CHAPTER EIGHTEEN

shaping and routing

Shaping refers to an operation in which wood is cut by knives or cutters that rotate horizontally, with the shaft in a vertical position. This is the opposite to the cutting action of a circular saw blade, where the blade is in a vertical position and the shaft is horizontal. These two methods of cutting are illustrated in Figure 18:1.

The shaping operation cuts irregular shapes to a definite design and produces a finished edge in one operation. A good example of this is the moulded edge on a straight or curved table top.

Routing is the cutting of a recess or a groove that does not go all the way through the stock, and is of such a shape that it cannot easily be cut with a power saw.

There are three general types of shapers: heavy duty or production shapers; medium shapers, used in schools and small shops; and portable shapers or routers. All of these machines will perform more or less the same operations although not necessarily with the same efficiency, speed, and accuracy. Shapers are the most versatile of all woodworking machines. There is almost no end to the operations that can be performed on them through the use of jigs, templates, and the wide range of bits and cutters that are available.

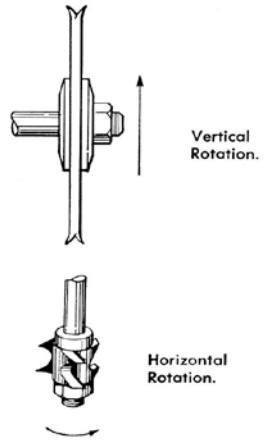

Fig. 18:1 Methods of Cutting

Routers

Let us consider first the router, which is actually a portable shaper. The router is used in cabinet and furniture making for cutting edge mouldings of all types, for cutting channels for inlay work, for making dovetail joints, and for many other operations. Routers are used by carpenters for cutting hinge gains, for mortising locks, and for stair mortising.

The router consists of a high-speed motor with a collet-type chuck attached to the end of the shaft in which the cutters are held. This arrangement makes for a simple, efficient, direct-drive machine. The motor can be raised or lowered in the frame to determine the depth of the cut.

For quick, accurate depth setting, the router can be adjusted by turning the large calibrated ring that is threaded on the motor unit. The position of this ring determines the height of the motor in the frame. For finer adjustments a micrometer-type setting can be made (see Figure 18:3). A quick-action lock holds the motor at the required height setting.

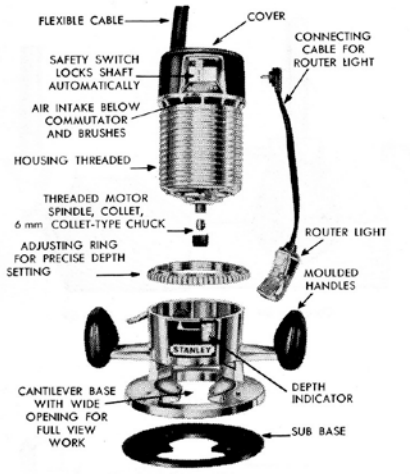

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Fig. 18:2 Parts of a Router

Routers range in size and power from a light 0.18 kW hobby size to the heavy-duty 2 kW production type used by building contractors and in woodworking plants. A heavy-duty router is shown in Figure 18:4.

Bits A to E, in Figure 18:5, are called one-piece bits because the shank and the cutter sections are forged out of one piece. The shaper cutters (G, H, I) have a hole in the centre and must be mounted on an arbor (F) between spacing collars in order to secure the desired cut. Most of the one-piece bits have a pilot below the cutter section that controls the horizontal depth of the cut by riding along the edge of the work. This edge must be finished smooth and to the correct shape before one of these bits is used.

Figure 18:6 illustrates a router with a bit with a pilot being used to put the moulded edge on a table top.

Router bits of the types shown in Figure 18:5 (A and C) have no pilot on the end of them as they are intended to cut a groove that is not at the edge of the

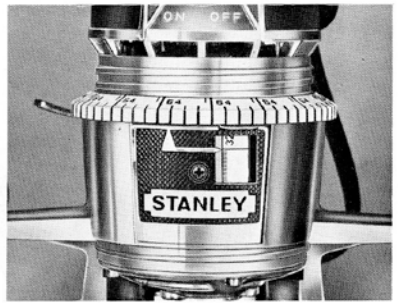

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Fig. 18:3 Depth Setting

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Fig. 18:4 Heavy-Duty Router

work. When using this type of bit in a router you must use a guide. An adjustable guide, shown in Figure 18:7, is used for straight edges.

If the work is curved, as shown in Figure 18:8, a piece of wood can be cut to fit the contour of the work and attached to the guide.

If the groove is to be cut too far in from the edge for a guide to be attached to the router, a piece of scrap wood can be tacked or clamped to the face of the work to serve as a guide. For cutting rabbets in inside corners on such work as

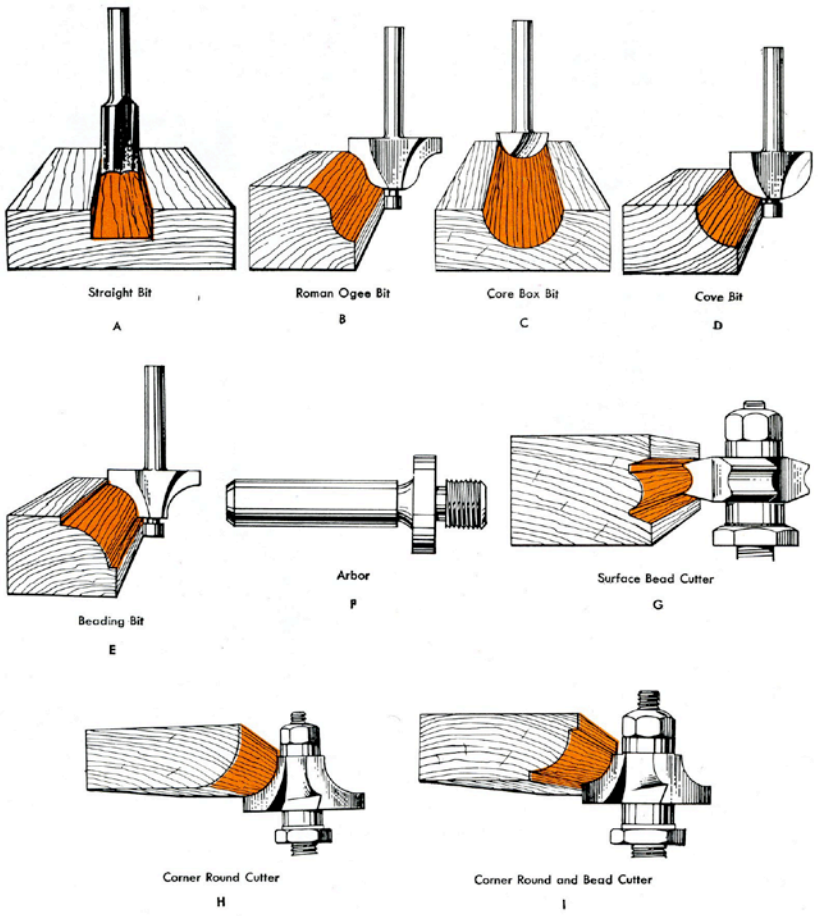

Fig. 18:5 Some of the Many Bits Available for the Router

picture frames or window sashes, a block with a square corner can be fastened to the guide, as shown in Figure 18:9.

Circular grooves can be cut by using a trammel point guide arrangement, as shown in Figure 18:10. It has a sharp centre point that acts as a centre similar to that of a pair of compasses. When the point is held in the wood, the route can be moved around it, forming a perfect circle.

Although it is best to use some type of

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Fig. 18:6 Routing a Table Top

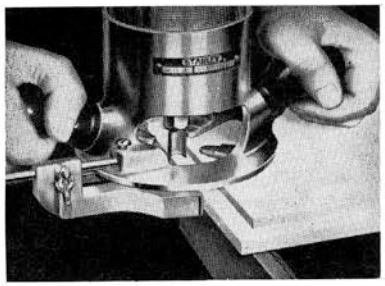

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Fig. 18:7 Routing with a Guide

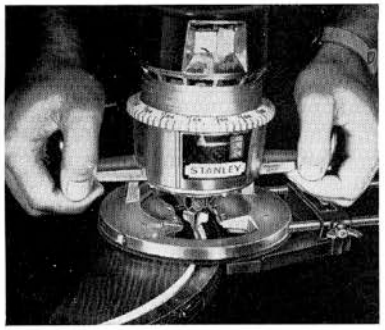

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Fig. 18:8 Wood Section Added to Guide

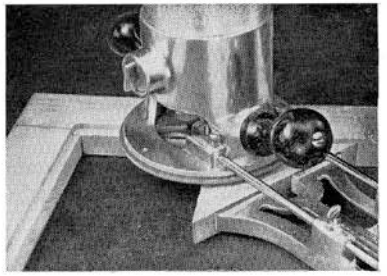

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Fig. 18:9 Routing an Inside Corner

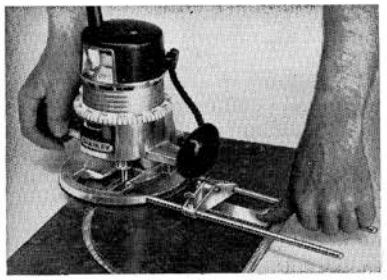

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Fig. 18:10 Routing a Circle

pilot or guide for cutting with a router, it is possible to make most router cuts freehand; in fact, some cuts must be made this way. However, freehand cutting requires considerable skill and experience, and should not be attempted by the beginner.

Template routing

By using a straight router bit, and templates and template guides, duplicate pieces with irregular shapes or intricate designs can be cut quickly and accurately. A template is a pattern or guide that is cut to the size and shape desired for the finished work, and eliminates the slowness and difficulty of cutting intricate designs freehand. The template guides the router over the work to cut the

desired design. It may take a little time to make a good template, but once it is made, it can be used over and over again for routing any number of identical pieces.

Figure 18:11 shows some bits and a template guide. The guide is attached to the base of the router. The bit projects through the hole in the collar of the guide. The collar slides along the template. The template must be made slightly larger than the work to be cut to allow for the distance from the collar of the template guide to the cutting edge of the bit. No radius on the template should be smaller than that of the collar (see Figure 18:13).

Templates can easily be made from 6 mm plywood or hardboard. Simply lay out the design on paper and trace it onto the template material, as shown in Figure 18:12. The shape can now be cut out on the jigsaw or freehand with the router.

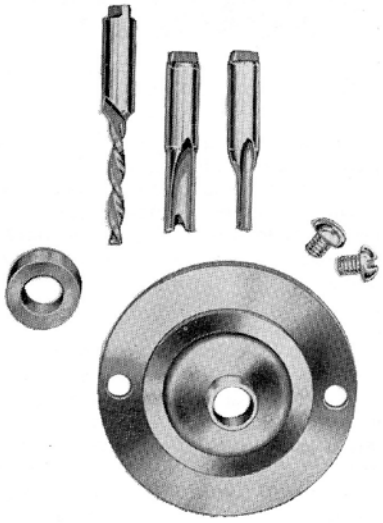

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Fig. 18:11 Bits and Template Guide

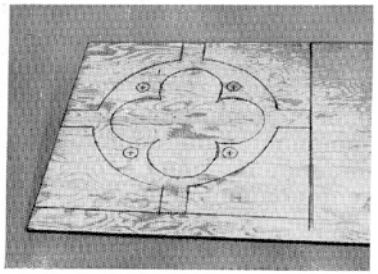

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Fig. 18:12 Template Layout

The edges should be well sanded to ensure a smooth guiding surface.

Clamp or tack the template to the work, as shown in Figure 18:13. Start the cut near the edge of the template, keeping the base of the router flat on the template and the collar of the guide against the edge. Let the router follow around the template until the pattern is entirely cut.

Metal templates are made for production operations in shops and for use by carpenters in the building trade. Figure 18:14 shows a template being used for the routing out of dovetail joints for cabinet drawer fronts. An adjustable butt hinge template is illustrated in Figure

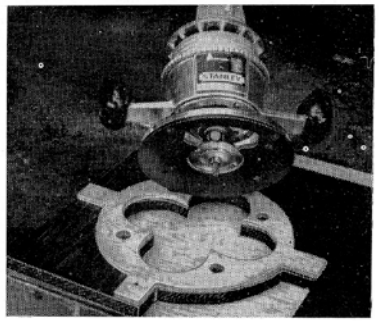

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Fig. 18:13 Use of Template

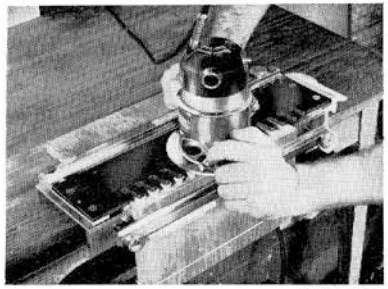

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Fig. 18:14 Dovetail Template

18:15. This is used on either the door or the door frame. A great deal of time and effort can be saved by the carpenter through the use of the router in making the housed joints between the stair stringers and the treads and risers. An adjustable metal stair template is shown in Figure 18:16.

It is often more convenient to move the work than to pass the router over it, especially if the work is large. For this reason the router may be mounted under a table with the bit or cutter projecting through, as shown in Figures 18:17 and 18:18. The router motor unit can be tilted to 45°. Each degree that it is tilted produces a different shape with the same cutter.

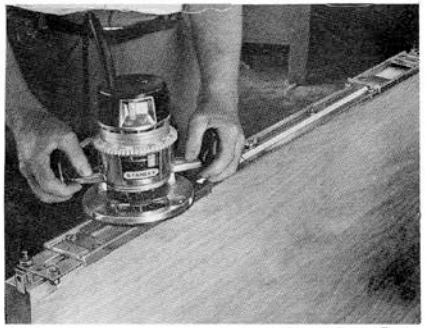

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Fig. 18:15 Butt Hinge Template

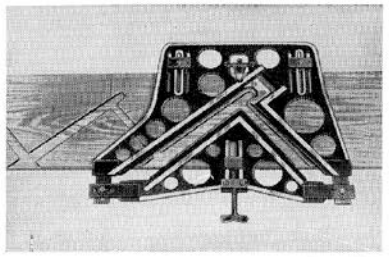

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Fig. 18:16 Stair Template

The router motor unit may also be placed in a plane frame, thus making a portable electric plane. These planes are very useful for fitting doors and sash or planing the edge of any stock that is too large to plane conveniently on a jointer. A large jointer is not always available,

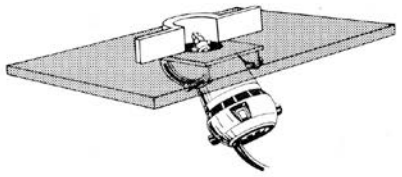

Fig. 18:17 Router and Table Attachment. (Note: The guard must be in place for this operation. It has been omitted here to show the details clearly.)

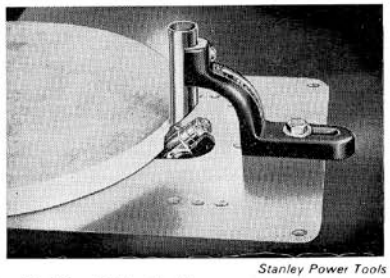

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Fig. 18:18 Table Guide

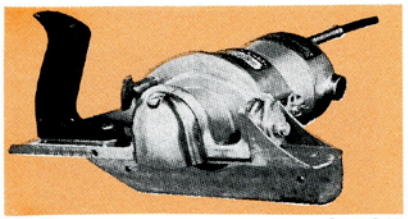

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Fig. 18:19 Electric Plane Attachment

especially in a new house where most of the doors and sash are fitted. A spiral-type cutter is used (see Figure 18:20). Because of the high speed of the router, a very smooth cut can be obtained.

Pointers on the use of a router

Since the router bits and cutters revolve in a clockwise direction, the router should be moved from left to right for straight cuts. When routing circular edges, move the router in a counter-clockwise direction.

The speed at which the router is passed over the work depends on the size of the cut and the type of wood. If the router is moved too rapidly, it will overload the motor, causing the r/min to drop, and the result will be a rough cut. If the router is moved too slowly, the friction of the knife will burn the wood. The router must be kept in motion at all times when routing edges, or serious burning will result from the high speed of the router knives. Most routers run at a speed of between 18 000 and 24 000 r/min.

When changing bits, make sure the round shank is inserted all the way into the chuck and tightened securely. For

Fig. 18:20 Cutter Used in the Electric Plane

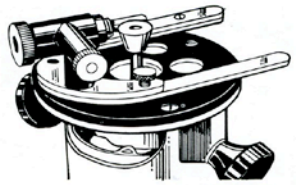

Fig. 18:21 Sharpening Attachment

making smooth, even cuts, the bits and cutters must be kept sharp. A special grinding wheel and grinding fixture can be used to sharpen the bits and cutters. The grinding wheel is rotated by the router, while the fixture holds the bit. This is shown in Figure 18:21.

Safety precautions for the router

Because the cutting tools of the router are exposed during its operation, the following precautions must be observed:

1. Keep your fingers well away from revolving bits and cutters.
2. Do not attempt to rout stock that is too small.
3. If the router is to be passed over the work, make sure the wood is clamped down.
4. Keep the base of the router flat on the surface of the work.
5. Hold the router firmly when you turn on the switch; this is necessary to overcome the starting torque of the motor.
6. Always disconnect the router before changing the cutters or bits.
7. Special care is needed when using the router in the inverted position with the cutter projecting through the table. In this position your hands are exposed to the cutter.

Shapers

The *spindle shaper* consists of a frame, a power-driven vertical spindle projecting through the table top, a guide fence, a safety guard, and an assortment of cutters and collars.

Figure 18:22 shows a medium-sized shaper of the type that might be used in school and small woodworking shops. A larger production shaper is used in factories and mills.

In order to speed up production, the shapers often used in industry have a double spindle. The spindles revolve in opposite directions, allowing the operator to feed the work from either the right or the left. This not only is easier for the operator, but also allows the work to be fed into the machine so that the cutters cut into the grain of the wood, making a much smoother cut with less chance of splintering. Figure 18:23 illustrates the direction in which the work should be fed.

The single spindle shaper shown in Figure 18:22 is often made with a reversing switch that changes the direction of rotation of the spindle.

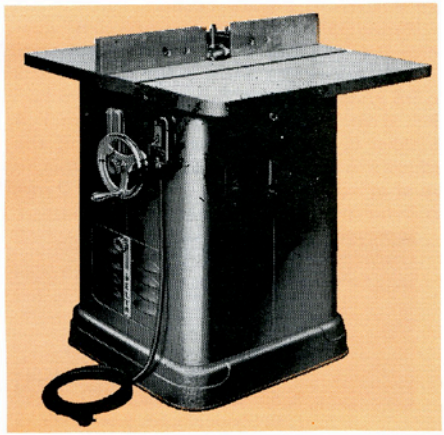

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Fig. 18:22 Medium-Sized Shaper

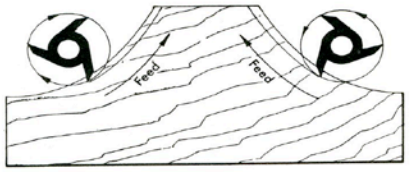

Fig. 18:23 The work should be fed into the grain and against the cutter.

There are two general types of cutters used on shapers: the *one-piece knife* type (Figure 18:24), which has three cutting lips, and the *open-faced knives* type, which has two individually ground blank knives (Figure 18:25). The one-piece cutters are used on smaller machines and are considered to be safer, as there is no danger of their leaving the spindle while it is rotating. The open-faced knives are more commonly used because they can so easily be ground to any desired shape. They fit between two slotted collars, which are held in place by a nut on the top of the spindle.

It is absolutely essential that the two

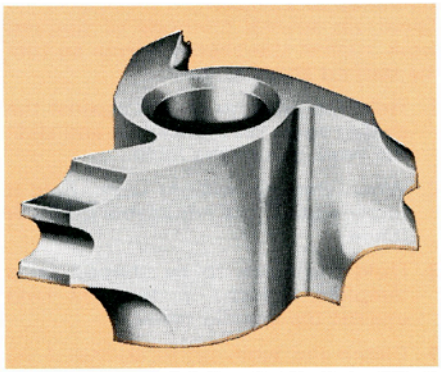

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Fig. 18:24 One-Piece Cutter

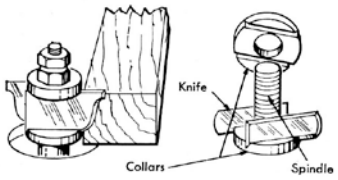

Fig. 18:25 Open-Faced Knives

knives be exactly the same width. If they are not, one will always be loose regardless of how tightly the nut is tightened. A loose cutter knife can cause serious injury if it flies out. The knives should be tested for width before they are used. This can be done by placing the knives in position and tightening the nut by hand. Grasp both knives and pull them outward simultaneously. If one knife slides more easily than the other, the knives are not matched and should not be used together.

Still another type of shaper knife is the *cutter head*, which has a solid centre section with three removable blades held firmly in place by Allen screws (see Figure 18:26). These are used mainly as an attachment for a circular saw.

Operation of a shaper

There are several methods of guiding work against the shaper knives so that the desired shape is cut.

1. Hold the work to be cut against the shaper collar on the spindle and slide the work across the table.
2. When shaping straight work, hold it firmly against the adjustable guide or fence.
3. Hold the stock to be shaped on a template, which, in turn, is held against the spindle collar.
4. Clamp the work on or against a jig or form, such as was described for the router earlier in this chapter.

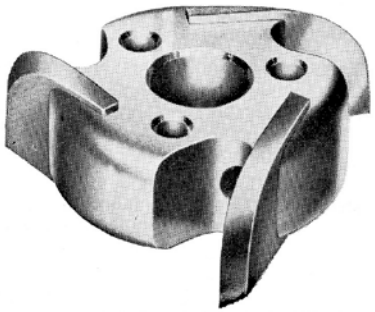

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Fig. 18:26 Cutter Head with Three Knives

Whenever possible, use the fence to ensure safe operation. It will be noted that the depth of the cut can be regulated by moving the fence (see Figure 18:27).

Most shaping is done against a collar because it is so convenient to shape curved edges in this way. The work needs only to be held firmly against the collar, which will automatically control the depth of the cut if the knives are set correctly. The collar, knives, and work are shown in Figure 18:28.

Industrial plants use patterns to advantage for shaping work to an exact size, as they allow the entire edge of the work to be shaped. (This is not possible when the work must ride on the collar.) A pattern is cut to the exact size and the edges are finished smoothly. The work to be shaped is cut to rough size, i.e. 2 mm to 3 mm oversize. It is held to the pattern

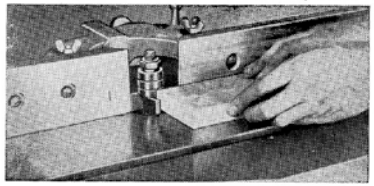

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Fig. 18:27 Shaping with Work Against the Fence

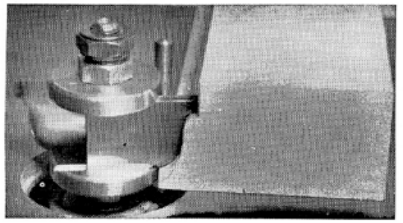

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Fig. 18:28 Shaping with a Collar

by anchor points, usually brads or nails driven through the pattern so that the points project, as shown in Figure 18:29. The template slides on the collar, making it possible to cut the full thickness of the work.

Safety precautions for the shaper

Of all the woodworking power machines the shaper is probably the most dangerous because it is impossible to keep the knives covered and because the work is fed into the machine by hand. For these reasons it is essential that you take every possible safety precaution when operating the shaper. The safety precautions listed for the router apply also to the shaper, as well as these additional ones:

1. Make sure the spindle nut is tight and that the knives are correctly adjusted before starting the shaper.
2. Use all guards and hold-down devices on the machine that will add to the safety of the operator. Figure 18:30 illustrates the hold-down arrangement on some shapers.
3. See that the spindle is free before turning on the machine. A lock is provided to secure the spindle while the nut is being tightened.
4. Keep your fingers as far away from the knives as the size of the work will permit.
5. Do not attempt to shape small pieces unless they are held in a form or jig.

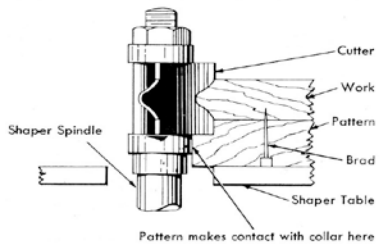

Fig. 18:29

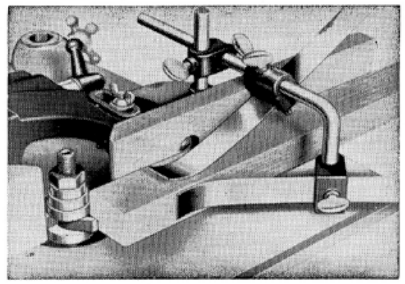

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Fig. 18:30 Safety Hold-Down Arrangement

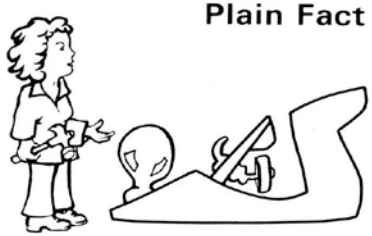
ASSIGNMENT

1. What is the difference between shaping and routing?
2. List three types of shapers.

Router

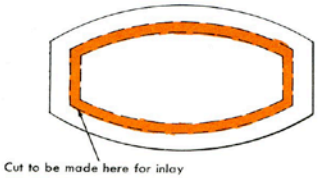
3. List four operations performed with the router (a) by cabinetmakers, (b) by carpenters.

Plain Fact

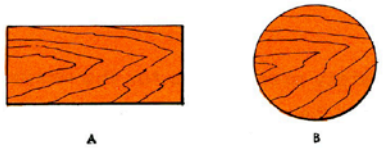


THE SHAPER IS THE MOST DANGEROUS OF ALL WOODWORKING MACHINES. TREAT IT WITH RESPECT!

4. How is the depth of the cut regulated?
5. Name and draw the shapes of four commonly used router bits.
6. What is the difference between a router bit and a router cutter?
7. Why do many router bits have a pilot pin below the cutting section?
8. Draw the shape of the part that must be cut and attached to the guide to make the inlay cut in the table top shown below.



9. Why should a guide be used when cutting with a router?
10. What is the advantage of using templates for cutting parts to size with the router?
11. Explain how the template guide is used with the template in cutting work to size. You may use a drawing to clarify your answer.
12. For what operation do carpenters use router templates in home construction?
13. For what operation is an electric plane used?
14. Indicate with an arrow the direction in which the router should be moved when shaping the edge of the two pieces of stock shown here.



15. What would be the result if the router were moved too rapidly over the work? if it were moved too slowly?
16. List the three safety precautions that you consider most important when operating the router.

Shaper

17. What is the advantage of a double spindle shaper over a single spindle shaper?
18. Name the two general types of cutters used on the shaper. Which type is considered to be the safer?
19. (a) Why must shaper knives that are used in pairs have exactly the same width?
    (b) Explain the method of testing the knives for proper width.
20. State the three methods of guiding the work against the shaper knives.
21. Explain how the collar on the spindle determines the depth of the shaper cut.
22. Explain how a template is used in cutting work to the correct size on the shaper.
23. Why is the shaper more dangerous than most other woodworking machines?
24. What is meant by the torque of a motor? (See Glossary of Terms.)

CHAPTER FIFTEEN

drill press and mortiser

Drill press

The drill press is a useful, versatile, and easily operated machine. It is often considered a machinist's tool because of its use for drilling holes in metals; however, it is also very adaptable to woodworking for such operations as boring, mortising, routing, and sanding, which can be performed with the aid of attachments.

The drill press (see Figure 15:1) consists of a vertical column set on a base. On the upper end of the column the motor and the drill spindle are mounted. The spindle is driven by a belt and cone pulley arrangement that can be moved up and down by operating a hand lever, or by a foot feed. The table can also be moved up or down on the column to accommodate work of different sizes. The table can be tilted to 45° for angle boring. A depth gauge is generally provided to control the depth of the holes.

Most drill presses are fitted with two cone pulleys, one on the motor and the other on the spindle, so that selective speeds can be obtained for various operations. The cone pulleys used vary in diameter, but the average speeds required for woodworking operations are 680, 1250, 2400, and 4600 revolutions per minute (r/min). The speeds are changed by moving the V belt from one step on the cone pulley to the other. Some drill presses are equipped with a third cone pulley for a greater variation of speeds (see Figure 15:2).

Drill presses are made in both floor and bench models, the only difference being the length of the column. A bench-type drill press is shown in Figure 15:1.

The bits used for boring holes with a drill press differ from those used in the hand brace. Since three-jawed chucks are used on the drill press, the bits must have a round shank in place of the square one used with the brace. Bits with a screw feed should not be used unless the speed of the drill press can be reduced to that of the lead of the screw; otherwise the bit will lift the work and it will spin with the bit. For this reason most bits used have brad points (ones with no threads). Large-size bits are sometimes referred to as *cutters*, which bore holes up to 75 mm in diameter. Some of the bits used in a drill press are shown in Figures 15:3 to 15:7.

The speed at which the drill press should be operated for drilling in wood will depend on the diameter of the bit being used. For holes up to 20 mm in diameter the second-lowest speed (about 1250 r/min) should be used. For larger bits and cutters the speed should be reduced to the slowest speed (about 680 r/min).

Drill press attachments

One of the most useful attachments that can be used with a drill press is the mortising attachment.

Mortising is the operation of making square or rectangular-shaped holes to receive the tenon half of a mortise-and-tenon joint. The square holes are made by placing a bit inside a hollow chisel. The bit revolves, removing the wood, and the square chisel slices the wood from the side of the hole as it is forced down by the drill press. This leaves a neat, square hole of the required size and depth.

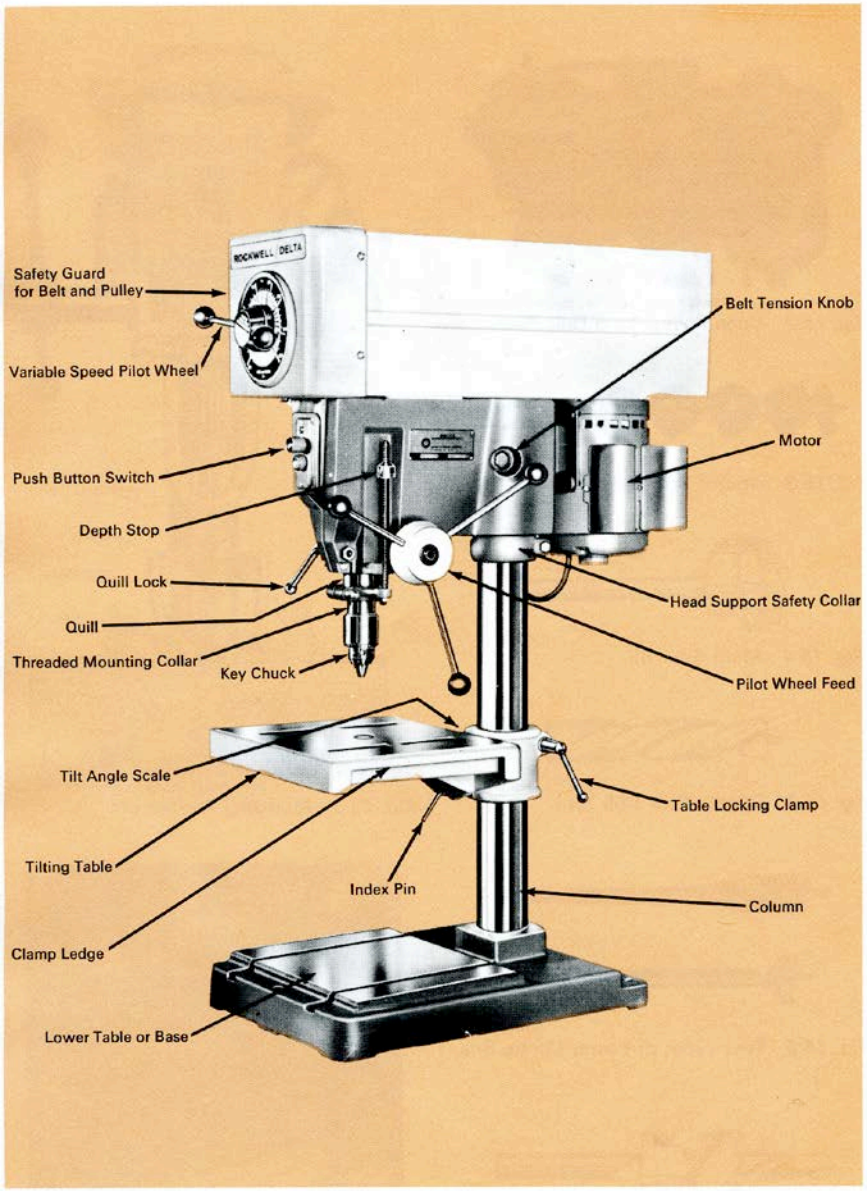


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Fig. 15:1 380 mm Drill Press

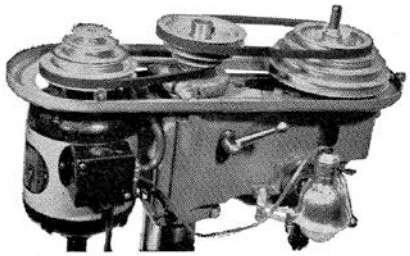

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Fig. 15:2 Cone Pulleys on a Drill Press

Fig. 15:3 Double Spur Drill Press Bit

Fig. 15:4 Multi-Spur Bit

Fig. 15:5 Double Spur Drill Type

Stanley Tools

Stanley Tools

Fig. 15:6 Two Types of Power Centre Bits

Fig. 15:7 Adjustable Countersink Bit

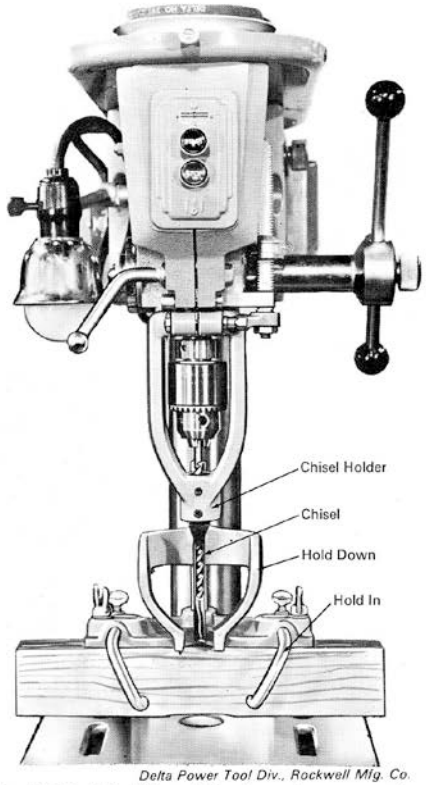

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Fig. 15:8 Mortising Attachment

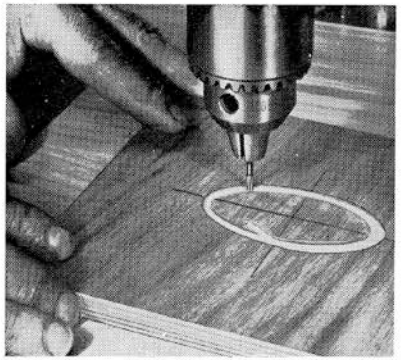

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Fig. 15:9 Cutting a Design with a Router Bit

The mortising attachment is shown in Figure 15:8. Note the fence and hold-down and hold-in arrangements, which secure the work in place while the mortising is done. Since both the drill press and the mortiser require the same set-up for the mortising operation, the set-up procedure is described with the mortiser on pages 96-7.

Another important operation that can be performed with the drill press is *routing*, cutting a continuous hole or groove. This type of cut is used for inlay work and many other special purposes. Figure 15:9 illustrates one application of a router bit: cutting an inlay design.

Special bits or cutters are used for routing. A short, fluted, flat-bottomed bit is generally used (see Figure 15:11). The bit may be fastened in the chuck or in some cases a special collar is used on the spindle of the drill press to hold the router bit more firmly.

Several rules must be followed when using a router bit with a drill press:

(a) The work must be fed into the bit against the rotation of the bit.

(b) For making straight cuts a fence must be used to guide the work. Slide the work along the fence so that the rotation of the bit will force the work against the fence. This generally means that the work should be moved from left to right, as shown in Figure 15:12.

(c) Only light 2 mm cuts should be made. If deeper cuts are required, several passes should be made. When heavy cuts are made, the cutter tends to grab the work and tear pieces of wood out instead of making a smooth cut.

(d) The router bit must rotate at high speeds to make a smooth cut.

(e) Keep the bits sharp. For curved cuts, special set-ups involving some type of guide arrangements should be used. One of these is shown in Figure 15:17.

Fig. 15:10 Fluted Router Bit

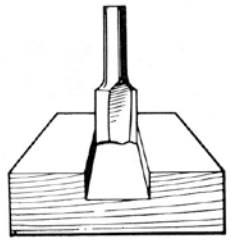

Fig. 15:11 Router Bit with Small Shank

Shaping can be done on the drill press by using special cutter knives. Mouldings can be cut on the edge of stock by using any one of a great number of cutters available, or a combination of several cutters may be used to cut almost any desired design on the edge of the work. Some of the possible shapes are shown in Figure 15:13. More is said about shaping in Chapter 18.

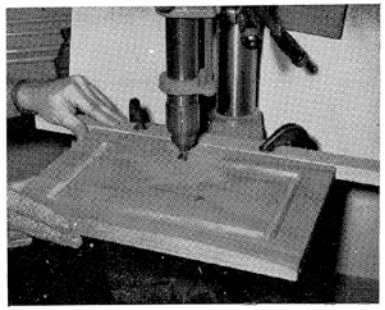

Fig. 15:12 Note the direction of the feed.

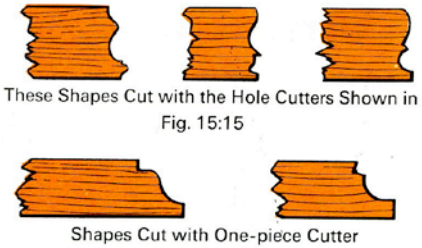

Fig. 15:13

There are two types of cutters in general use:

(a) The straight cutter, which can be used in the drill chuck, such as the one shown in Figure 15:14.

(b) The hole cutter, which is made with three cutting surfaces with a hole in the centre. This cutter fits over a spindle with a collar attached. The collar rides on the edge of the work and governs the depth of the cut to be made. Some of these cutters are shown in Figure 15:15. For straight work a fence should be used; for curved edges a collar or the round part of the cutter acts as the guide.

As for routing, the cutter must travel at a high speed for shaping: 4600 r/min makes a smooth shaping operation. To prevent burning, keep the bits sharp and

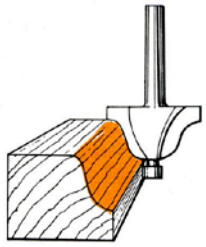

Fig. 15:14 Straight Cutter

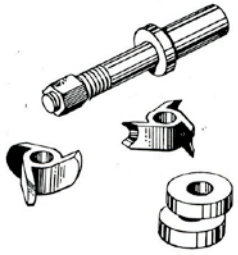

Fig. 15:15 Hole Cutters

the work moving past the cutter. If the work is allowed to remain stationary while in contact with the revolving cutter, the moulded edge will be burned or discoloured.

Shaping can also be done with the router or spindle shaper if they are available. These machines are described in Chapter 18.

Some sanding operations can be performed on the drill press to advantage, especially on curved surfaces. Sanding drums of various sizes are used. They generally consist of a metal shaft, a rubber drum, and a garnet sandpaper sleeve. The sandpaper is slid over the rubber drum and the nut on the end tightened. This expands the rubber, making the paper tight. Sandpaper sleeves in various grits and diameters are available for this operation. Three sizes are shown in Figure 15:18.

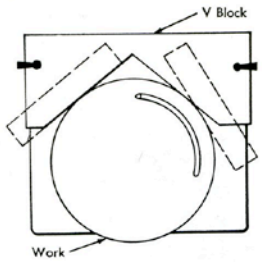

Fig. 15:16 Inlay Work on Curved Edges

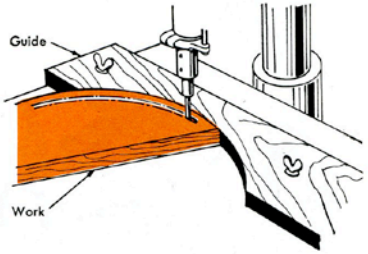

Fig. 15:17 Inlay Work on Curved Edges

Safety precautions for the drill press

(a) When boring holes in small pieces of wood, make sure the wood is held securely.

(b) Be sure to use a bottoming piece under the work so that you will not drill into the table.

(c) Operate the drill only at the correct speed.

(d) Made sure the bit is tight in the chuck.

(e) Locate the centre of the hole with an awl. Do not work by guess.

(f) Always switch off the drill before leaving it.

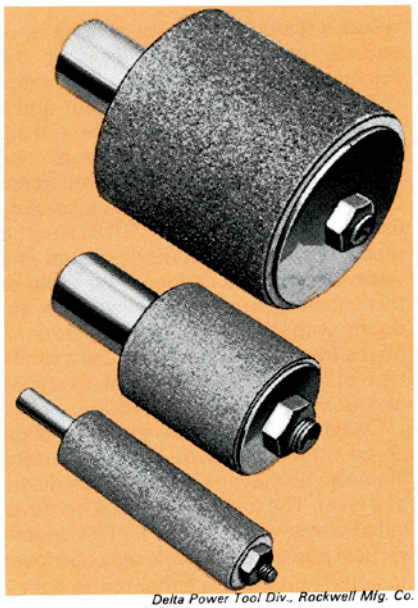

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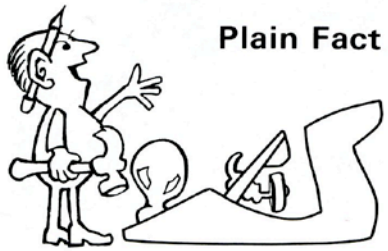
Fig. 15:18 Drum Sanders

Hollow chisel mortiser

The mortiser is a machine designed exclusively for mortising. It performs the same operation as the mortising attachment for the drill press. The same types of bits and chisels are used in both machines. However, these operations can be performed faster and more efficiently on the mortiser because it is a heavier, more powerful machine designed especially for this operation.

There are two general types of mortisers: (a) the *hollow chisel mortiser*, and (b) the *chain saw mortiser*, where the



Plain Fact

THE DRILL PRESS IS A MOST USEFUL MACHINE; IT CAN SERVE NOT ONLY FOR DRILLING, BUT ALSO FOR MORTISING, ROUTING, SHAPING, AND SANDING. WHEN PROPERLY SET UP IT IS EASY TO OPERATE AND SAFE TO USE.

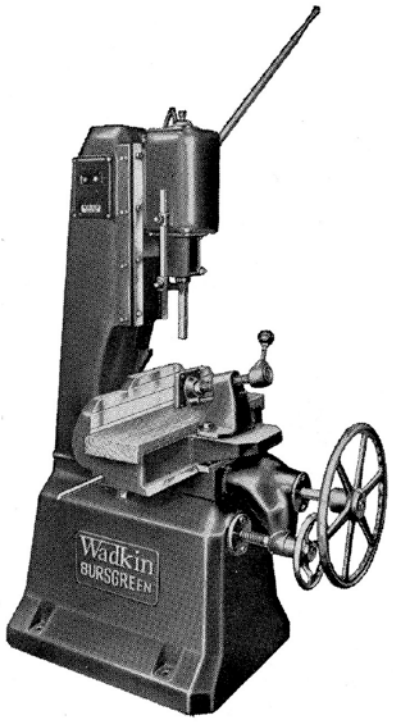
wood is removed from the mortise by an endless chain saw arrangement that rotates around two sprockets. The hollow chisel type is the most common and is the one that we will describe here. It can be used for most general types of mortising and is easily set up and operated. One type of modern hollow chisel mortiser is shown in Figure 15:19. Another type of hollow chisel mortiser that is in wide use has a foot feed. The table on this machine generally moves up and down, with the motor unit held stationary on the frame. Both machines use a similar type of clamping arrangement, as shown on the mortiser in Figure 15:19.

Certain main parts make up the hollow chisel mortiser shown here. The motor head can be moved up or down by means of a lever. The motor unit slides on dovetailed ways, which keeps it in a perfectly vertical position. The table may be moved in a horizontal plane either to the right or to the left, in toward the main column, or out toward the operator, which enables him or her to cut a fairly long mortise without resetting the stock in the clamps on the table. There is a fence at the back of the table, and an adjustable clamp that holds the work firmly against this fence at the correct location while the cut is being made. The upper end of the hollow chisel fits into a bushing, which, in turn, is attached to the motor shaft. The bit, which fits inside the chisel, revolves and removes the bulk of the wood, leaving only a small amount of wood in the corners to be cut out by the chisel.

The machine can be set to cut any desired depth of mortise. Care must be taken to allow clearance between the bit and the chisel or the bit will heat up in operation.

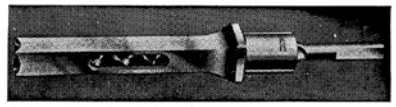
To set up and cut the mortise

The set-up of the mortiser for cutting any particular mortise will depend to some extent on the make of the machine.



Wadkin

Fig. 15:19 Hollow Chisel Mortiser



Wadkin

Fig. 15:20 Hollow Chisel and Bit

Care must be taken to attach the chisel properly in the bushing and sleeve, and to secure the work on the table in the correct location.

The general steps that are listed here should be adaptable to most makes of hollow chisel mortisers as well as to the mortising attachment for the drill press.

1. Lay out the position of the mortise on the stock. If several pieces with identical mortises are to be cut, the layout need be made on only one piece.
2. Lower the chisel to the face of the work and adjust the fence so that the edge of the chisel will cut on the edge of the layout, as shown in Figure 15:21.
3. Mark the correct depth of the cut on the end of the stock. Set the chisel to this depth, as illustrated in Figure 15:22. Set the depth gauge arrangement.
4. Tighten the clamps and the hold-down arrangement to secure the work firmly in position.
5. Make the first cut at the start of the mortise. Lift the chisel often to clear the chips and prevent it from overheating.

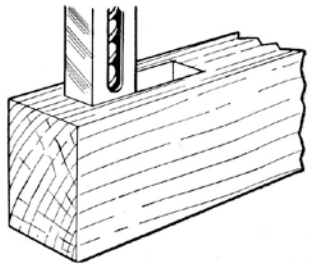


Fig. 15:21 Mortise Bit in the Work

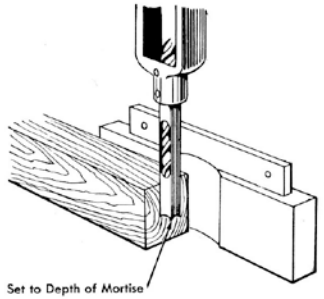


Fig. 15:22

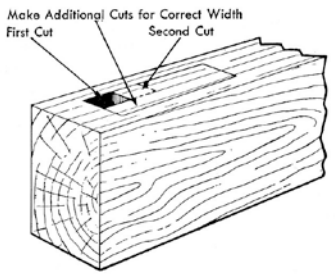


Fig. 15:23

6. Move the table or the work ahead three-quarters of the width of the mortise and make another cut.
7. Continue making cuts until the end of the mortise is reached. To make the mortise the exact length required, it is advisable to make the two end cuts first.
8. Wherever possible the hollow chisel used should be the same size as the width of the moritse. However, where a width of mortise other than a standard-sized chisel is required or where the correct size is not available, additional cuts must be made, as shown in Figure 15:23.

Bits and chisels commonly come in sizes of 6 mm, 8 mm, 10 mm, 12 mm, 14 mm, 16 mm, 20 mm, and 24 mm. The spindle speed of most mortisers is from 3000 to 3600 r/min. If a mortise attachment is being used on the drill press, the belt should be on the second highest speed (2400 r/min).

ASSIGNMENT

Drill press

1. What operations can be performed on the drill press?
2. What are the four speeds generally used for the drill press?
3. If you wish to increase the speed of the drill press, would you (a) move

the belt to a larger section of the cone pulley on the drill spindle, or (b) move the belt to a larger section of the cone pulley on the motor?

4. When a third cone pulley is used, as is shown in Figure 15:2, how many different speeds may be obtained?
5. How do bits used on a drill press differ from those used with a hand brace?
6. What is the recommended drill speed for a 12 mm bit?
7. List four types of bits that may be used on a drill press.
8. Explain how the mortise bit and chisel operate to cut a square hole.
9. List three safety rules that must be observed while operating the drill press.
10. For what purpose other than inlay work might you require the routing operation?
11. When routing, why should the work be fed into the bit against the rotation of the bit? Why should only light cuts be taken?
12. What is meant by shaping with a drill press? What types of bit or cutter are used?
13. At what speed should the bit be travelling for the routing or shaping operation?
14. If the motor speed is 1450 r/min, and the belt is running from the 100 mm step of its cone pulley to the 150 mm step on the cone pulley on the drill press, what would be the r/min of the drill chuck?

Mortising

15. List two types of mortisers.
16. What advantage does a hollow chisel mortising machine have over the mortising attachment on a drill press?
17. How is the work held in the correct position when making a mortise cut?
18. List the first four steps required in the mortising operation.
19. In what standard sizes are hollow chisels made for use on a mortiser?
20. With the aid of a sketch, explain the order of the cuts required to cut a mortise 13 mm wide and 80 mm long on the mortiser.

CHAPTER TWENTY-FOUR

finishing — part 1

It is the finish applied to a well-sanded base that adds beauty and durability to a project. For this reason it is important that the correct type of finish be selected and properly applied.

There are three general classifications of wood finishes: stain, natural, and paint or enamel. There are, of course, many variations of each of these types and others are being developed all the time. The type of finish used on a project depends on several factors, such as:

(a) The type of wood used. Some woods, such as walnut, oak, and mahogany, are better adapted to natural finishes. These woods have an attractive grain formation as well as a distinctive colour. Other woods, such as maple, birch, and beech, have an attractive grain formation but are generally considered too light in colour for natural finishes, and because of this they are often stained. Still other woods, such as basswood and spruce, are generally considered better adapted to a paint finish.

(b) The use to which the furniture is to be put. Kitchen furniture and outdoor furniture are generally painted, while other furniture more often has a stained or natural finish.

(c) The type of finish on the other furniture that the new project must match.

Stained finishes

We shall consider first the stained finish. Wood is stained to give it a desired colour, to bring out the natural beauty of the grain, and, in some cases, to provide some measure of protection for the wood. Stains are made in the colours of dark-coloured woods such as walnut, oak, or mahogany, either to make light-coloured woods resemble the more highly coloured woods, or to deepen the colour of the dark woods. Most stains can be classified as water stain, oil stain, or spirit or lacquer stain. These stains differ mainly in the solvent that is used to dissolve the colour pigments.

Water stains

These are made by mixing colouring materials that are soluble in hot water. They are brilliant, have an even penetration, and are non-fading. Water stains, however, have the disadvantage of causing the grain to rise, a factor that makes resanding the work necessary.

Oil stains

There are two general types of oil stains —*penetrating oil stains* and *pigment oil stains*. Oil stains are not as bright, nor do they penetrate as deeply, as water stains, but they have the advantage of not raising the grain of the wood. Penetrating oil stains are made with aniline and coal tar dyes using light oils such as turpentine, naphtha, or benzol as a solvent or base. They are mixed when hot. Pigment oil stains are made from colour pigments similar to those used for tinting paint. These are mixed with linseed oil. Oil stains are very convenient to apply because they do not dry too rapidly and can be brushed over several times if necessary so that no lap joints will show. They are referred to as *wiping stains* because they can be wiped over while

they are still wet to make the stain lighter and the grain show through.

Oil stains, if not protected by shellac or varnish, tend to fade when exposed to the light. The stain will bleed (dissolve slightly) if varnish is applied directly over it. This can be avoided by giving the work a wash coat of shellac over the stain before varnishing. Oil stains are more expensive than water stains but are used more extensively because of their convenience and their easy application.

Spirit stains

These stains have a base of alcohol to which pigments or dyes have been added. They are bright and have good penetration, but will fade if not protected by varnish. Shellac should not be used directly over spirit stains as the alcohol in the shellac will dissolve the stain. The main advantange of these stains is that they are quick-drying. They can be recoated in 10 to 15 min. This factor makes them very popular in industry because the work can be stained, filled, and varnished all in the same day. They are referred to in industry as *N.G.R.* (non-grain-raising) stains. Their disadvantage is that they are difficult to apply with a brush because they dry so rapidly; a spray gun is generally used.

How to apply stain

The following points should be observed when applying oil stain:

1. The work must be free from all dust.
2. As end grain has more suction and absorbs stain more readily than flat grain, it should be given a coat of the oil that has been used as the solvent or base of the stain. With most oil stains linseed oil can be used for this purpose. The oil should be allowed to dry before staining.
3. Apply the stain with a brush or cloth. Start on the unexposed portion of the project. Work stain into all the angles or awkward spots, making sure no spots are missed.
4. Allow the stain to penetrate for a few minutes or until it becomes dull. Then wipe it over with a soft cloth to remove the excess stain and to make a more uniform colour. Do not wipe too soon, or too much of the stain will be removed; but do not wait too long, or the wiping will make the job streaky. In general, the longer the stain is left before wiping, the darker the finish will be.
5. Let the work dry for 24 h in a dust-free area before recoating.

The same procedure is followed when applying water stain except that a sponge coat of clear water is applied first. This raises the grain. After it dries, it is sanded down before staining. This minimizes the amount of sanding required after staining.

Spirit stains are seldom brushed on because they dry so quickly. A spray gun should be used. Spirit stains are not wiped and therefore must be applied evenly so that no laps or streaks will appear. Dark patches may be lightened by rubbing them with a cloth that has been moistened with spirits.

Fig. 24:1 Wiping an Oil Stain

Wood fillers

There are two types of wood fillers — *paste filler* and *liquid filler*. Either is used as a base for a shellac or varnish finish. We do not refer here to the thick commercial wood fillers that are used to cover defects, nail-holes, open joints, or other signs of poor work. A careful worker has no need for this type of filler.

Paste or liquid fillers are required on most woods to fill the open pores of the wood and make a smooth surface. If the pores are not filled, the finish will be uneven and pitted.

Woods are divided into two general classes — open-grain woods and closed-grain woods. The open-grain woods, such as oak, ash, or elm, have a very coarse grain with large pores that require a paste filler, while the closed-grain woods, such as birch, cherry, or maple, which have a finer wood texture, require only a liquid filler. Some of the soft-woods, such as pine, basswood, or cedar, which have a very close grain, do not require a filler of any type; however, a liquid sealer of some type should be used. No two species of woods have identical wood textures. With different-sized wood cells it is difficult to classify all woods as having definite closed or open grains; some are in between. The filler used must be mixed according to the wood.

Paste wood fillers may be bought already prepared from the paint store, or they can be mixed. The ingredients of fillers vary somewhat according to the wood on which they are used, but a more or less standard mixture that is used by many finishers can be made as follows:

500 mL boiled linseed oil
1000 mL turpentine
170 mL Japan drier

To this mixture add enough silex powder to make a thick paste. Stir the mixture well and strain through a wire screen. Thin with benzine or naphtha to the consistency of thick cream.

The basic ingredient of filler is the silica powder, which fills the wood pores. It is made from very finely ground quartz rock, is pure white in colour, and is commonly called *silex*. Although other powders, such as cornstarch, are sometimes used in fillers, silex is considered the best for general use. Stain may be added to the filler either to darken the stain already on the work, or to stain and fill the work in one operation. This is sometimes done to save time but is not as good a method as the two-coat application.

Liquid filler may also be bought already prepared or it may be mixed. The ingredients for this filler, as used by many finishers, are:

4 L rubbing alcohol
1 L turpentine
500 mL Japan drier
1 kg silex powder

Stir well and thin with benzine or turpentine to an easy brushing consistency. If the filler is to serve the dual purpose of a stain and filler, colour must be added.

How to apply wood filler

Paste wood filler should be applied to open-grain woods after the work has been stained in order to allow the stain to penetrate into the wood but still leave open the pores that must be filled.

The filler should be applied liberally and worked well into the wood fibres with a stiff brush or cloth. Brush across the grain, working the filler well into the pores of the wood. The excess filler must be rubbed off with excelsior, burlap, or fine shavings. Before being rubbed, the filler should be allowed to set 5 to 10 min or until it loses its wet, shiny appearance. Rub vigorously across the grain. No surplus filler should remain, or it will create a foggy appearance when succeeding coats are applied. Care should be taken not to rub too hard with the grain, or the filler may be drawn out of the wood pores. Let the work dry for 24 h before recoating.

Liquid fillers should be applied in the same manner as paste fillers, but less wiping is required.

In some cases the stain is sealed by giving it a wash coat consisting of 1 part shellac to 4 parts alcohol before the filler is applied. The advantage of sealing the stain is to prevent the filler from softening the stain and to make the filler easier to wipe. The filler, in turn, is generally sealed with the same mixture before finish coats of shellac, varnish, or lacquer are used. On many softwoods, such as fir or pine, the bare wood is sealed instead of using a filler of any type. The pores are sealed instead of being filled. The sealer used may be either a diluted shellac or one of the many commercial sealers that are sold for this purpose. Some of these lacquer sealers are now used extensively on hardwood floors in place of fillers.

Shellac

Pure shellac is manufactured from a gum called *lac*, which is deposited on the branches of certain species of tropical trees by swarms of tiny lac insects. The gum-laden twigs and branches, which are called *lac sticks*, are gathered by workers, and the dark, resinous, gummy material is heated and separated from the bark and wood, and then allowed to dry into hard, flake shellac.

The shellac gum can be dissolved in denatured alcohol to a liquid state so that it can be brushed or sprayed. The amount of alcohol used to dissolve the shellac gum determines the grade or strength of the shellac. Most good shellacs are a solution of 1 kg of shellac dissolved in 2.5 L of alcohol. Other grades range from 0.5 kg to 1.2 kg dissolved in 2.5 L of alcohol.

Shellac in its natural form is a dark orange colour, hence the name *orange shellac* when it is used in its natural colour. Orange shellac should be used only on dark-coloured woods. The natural shellac gum must be bleached to make *white shellac*, which is used as an almost transparent finish suitable for light-coloured woods. A type of synthetic shellac with a plastic base is now being manufactured.

Shellac may be used as a filler, a sealer, and a base for a wax or varnish finish, or it may be used as a final finish. In some cases it may be used for special finishes, such as French polish or dip-and-rub finish. Shellac makes a hard, bright, smooth finish that dries fairly rapidly. It has, however, the disadvantage that it cannot withstand moisture. The finish will take on a milky look if it comes into contact with moisture. It will not withstand high temperatures either. A shellacked table-top may become gummy if placed in front of a window on a bright sunny day. For these reasons shellac finishes are not as popular as they once were. They have to some extent been replaced by synthetic varnishes; however, shellac is still used and is considered important enough to be discussed here.

How to apply shellac

Shellac may be applied with a spray gun or with a brush. For the first two coats the shellac should be diluted to a solution of 0.5 kg of shellac dissolved in 2.5 L of alcohol; for remaining coats, use a solution of 1 kg of shellac dissolved in 2.5 L of alcohol.

When applying shellac, use a soft varnish brush. Use long, running strokes, brushing with the grain of the wood. Work quickly and do not brush back and forth over the work too often, or the shellac will build up in ridges and will show lap marks. If a spot is missed leave it to be covered in the next coat, as it is very difficult to touch up shellac.

For the first coat allow 3 to 6 h drying time; for succeeding coats allow 12 h. Rub the work down between coats with fine sandpaper or steel wool, rubbing with the grain. After each sanding, dust the work with a cloth before recoating. If the cloth is dampened with benzine, it does a better job of picking up all the dust particles.

French polish

This type of finish has been used on fine furniture for many generations. It takes considerable time and care, but the resulting fine finish is worth the effort.

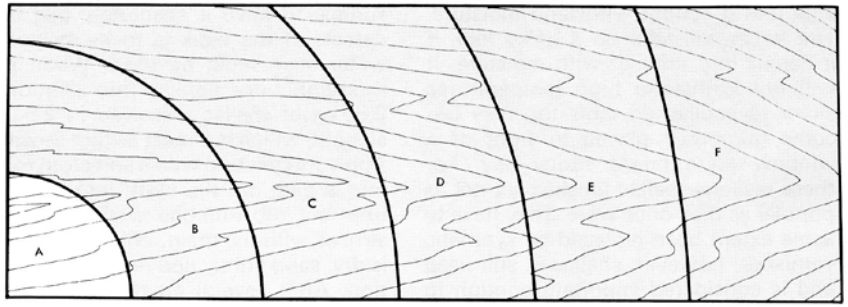
Care must be taken in preparing the surface to have it absolutely free from defects. If the work is to be stained, a water stain must be used. When it is thoroughly dry, apply a thin solution of 0.25 kg of shellac dissolved in 2.5 L of alcohol, which is almost as thin as water. Apply this mixture with a soft cloth rolled into a pad; dip the cloth into the mixture and rub into the work in straight strokes with the grain. When the surface is dry, sand lightly and repeat the operation. After several coats a light sheen will appear. At this stage add a few drops of boiled linseed oil and continue the rubbing, but change to a rotary motion. For each succeeding coat add a little more oil. Continue until the work has a deep, glowing finish.

French polish may also be used to refinish a surface that has become scratched or blemished. For this operation care must be taken to rub in an even circular motion. The secret is to keep the pad in constant motion. Even a slight pause will cause the tacky cloth to stick and leave a rough blemish in the polished surface. If this occurs, the new finish must be removed with alcohol and the French polishing operation started over. Rub with an even circular motion, which produces a series of overlapping circles, until all the surface has been covered. Repeat the operation, refilling the pad with the polishing material as required. During this process the old finish is softened and blends in with the new polish, filling in all scratches and blemishes and producing a hard smooth surface that should last for years.

Dip-and-rub finish

This finish is similar to the French polish but is a little easier to apply. Over the stain, brush on a thin coat of shellac, and sand smooth.

Make a pad of a clean, soft rag and dip it alternately into containers of white



A Well sanded surface
B Stain
C Sealer—protects the colour of the stain and keeps it from bleeding through into the finished coat.
D Paste wood filler—on open-grained woods only.
E Sealer—a diluted coat of same material as the final finish.
F Final shellac, varnish or lacquer finish—one to six coats depending on the finish required.
Note: If the paste filler is omitted, only one coat of sealer is required.

Fig. 24.2 Steps in Finishing a Piece of Furniture

shellac (1 kg dissolved in 2.5 L of alcohol) and then into pure turpentine. Rub this into the work in a rotary motion, covering the entire surface. Apply four or five coats in the same manner, sanding between coats. This generally produces a rich gloss, but if a brighter polish is desired, allow the work to dry for 18 h, and rub with a cloth dipped in boiled linseed oil.

ASSIGNMENT

1. What are the three general types of wood finishes?
2. What factors determine the type of finish that should be used on a project?

Stains

3. Why are wood stains used?
4. List two advantages and one disadvantage of the three types of wood stains.
5. How should end grain be treated to prevent it from absorbing too much stain?
6. Explain the wiping operation that is used when applying oil stain.
7. Why should the work be given a wash coat of water before applying water stain?
8. What precautions must be taken when applying spirit stains?
9. Would you be more likely to use oak stain on a project made of birch or of oak?
10. Define the words *solvent*, *pigments*, and *soluble*.

Fillers

11. Why are paste wood fillers used on open-grain woods?
12. List three open-grain woods and three closed-grain woods.
13. What are the ingredients of liquid wood filler?
14. How is paste wood filler applied?

Shellac

15. What is the base material used for natural shellac?
16. List the advantages and the disadvantages of a shellac finish.
17. List in point form the steps in applying a French polish finish.