3-59.-Hollow-chisel mortising machine.

Mortises are cut mechanically on a hollow-chisel mortising machine like the one shown in figure 3-59. The cutting mechanism on this machine consists of a boring bit encased in a square, hollow, steel chisel. As the mechanism is pressed into the wood, the bit takes out most of the waste while the chisel pares the sides of the mortise square. Chisels come in various sizes, with corresponding sizes of bits to match. If a mortising machine is not available, the same results can be attained by using a simple drill press to take out most of the waste and a hand chisel, for paring the sides square.

In some mortise-and-tenon joints, such as those between rails and legs in tables, the tenon member is much thinner than the mortise member. Sometimes a member of this kind is too thin to shape in the customary reamer, with shoulder cuts on both faces. When this is the case, a barefaced mortise-and-tenon joint can be used. In a barefaced joint, the tenon member is shoulder cut on one side only. The cheek on the opposite side is simply a continuation of the face of the member.

Mortise-and-tenon joints are fastened with glue and with additional fasteners, as required.

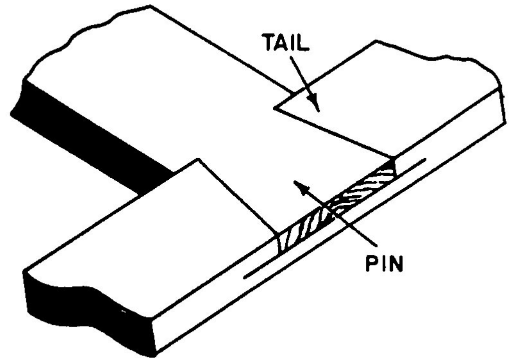


Figure 3-60.-Dovetail half-lap Joint.

Dovetail Joints

The dovetail joint (figure 3-49) is the strongest of all the woodworking joints. It is used principally for joining the sides and ends of drawers in fine grades of furniture and cabinets. In the Seabee units, you will seldom use dovetail joints since they are laborious and time-consuming to make.

A through dovetail joint is a joint in which the pins pass all the way through the tail member. Where the pins pass only part way through, the member is known as a blind dovetail joint.

The simplest of the dovetail joints is the dovetail half-lap joint, shown in figure 3-60. Figure 3-61 shows how this type of joint is laid out, and figure 3-62 shows the completed joint.

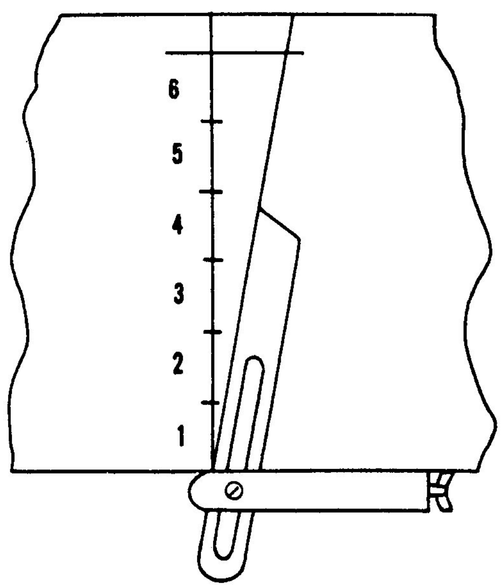


Figure 3-61.-Laying off 10° angle for dovetail joint.

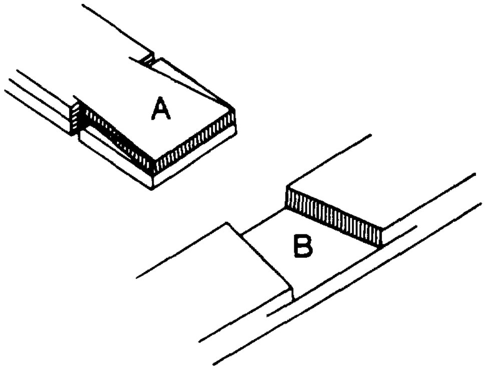


Figure 3-62.-Making a dovetail half-lap joint.

A multiple dovetail joint is shown in figure 3-63; figure 3-64 indicates how the waste is chiseled from the multiple joint.

Box Corner Joints

With the exception of the obvious difference in the layout, the box corner joint (figure 3-48) is made in a similar manner as the through-multiple-dovetail joint.

Coping Joints

Inside corner joints between molding trim members are usually made by butting the end of one member against the face of the other. Figure 3-65

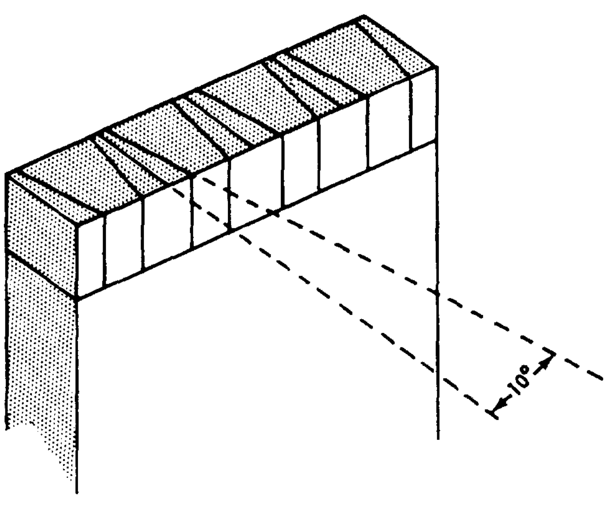


Figure 3-63.-Laying out a pin member for a through-multiple-dovetail joint.

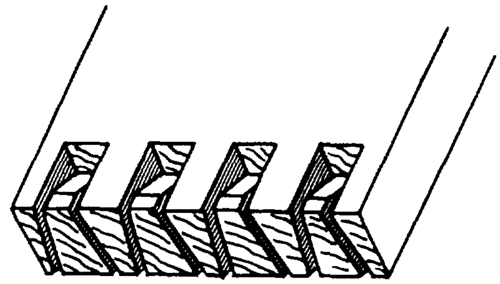


Figure 3-64.-Chiseling out waste in a through-multiple-dovetail joint.

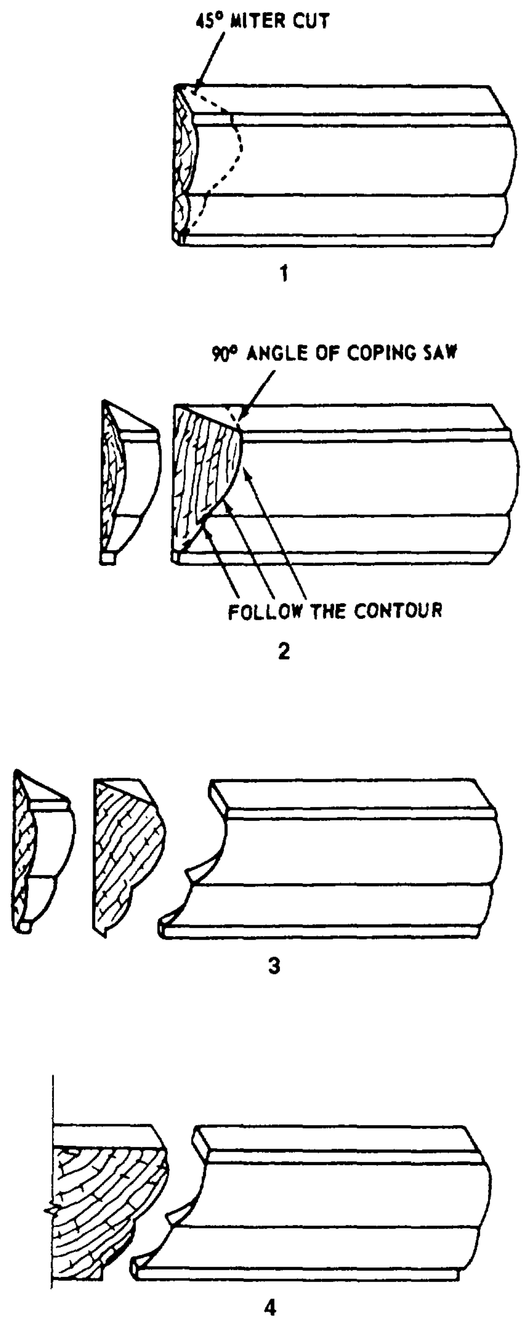


Figure 3-65.-Making a coping Joint.

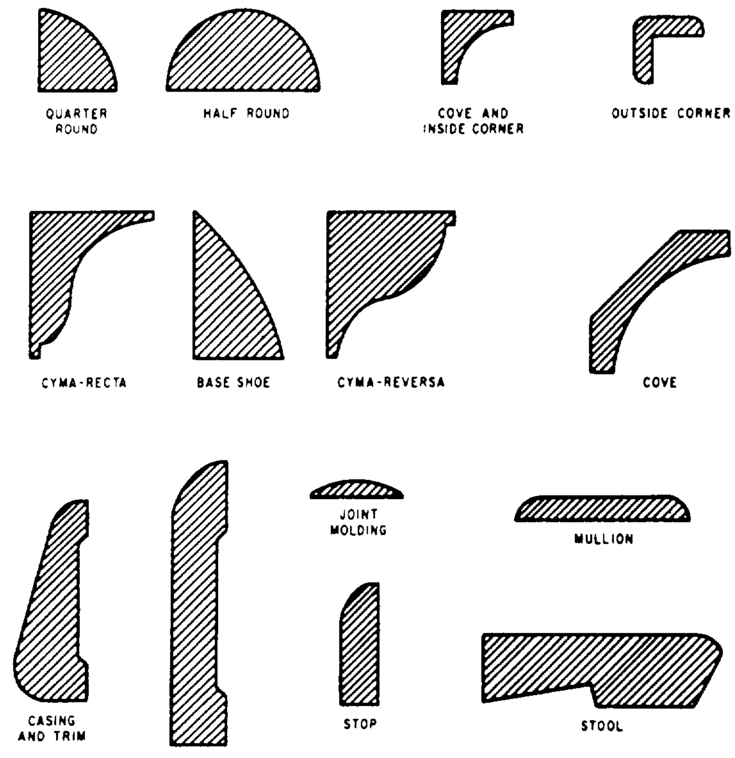


Figure 3-66.-Simple molding and trim shapes.

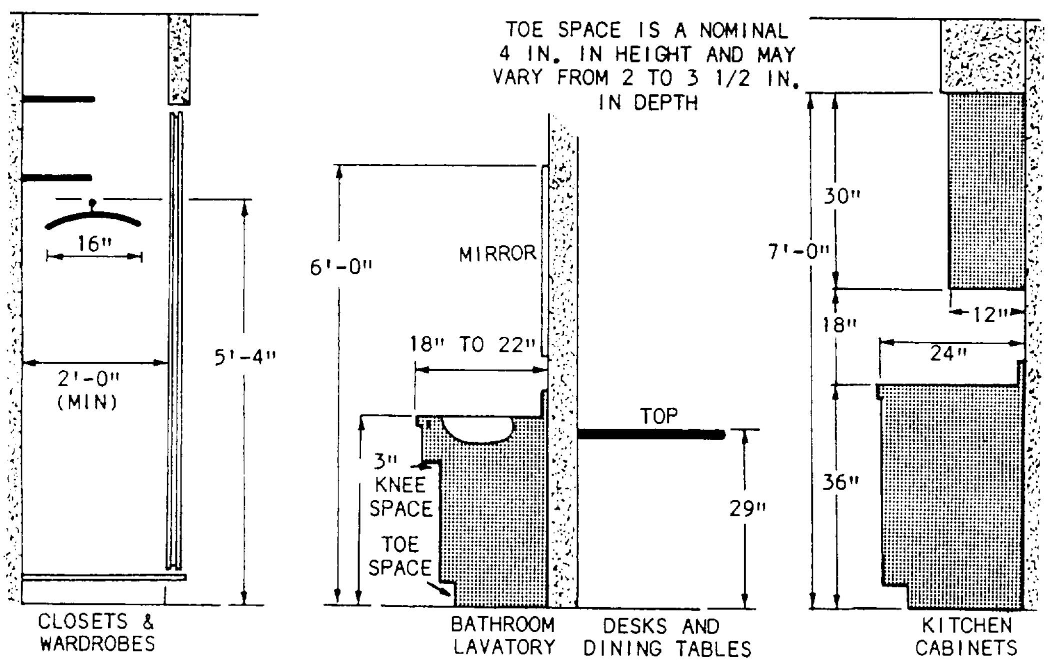


Figure 3-67.-Typical dimensions for cabinetwork.

shows the method of shaping the end of the abutting member to tit the face of the other member. First, saw off the end of the abutting member square, as you would for an ordinary butt joint between ordinary flat-faced members. Then, miter the end to 45°, as shown in the first and second views of figure 3-65. Set the coping saw at the top of the line of the miter cut, hold the saw at 90° to the lengthwise axis of the piece, and saw off the segment shown in the third view, following closely the face line left by the 45° miter cut. The end of the abutting member will then match the face of the other member, as shown in the third view. A joint made in this reamer is called a coping joint. You will have to cut coping joints on a large variety of moldings. Figure 3-66 shows the simplest and most common moldings and trims used in woodworking.

MILLWORK

LEARNING OBJECTIVE: Upon completing this section, you should be able to recognize the various types of millwork products and procedures.

As a general term, millwork usually embraces most wood products and components that require manufacturing. It not only includes the interior trim and doors, but also kitchen cabinets and similar units. Most of these units are produced in a millwork manufacturing plant and are ready to install. Figure 3-67 is an example of the dimensions you might be working with.

BUILDING CABINETS IN PLACE

One of the most common ways of building cabinets, such as those shown in figure 3-68, is to cut

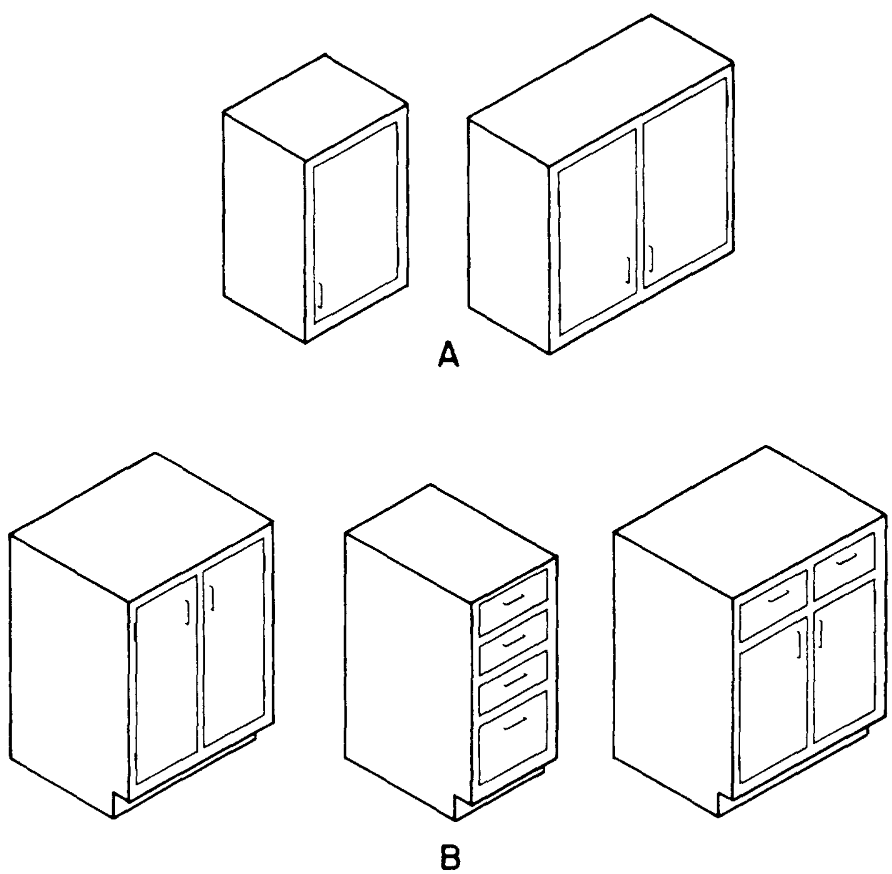


Figure 3-68.-Typical kitchen cabinets: wall (view A) and base (view B).

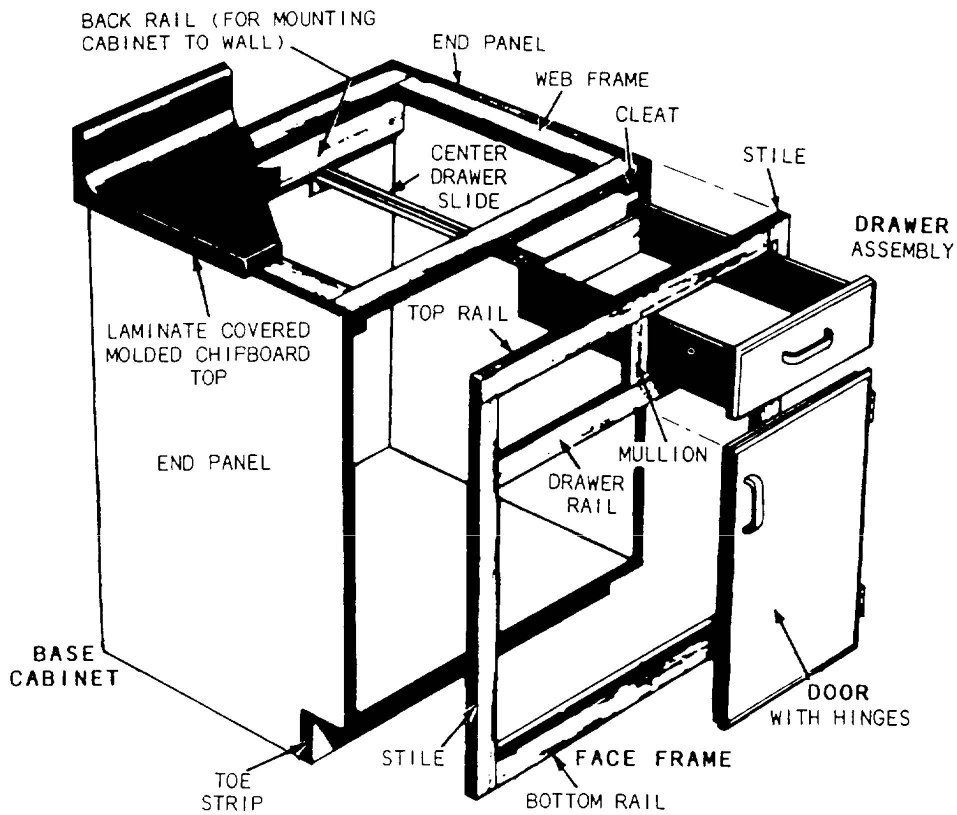


Figure 3-69.-Typical frame construction of a cabinet.

the pieces (figure 3-69) and assemble them in place. Think of building in-place cabinets in four steps.

1. Construct the base first. Use straight 2-by-4 lumber for the base. Nail the lumber to the floor and to a strip attached to the wall. If the floor is not level, place shims under the various members of the base. Later, you can face any exposed 2-by-4 surfaces with a finished material, or the front edge can be made of a finished piece, such as base molding.

2. Next, cut and install the end panels. Attach a strip along the wall between the end panels and level with the top edge. Be sure the strip is level throughout its length. Nail it securely to the wall studs.

3. Cut the bottom panels and nail them in place on the base. Follow this with the installation of the partitions, which are notched at the back corner of the top edge so they will fit over the wall strip.

4. Finally, plumb the front edge of the partitions and end panels. Secure them with temporary strips nailed along the top.

Wall units are made using the same basic steps as the base units. You should make your layout lines directly on the ceiling and wall. Nail the mounting strips through the wall into the studs. At the inside corners, end panels can be attached directly to the wall.

Remember to make your measurements for both base and wall units carefully, especially for openings for built-in appliances. Refer frequently to your drawings and specifications to ensure accuracy.

Shelves

Shelves are an integral part of cabinetmaking, especially for wall units. Cutting dadoes into cabinet walls to fit in shelves may actually strengthen the cabinet (figure 3-70.) When adding shelves, try to make them adjustable so the storage space can be altered as needed. Figure 3-71 shows two methods of installing adjustable shelves.

Whatever method of shelf support you use, make sure that your measurements are accurate and the shelves are level. Most of the time, you will find it easier to do your cutting and drilling before you start assembling the cabinets. If the shelf standards are the type that are set in a groove, you must cut the groove

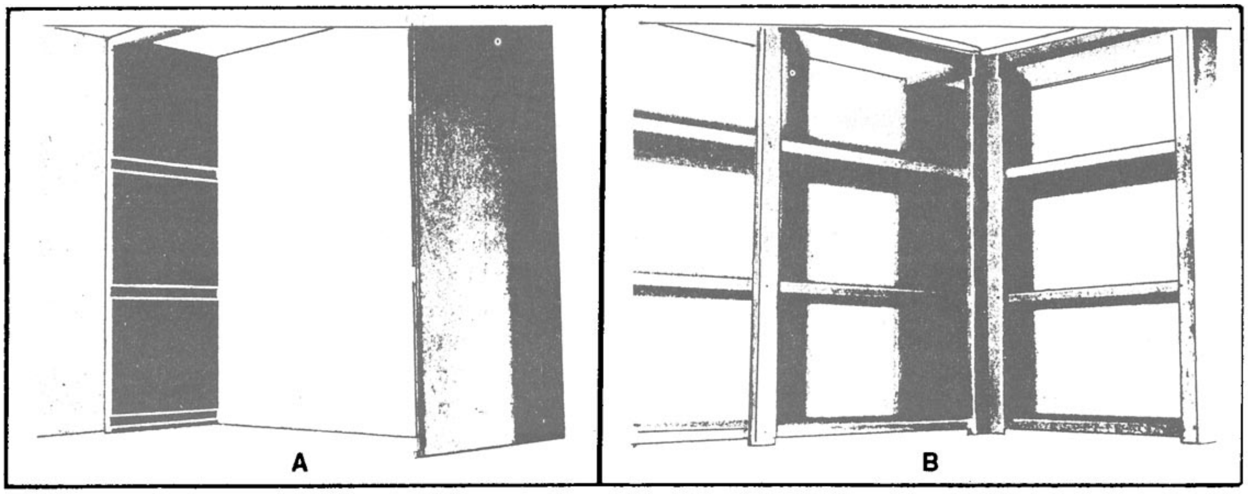


Figure 3-70.-End panels of a wall cabinet in place (view A) and completed framing with facing partially applied (view B).

before assembly. Some adjustable shelf supports can be mounted on the surface.

Shelving supports for 3/4-inch shelves should be placed no more than 42-inches apart. Shelves designed to hold heavy loads should have closer supports. To improve the appearance of plywood shelving, cover the laminated edge with a strip of wood that matches the stock used for the cabinet.

Cabinet Facing

After completing the frame construction and shelving, apply finished facing strips to the front of the cabinet frame. These strips are sometimes assembled into a framework (called a faceplate or face frame) by commercial sources before they are attached to the basic cabinet structure. The vertical members of the facing are called stiles, and the horizontal members are known as rails.

As previously mentioned for built-in-place cabinets, you cut each piece and install it separately. The size of each piece is laid out by positioning the facing stock on the cabinet and marking it. Then, the finished cuts are made, A cut piece can be used to lay out duplicate pieces.

Cabinet stiles are generally attached first, then the rails (figure 3-72). Sometimes a Builder will attach a

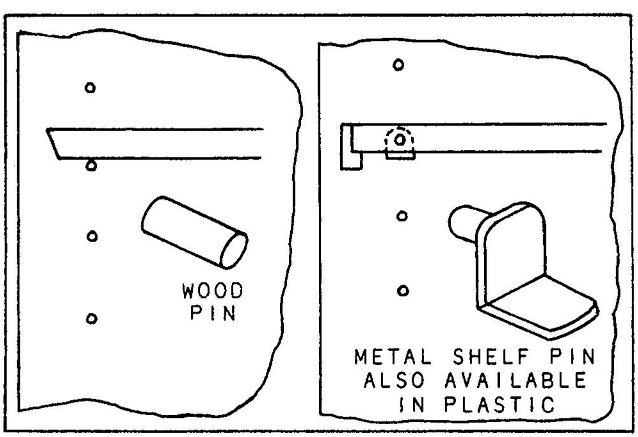


Figure 3-71.-Two methods of supporting shelves.

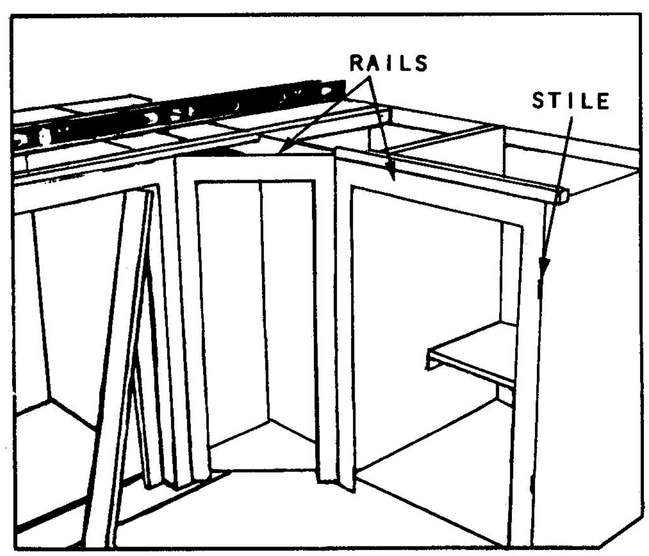


Figure 3-72.-Facing being placed on a cabinet.

plumb end stile first, and then attach rails to determine the position of the next stile.

Use finishing nails and glue to install facing, When nailing hardwoods, drill nail holes where you think splitting might occur.

Drawers

Seabees use many methods of building drawers. The three most common are the multiple dovetail, lock-shouldered, and square-shouldered methods (figure 3-73).

There are several types of drawer guides available. The three most commonly used are the side guide, the corner guide, and the center guide (shown in figure 3-74, view A).

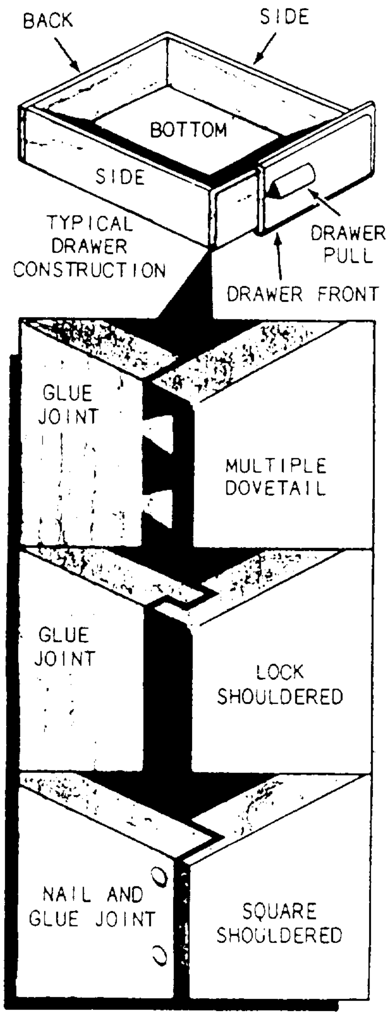


Figure 3-73.-Three common types of joints used in drawer construction.

The two general types of drawer faces are the lip and flush faces (shown in figure 3-74, view B), A flush drawer must be carefully fitted. A lip drawer must have a rabbet along the top and sides of the front. The lip style overlaps the opening and is much easier to construct.

Cabinet Doors

The four types of doors commonly used on cabinets are the flush, lipped, overlay, and sliding doors. A flush door, like the flush drawer, is the most difficult to construct. For a finished look, each type of door must be fitted in the cabinet opening within 1/16-inch clearance around all four edges. A lipped door is simpler to install than a flush door since the lip, or overlap, feature allows you a certain amount of adjustment and greater tolerances. The lip is formed by cutting a rabbet along the edge.

Overlay doors are designed to cover the edges of the face frame. There are several types of sliding doors used on cabinets. One type of sliding door is rabbeted to fit into grooves at the top and bottom of the cabinet. The top groove is always made to allow the door to be removed by lifting it up and pulling the bottom out.

INSTALLING PREMADE CABINETS

To install premade cabinets, you can begin with either the wall or base cabinets. The general procedures for each are similar.

Installing the Wall Cabinets First

When layouts are made and wall studs located, the wall units are lifted into position. They are held with a padded T-brace that allows the worker to stand close to the wall while making the installation. After the wall cabinets are securely attached and checked, the base cabinets are moved into place, leveled, and secured.

Installing the Base Cabinets First

When base cabinets are installed first, the tops of the base cabinets can be used to support braces that hold the wall units in place while they are fastened to the wall.

Procedures

The following procedures are a simple way of installing premade cabinets:

1. First, locate and mark the location of all wall studs where the cabinets are to be hung. Find and mark the highest point in the floor. This will ensure the base cabinet is level on uneven floor surfaces. (Shims should be used to maintain the cabinet at its designated leveled height.)

2. Start the installation of a base cabinet with a corner or end unit. After all base cabinets are in position, fasten the cabinets together. To get maximum holding power from screws, place one hole close to the top and one close to the bottom.

3. Starting at the highest point in the floor, level the leading edges of the cabinets. After leveling all the leading edges, fasten them to the wall at the studs to obtain maximum holding power.

4. Next, install the countertop on the base cabinets making sure to drill or screw through the top.

5. Then, make a brace to help support the wall cabinets while they are being fastened. Start the wall cabinet installation with a corner or end cabinet. Make sure you check for plumb and level as you install these cabinets.

6. After installing the cabinets and checking for plumb and level, join the wall cabinets through the sides as you did with the base cabinets.

7. Finally, after they are plumb and level, secure the cabinets to the wall at the studs for maximum holding power.

Here are some helpful hints for the general construction of cabinets:

- Cabinet parts are fastened together with screws or nails. They are set below the surface, and the holes are filled with putty. Glue is used at all joints. Clamps should be used to produce better fitting, glued joints.

- A better quality cabinet is rabbeted where the top, bottom, back, and side pieces come together. However, butt joints are also used. If panels are less than 3/4-inch thick, a reinforcing block should be used with the butt joint. Fixed shelves are dadoed into the sides.

- Screws should go through the hanging strips and into the stud framing. Never use nails. Toggle bolts are required when studs are inaccessible. Join units by first clamping them together and then, while aligned, install bolts and T-nuts.

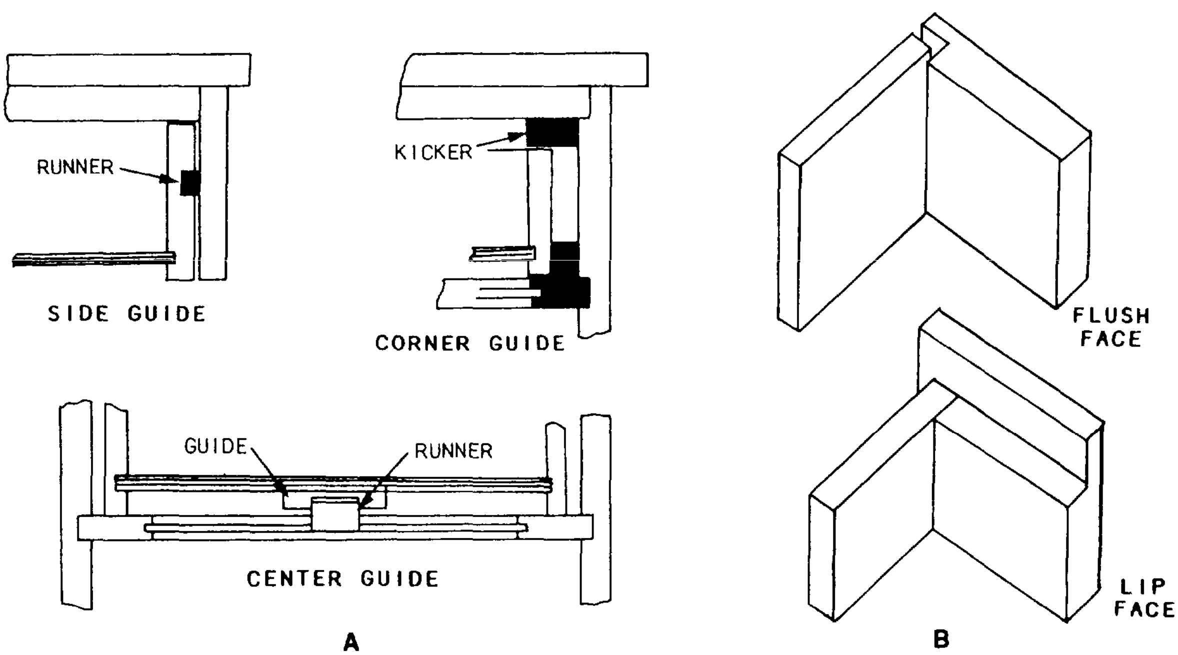


Figure 3-74.-Types of drawer guides (view A) and faces (view B).

COUNTERS AND TOPS

In cabinetwork, the counters and tops are covered with a 1/16-inch layer of high-pressure plastic laminate. Although this material is very hard, it does not possess great strength and is serviceable only when it is bonded to plywood, particle board, or wafer wood. This base, or core material, must be smooth and is usually 3/4-inch thick.

Working Laminates

Plastic laminates can be cut to rough size with a table saw, portable saw, or saber saw. Use a fine-tooth blade, and support the material close to the cut. If no electrical power is available, you can use a finish handsaw or a hacksaw. When cutting laminates with a saw, place masking tape over the cutting area to help prevent chipping the laminate. Make cut markings on the masking tape.

Measure and cut a piece of laminate to the desired size. Allow at least 1/4-inch extra to project past the edge of the countertop surface. Next, mix and apply the contact bond cement to the underside of the laminate and to the topside of the countertop surface. **Be sure to follow the manufacturer's recommended directions for application.**

Adhering Laminates

Allow the contact bond cement to set or dry. To check for bonding, press a piece of waxed brown paper on the cement-coated surface. When no adhesive residue shows, it is ready to be bonded. Be sure to lay a full sheet of waxed brown paper across the countertop. This allows you to adjust the laminate into the desired position without permanent bonding. Now, you can gradually slide the paper out from under the laminate, and the laminate becomes bonded to the countertop surface.

Be sure to roll the laminate flat by hand, removing any air bubbles and getting a good firm bond. After sealing the laminate to the countertop surface, trim the edges by using either a router with a special guide or a small block plane. If you want to bevel the countertop edge, use a mill file.

METHODS OF FASTENING

LEARNING OBJECTIVE: Upon completing this section, you should be able to identify the different types of fastening devices.

A variety of metal fastening devices are used by Seabees in construction. Although nails are the most commonly used fastener, the use of staples to attach wood structural members is growing. For certain operations, screws and bolts are required. In addition, various metal devices exist for anchoring materials into concrete, masonry, and steel.

The increasing use of adhesives (glues and mastics) is an important development in the building industry. Adhesives are used in combination with, or in place of, nails and screws.

NAILS

Nails, the most common type of metal fasteners, are available in a wide range of types and sizes.

Basic Nail Types

Some basic types are shown in figure 3-75. The common nail is designed for rough framing. The box nail is used for toenailing and light work in frame construction. The casing nail is used in finished carpentry work to fasten doors and window casings and other wood trim. The finishing nail and brad are used for light, wood-trim material and are easy to drive below-the surface of lumber with a nail set.

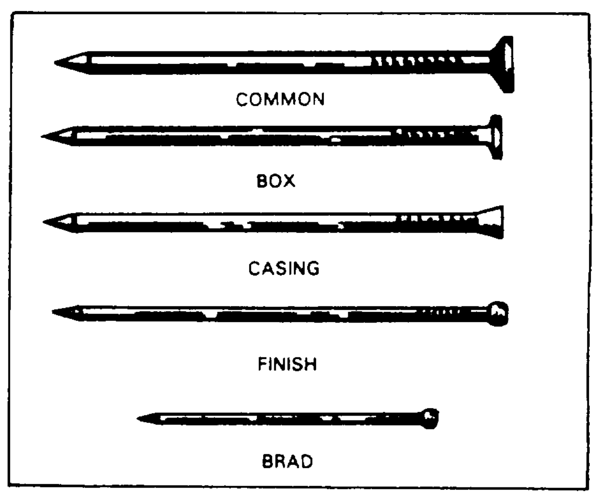
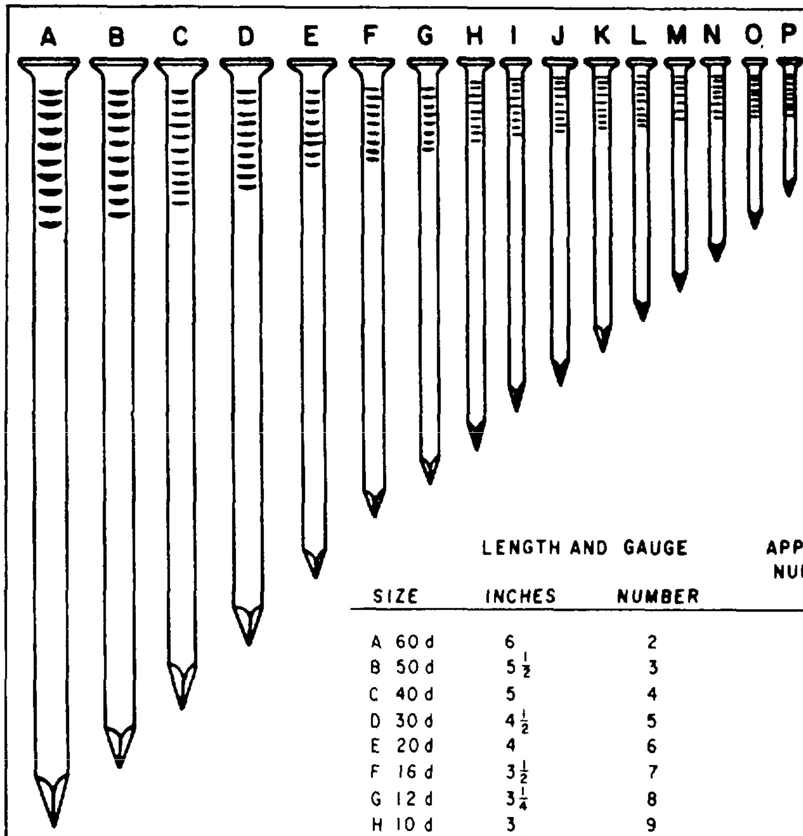


Figure 3-75.-Basic types of nails.

The size of a nail is measured in a unit known as a penny. Penny is abbreviated with the lowercase letter **d.** It indicates the length of the nail. A 6d (6-penny) nail is 2-inches long. A 10d (10-penny) nail is 3-inches long (figure 3-76). These measurements apply to common, box, casing, and finish nails only. Brads and small box nails are identified by their actual length and gauge number.

A nail, whatever the type, should be at least three times as long as the thickness of the wood it is intended to hold. Two-thirds of the length of the nail is driven into the other piece of wood for proper anchorage. The other one-third of the length provides the necessary anchorage of the piece being fastened. Protruding nails should be bent over to prevent damage to materials and injury to personnel.

There are a few general rules to be followed in the use of nails in building. Nails should be driven at an angle slightly toward each other to improve their holding power. You should be careful in placing nails to provide the greatest holding power. Nails driven with the grain do not hold as well as nails driven across the grain. A few nails of proper type and size, properly placed and properly driven, will hold better than a great many driven close together. Nails can generally be considered the cheapest and easiest fasteners to be applied.



COMMON WIRE NAILS

SIZE	LENGTH AND GAUGE INCHES	NUMBER	APPROXIMATE NUMBER TO POUND
A 60 d	6	2	11
B 50 d	5½	3	14
C 40 d	5	4	18
D 30 d	4½	5	24
E 20 d	4	6	31
F 16 d	3½	7	49
G 12 d	3¼	8	63
H 10 d	3	9	69
I 9 d	2¾	10¼	96
J 8 d	2½	10¼	106
K 7 d	2¼	11½	161
L 6 d	2	11½	181
M 5 d	1¾	12½	271
N 4 d	1½	12½	316
O 3 d	1¼	14	568
P 2 d	1	15	876

Figure 3-76.-Nail sizes given in "penny" (d) units.

Specialty Nails

Figure 3-77 shows a few of the many specialized nails. Some nails are specially coated with zinc, cement, or resin materials. Some have threading for increased holding power of the nails. Nails are made from many materials, such as iron, steel, copper, bronze, aluminum, and stainless steel.

Annular and spiral nails are threaded for greater holding power. They are good for fastening paneling or plywood flooring. The drywall nail is used for hanging drywall and has a special coating to prevent rust. Roofing nails are not specified by the penny system; rather, they are referred to by length. They are available in lengths from 3/4 inch to 2 inches and have large heads. The double-headed nail, or duplex-head nail, is used for temporary construction, such as form work or scaffolding. The double head on this nail makes it easy to pull out when forms or scaffolding are torn down. Nails for power nailing come in rolls or clips for easy loading into a nailer. They are coated for easier driving and greater holding power. Table 3-10 gives the general size and type of nails preferable for specific applications.

STAPLES

Staples are available in a wide variety of shapes and sizes, some of which are shown in figure 3-78.

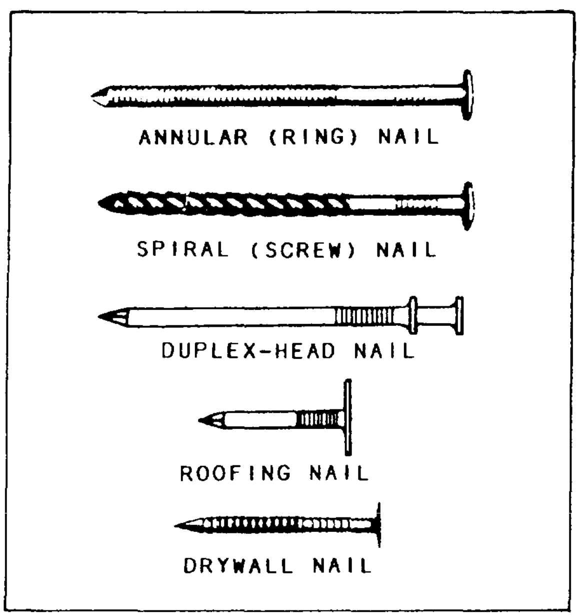


Figure 3-77.-Specialized nails.

Heavy-duty staples are used to fasten plywood sheeting and subflooring. Heavy-duty staples are driven by electrically or pneumatically operated tools. Light-duty and medium-duty staples are used for attaching molding and other interior trim. Staples are sometimes driven in by hand-operated tools.

SCREWS

The use of screws, rather than nails, as fasteners may be dictated by a number of factors. These may include the type of material to be fastened, the requirement for greater holding power than can be obtained by the use of nails, the finished appearance desired, and the fact that the number of fasteners that can be used is limited. Using screws, rather than nails, is more expensive in terms of time and money, but it is often necessary to meet requirements for superior results. The main advantages of screws are that they provide more holding power, can be easily tightened to draw the items being fastened securely together, are neater in appearance if properly driven, and can be withdrawn without damaging the material. The common wood screw is usually made of unhardened steel, stainless steel, aluminum, or brass. The steel may be bright finished or blued, or zinc, cadmium, or chrome plated. Wood screws are threaded from a gimlet point for approximately two-thirds of the length of the screw and are provided with a slotted head designed to be driven by an inserted driver. Wood screws, as shown in figure 3-79, are designated according to head style. The most common types are flathead, oval head, and

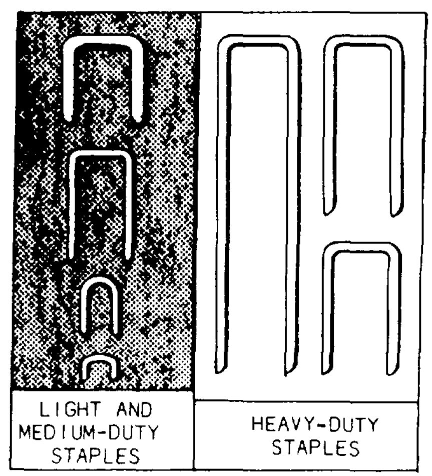


Figure 3-78.-Types of staples.

Table 3-10.-Size, Type, and Use of Nails

SIZE	LENGTH (IN.)[1]	DIAMETER (IN.)	REMARKS	WHERE USED
2d	1	.072	Small head	Finish work, shop work
2d	1	.072	Large flathead	Small timber, wood shingles, lathes
3d	1 1/4	.08	Small head	Finish work, shop work
3d	1 1/4	.08	Large flathead	Small timber, wood shingles, lathes
4d	1 1/2	.098	Small head	Finish work, shop work
4d	1 1/2	.098	Large flathead	Small timber, lathes, shop work
5d	1 3/4	.098	Small head	Finish work, shop work
5d	1 3/4	.098	Large flathead	Small timber, lathes, shop work
6d	2	.113	Small head	Finish work, casing, stops, etc., shop work
6d	2	.113	Large flathead	Small timber, siding, sheathing, etc., shop work
7d	2 1/4	.113	Small head	Casing, base, ceiling, stops, etc.
7d	2 1/4	.113	Large flathead	Sheathing, siding, subflooring, light framing
8d	2 1/2	.131	Small head	Casing, base, ceiling, wainscot, etc., shop work
8d	2 1/2	.131	Large flathead	Sheathing, siding, subflooring, light framing, shop work
8d	1 1/4	.131	Extra-large flathead	Roll roofing, composition shingles
9d	2 3/4	.131	Small head	Casing, base, ceiling, etc.
9d	2 3/4	.131	Large flathead	Sheathing, siding, subflooring, framing, shop work
10d	3	.148	Small head	Casing, base, ceiling, etc., shop work
10d	3	.148	Large flathead	Sheathing, siding, subflooring, framing, shop work
12d	3 1/4	.148	Large flathead	Sheathing, subflooring, framing
16d	3 1/2	.162	Large flathead	Framing, bridges, etc.
20d	4	.192	Large flathead	Framing, bridges, etc.
30d	4 1/2	.207	Large flathead	Heavy framing, bridges, etc.
40d	5	.225	Large flathead	Heavy framing, bridges, etc.
50d	5 1/2	.244	Large flathead	Extra-heavy framing, bridges, etc.
60d	6	.262	Large flathead	Extra-heavy framing, bridges, etc.

1This chart applies to wire nails, although it may be used to determine the length of cut nails.

roundhead, as illustrated in that order in figure 3-79, All of these screws can have slotted or Phillips heads.

To prepare wood for receiving the screws, bore a body hole the diameter of the screw to be used in the piece of wood that is to be fastened (figure 3-80). You should then bore a starter hole in the base wood with a diameter less than that of the screw threads and a depth of one-half or two-thirds the length of the threads to be anchored. The purpose of this careful preparation is to assure accuracy in the placement of the screws, to reduce the possibility of splitting the wood, and to reduce the time and effort required to drive the screw. Properly set slotted and Phillips flathead and oval head screws are countersunk sufficiently to permit a covering material to be used to cover the head. Slotted roundhead and Phillips roundhead screws are not countersunk, but they are driven so that the head is firmly flush with the surface of the wood. The slot of the roundhead screw is left parallel with the grain of the wood.

The proper name for a lag screw (shown in figure 3-79) is lag bolt or wood screw. These screws are often required in constructing large projects, such as a building. They are longer and much heavier than the common wood screw and have coarser threads that extend from a cone, or gimlet point, slightly more than half the length of the screw. Square-head and hexagonal-head lag screws are always externally driven, usually by means of a wrench. They are used when ordinary wood screws would be too short or too light and spikes would not be strong enough. Sizes of

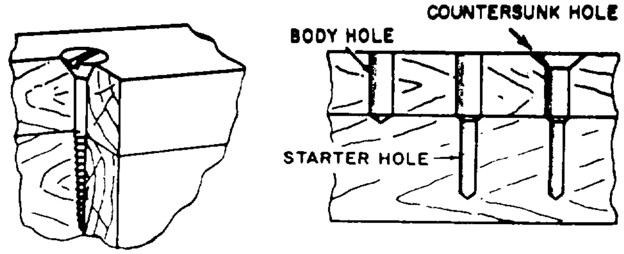


Figure 3-80.-Proper way to sink a screw.

lag screws are shown in table 3-11. Combined with expansion anchors, they are used to frame timbers to existing masonry.

Expansion shields, or expansion anchors as they are sometimes called, are used for inserting a predrilled hole, usually in masonry, to provide a gripping base or anchor for a screw, bolt, or nail intended to fasten an item to the surface in which the hole was bored. The shield can be obtained separately, or it may include the screw, bolt, or nail. After the expansion shield is inserted in the predrilled hole, the fastener is driven into the hole in the shield, expanding the shield and wedging it firmly against the surface of the hole.

For the assembly of metal parts, sheet metal screws are used. These screws are made regularly in steel and brass with four types of heads: flat, round, oval, and fillister, as shown in that order in figure 3-79.

Wood screws come in sizes that vary from 1/4 inch to 6 inches. Screws up to 1-inch in length increase by

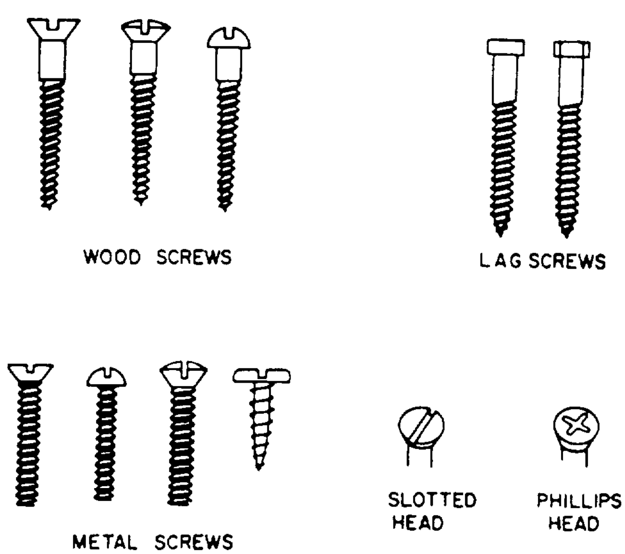


Figure 3-79.-Types of screws.

Table 3-11.-Lag Screw Sizes

LENGTH (INCHES)	DIAMETER (INCHES)			
	1/4	3/8 7/16 1/2	5/8 3/4	7/8 1
1	×	×		
1 1/2	×	×	×	
2, 2 1/2, 3 3 1/2, etc., 7 1/2 8 to 10	×	×	×	×
11 to 12		×	×	×
13 to 16			×	×

eighths, screws from 1 to 3 inches increase by quarters, and screws from 3 to 6 inches increase by half inches. Screws vary in length and size of shaft. Each length is made in a number of shaft sizes specified by an arbitrary number that represents no particular measurement but indicates relative differences in the diameter of the screws. Proper nomenclature of a screw, as shown in figure 3-81, includes the type, material, finish, length, and screw size number, which indicates the wire gauge of the body, drill or bit size for the body hole, and drill or bit size for the starter hole. Tables 3-12 and 3-13 provide size, length, gauge, and applicable drill and auger bit sizes for screws. Table 3-11 gives lengths and diameters of lag screws.

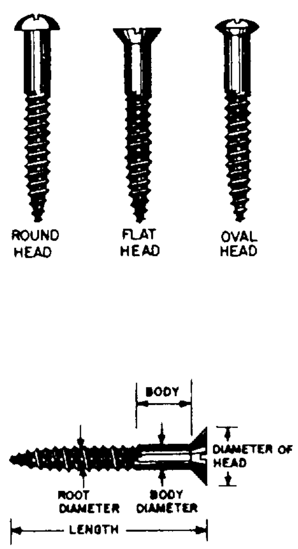


Figure 3-81.-Types and nomenclature of wood screws.

BOLTS

Bolts are used in construction when great strength is required or when the work under construction must be frequently disassembled. Their use usually implies the use of nuts for fastening and, sometimes, the use of washers to protect the surface of the material they are used to fasten. Bolts are selected for application to specific requirements in terms of length, diameter, threads, style of head, and type. Proper selection of head style and type of bolt results in good appearance as well as good construction. The use of washers between the nut and a wood surface or between both the nut and the head and their opposing surfaces helps you avoid marring the surfaces and permits additional torque in tightening.

Carriage Bolts

Carriage bolts fall into three categories: square neck finned neck and ribbed neck (figure 3-82). These bolts have round heads that are not designed to

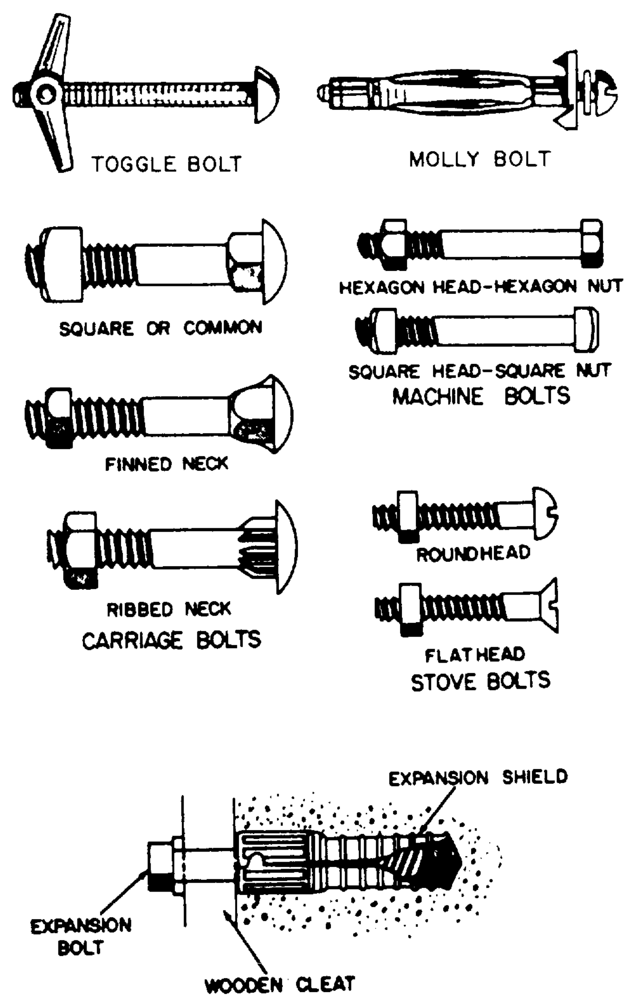


Figure 3-82.-Types of bolts.

Table 3-12.-Screw Sizes and Dimensions

LENGTH (in.)	SIZE NUMBERS																					
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	22	24
1/4	×	×	×	×																		
3/8	×	×	×	×	×	×	×	×	×	×												
1/2		×	×	×	×	×	×	×	×	×	×	×	×									
5/8		×	×	×	×	×	×	×	×	×	×	×	×		×							
3/4			×	×	×	×	×	×	×	×	×	×	×		×		×					
7/8			×	×	×	×	×	×	×	×	×	×	×		×		×					
1				×	×	×	×	×	×	×	×	×	×		×		×		×	×		
1 1/4					×	×	×	×	×	×	×	×	×		×		×		×	×		×
1 1/2					×	×	×	×	×	×	×	×	×		×		×		×	×		×
1 3/4						×	×	×	×	×	×	×	×		×		×		×	×		×
2						×	×	×	×	×	×	×	×		×		×		×	×		×
2 1/4						×	×	×	×	×	×	×	×		×		×		×	×		×
2 1/2						×	×	×	×	×	×	×	×		×		×		×	×		×
2 3/4							×	×	×	×	×	×	×		×		×		×	×		×
3							×	×	×	×	×	×	×		×		×		×	×		×
3 1/2									×	×	×	×	×		×		×		×	×		×
4									×	×	×	×	×		×		×		×	×		×
4 1/2													×		×		×		×	×		×
5													×		×		×		×	×		×
6															×		×		×	×		×
THREADS PER INCH	32	28	26	24	22	20	18	16	15	14	13	12	11		10		9		8	8		7
DIA OF SCREW (in.)	.060	.073	.086	.099	.112	.125	.138	.151	.164	.177	.190	.203	.216		.242		.268		.294	.320		.372

Table 3-13.-Drill and Auger Bit Sizes for Wood Screws

SCREW SIZE NO.		1	2	3	4	5	6	7	8	9	10	12	14	16	18
NOMINAL SCREW		.073	.086	.099	.112	.125	.138	.151	.164	.177	.190	.216	.242	.268	.294
BODY DIAMETER		$\frac{5}{64}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{7}{64}$	$\frac{1}{8}$	$\frac{9}{64}$	$\frac{5}{32}$	$\frac{11}{64}$	$\frac{11}{64}$	$\frac{3}{16}$	$\frac{7}{32}$	$\frac{15}{64}$	$\frac{17}{64}$	$\frac{19}{64}$
PILOT HOLE	Drill size	$\frac{5}{64}$	$\frac{3}{32}$	$\frac{7}{64}$	$\frac{7}{64}$	$\frac{1}{8}$	$\frac{9}{64}$	$\frac{5}{32}$	$\frac{11}{64}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{7}{32}$	$\frac{1}{4}$	$\frac{17}{64}$	$\frac{19}{64}$
	Bit size	—	—	—	—	—	—	—	—	—		4	4	5	5
STARTER HOLE	Drill size	—	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{5}{64}$	$\frac{5}{64}$	$\frac{3}{32}$	$\frac{7}{64}$	$\frac{7}{64}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{9}{64}$	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{13}{64}$
	Bit size	—	—	—	—	—	—	—	—	—	—	—	—		4

Table 3-14.-Carriage Bolt Sizes

LENGTH (INCHES)	DIAMETER (INCHES)			
	3/16, 1/4, 5/16, 3/8	7/16, 1/2	9/16, 5/8	3/4
3/4	×	—	—	—
1	×	×	—	—
1 1/4	×	×	×	—
1 1/2, 2, 2 1/2, etc., 9 1/2, 10 to 20	×	×	×	×

be driven. They are threaded only part of the way up the shaft. Usually, the threads are two to four times the diameter of the bolt in length. In each type of carriage bolt, the upper part of the shank, immediately below the head, is designed to grip the material in which the bolt is inserted and keep the bolt from turning when a nut is tightened down on it or removed. The finned type is designed with two or more fins extending from the head to the shank. The ribbed type is designed with longitudinal ribs, splines, or serrations on all or part of a shoulder located immediately beneath the head. Holes bored to receive carriage bolts are bored to be a tight fit for the body of the bolt and counterbored to permit the head of the bolt to fit flush with, or below the surface of, the material being fastened. The bolt is then driven through the hole with a hammer. Carriage bolts are chiefly for wood-to-wood application, but they can also be used for wood-to-metal applications. If used for wood-to-metal application, the head should be fitted to the wood item. Metal surfaces are sometimes predrilled and countersunk to permit the use of carriage bolts metal to metal. Carriage bolts can be obtained from 1/4 inch to 1 inch in diameter and from 3/4 inch to 20 inches long (table 3-14). A common flat washer should be used with carriage bolts between the nut and the surface.

Machine Bolts

Machine bolts (figure 3-82) are made with cut national fine and national coarse threads extending in length from twice the diameter of the bolt plus 1/4 inch (for bolts less than 6 inches in length) to twice the diameter of the bolt plus 1/2 inch (for bolts over 6 inches in length). They are precision made and generally applied metal to metal where close tolerance is desirable. The head may be square, hexagonal, rounded, or flat countersunk. The nut usually corresponds in shape to the head of the bolt with which it is used. Machine bolts are externally driven only. Selection of the proper machine bolt is made on the basis of head style, length, diameter, number of threads per inch, and coarseness of thread. The hole through which the bolt is to pass is bored to the same diameter as the bolt. Machine bolts are made in diameters from 1/4 inch to 3 inches and may be obtained in any length desired (table 3- 15).

Table 3-15.-Machine Bolt Sizes

LENGTH (INCHES)	DIAMETER (INCHES)				
	1/4, 3/8	7/16	1/2, 9/16, 5/8	1/2, 7/8, 1	1 1/8, 1 1/4
3/4	×	—	—	—	—
1 1/4	×	×	×	—	—
1 1/2, 2, 2 1/2	×	×	×	×	—
3, 3 1/2, 4, 4 1/2, etc., 9 1/2, 10 to 20	×	×	×	×	×
21 to 25	—	—	×	×	×
26 to 39	—	—	—	×	×

Stove Bolts

Stove bolts (figure 3-82) are less precisely made than machine bolts. They are made with either flat or round slotted heads and may have threads extending over the full length of the body, over part of the body, or over most of the body. They are generally used with square nuts and applied metal to metal, wood to wood, or wood to metal. If flatheaded, they are countersunk. If roundheaded, they are drawn flush to the surface.

Expansion Bolt

An expansion bolt (figure 3-82) is a bolt used in conjunction with an expansion shield to provide anchorage in substances in which a threaded fastener alone is useless. The shield, or expansion anchor, is inserted in a predrilled hole and expands when the bolt is driven into it. It becomes wedged firmly in the hole, providing a secure base for the grip of the fastener.

Toggle Bolts

A toggle bolt (figure 3-82) is a machine screw with a spring-action, wing-head nut that folds back as the entire assembly is pushed through a prepared hole in a hollow wall. The wing head then springs open inside the wall cavity. As the screw is tightened, the wing head is drawn against the inside surface of the finished wall material. Spring-action, wing-head toggle bolts are available in a variety of machine screw combinations. Common sizes range from 1/8 inch to 3/8 inch in diameter and 2 inches to 6 inches in length. They are particularly useful with sheetrock wall surfaces.

Molly Bolt

The molly bolt or molly expansion anchor (figure 3-82) is used to fasten small cabinets, towel bars, drapery hangers, mirrors, electrical fixtures, and other lightweight items to hollow walls. It is inserted in a prepared hole. Prongs on the outside of the shield grip the wall surfaces to prevent the shield from turning as the anchor screw is being driven. As the screw is tightened, the shield spreads and flattens against the interior of the wall. Various sizes of screw anchors can be used in hollow walls 1/8 inch to 1 3/4 inches thick.

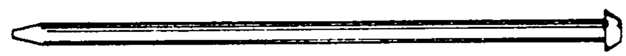


Figure 3-83.-Driftpin (driftbolt).

Driftpins

Driftpins are long, heavy, threadless bolts used to hold heavy pieces of timber together (figure 3-83). They have heads that vary in diameter from 1/2 to 1 inch and in length from 18 to 26 inches. The term “driftpin” is almost universally used in practice. However, for supply purposes, the correct designation is driftbolt.

To use the driftpin, you make a hole slightly smaller than the diameter of the pin in the timber. The pin is driven into the hole and is held in place by the compression action of the wood fibers.

CORRUGATED FASTENERS

The corrugated fastener is one of the many means by which joints and splices are fastened in small timber and boards. It is used particularly in the miter joint. Corrugated fasteners are made of 18- to 22-gauge sheet metal with alternate ridges and grooves; the ridges vary from 3/16 to 5/ 16 inch, center to center. One end is cut square; the other end is sharpened with beveled edges. There are two types of corrugated fasteners: one with the ridges running parallel (figure 3-84, view A); the other with ridges running at a slight angle to one another (figure 3-84, view B), The latter type has a tendency to compress the material since the ridges and grooves are closer at the top than at the bottom. These fasteners are made in several different lengths and widths. The width varies from 5/8 to 1 1/8 inches; the length varies from 1/4 to 3/4 inch. The fasteners also are made with different numbers of ridges, ranging from three to six ridges per fastener. Corrugated fasteners are used in a number of ways—to fasten parallel boards together, as in fastening tabletops; to make any type of joint; and as a substitute for nails where nails may split the timber. In small timber, corrugated fasteners have greater holding power than nails. The proper method of using the fasteners is shown in figure 3-84.

ADHESIVES

Seabees use many different types of adhesives in various phases of their construction projects. Glues

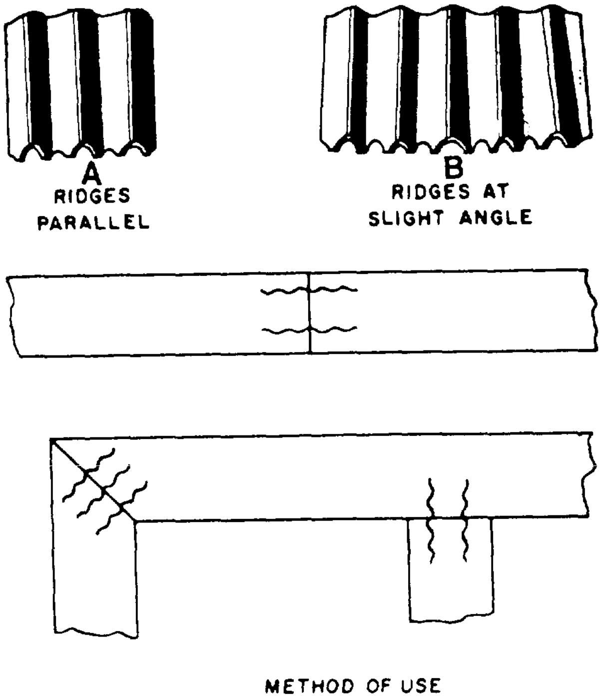


Figure 3-84.-Corrugated fasteners and their uses.

(which have a plastic base) and mastics (which have an asphalt, rubber, or resin base) are the two major categories of adhesives.

The method of applying adhesives, their drying time, and their bonding characteristics vary. Some adhesives are more resistant to moisture and to hot and cold temperatures than others.

SAFETY NOTE

Some adhesives are highly flammable; they should be used only in a well-ventilated work area. Others are highly irritating to the skin and eyes. **ALWAYS FOLLOW MANUFACTURER'S INSTRUCTIONS WHEN USING ADHESIVES.**

Glues

The primary function of glue is to hold together joints in mill and cabinet work. Most modern glues have a plastic base. Glues are sold as a powder to which water must be added or in liquid form. Many types of glue are available under brand names. A brief description of some of the more popular types of glue is listed below.

Polyvinyl resin, or white glue, is a liquid that comes in ready-to-use plastic squeeze bottles. It does a good job of bonding wood together, and it sets up (dries) quickly after being applied. Because white glue is not waterproof, it should not be used on work that will be subjected to constant moisture or high humidity.

Urea resin is a plastic based glue that is sold in a powder form. The required amount is mixed with water when the glue is needed. Urea resin makes an excellent bond for wood and has fair water resistance.

Phenolic resin glue is highly resistant to temperature extremes and water. It is often used for bonding the veneer layers of exterior grade plywood.

Resorcinol glue has excellent water resistance and temperature resistance, and it makes a very strong bond. Resorcinol resin is often used for bonding the wood layers of laminated timbers.

Contact cement is used to bond plastic laminates to wood surfaces. This glue has a neoprene rubber base. Because contact cement bonds very rapidly, it is useful for joining parts that cannot be clamped together.

Mastics

Mastics are widely used throughout the construction industry. The asphalt, rubber, or resin base of mastics gives them a thicker consistency. Mastics are sold in cans, tubes, or canisters that fit into hand-operated or air-operated caulking guns.

These adhesives can be used to bond materials directly to masonry or concrete walls. If furring strips are required on a wavy concrete wall, the strips can be applied with mastic rather than by the more difficult procedure of driving in concrete nails. You can also fasten insulation materials to masonry and concrete walls with a mastic adhesive. Mastics can also be used to bond drywall (gypsum board) directly to wall studs. They can also be used to bond gypsum board to furring strips or directly to concrete or masonry walls. Because you don't use nails, there are no nail indentations to fill.

By using mastic adhesives, you can apply paneling with very few or no nails at all. Wall panels can be bonded to studs, furring strips, or directly against concrete or masonry walls. Mastic adhesives can be used with nails or staples to fasten plywood panels to floor joists. The mastic adhesive helps eliminate squeaks, bounce, and nail popping. It also increases the stiffness and strength of the floor unit.

RECOMMENDED READING LIST

NOTE

Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. You therefore need to ensure that you are studying the latest revision.

Carpentry I, Headquarters, EN5155, U.S. Army Engineering School, Fort Belvoir, Va., 1988.

Carpentry III, Headquarters, EN0533, U.S. Army Engineering School, Fort Belvoir, Va., 1987.