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.

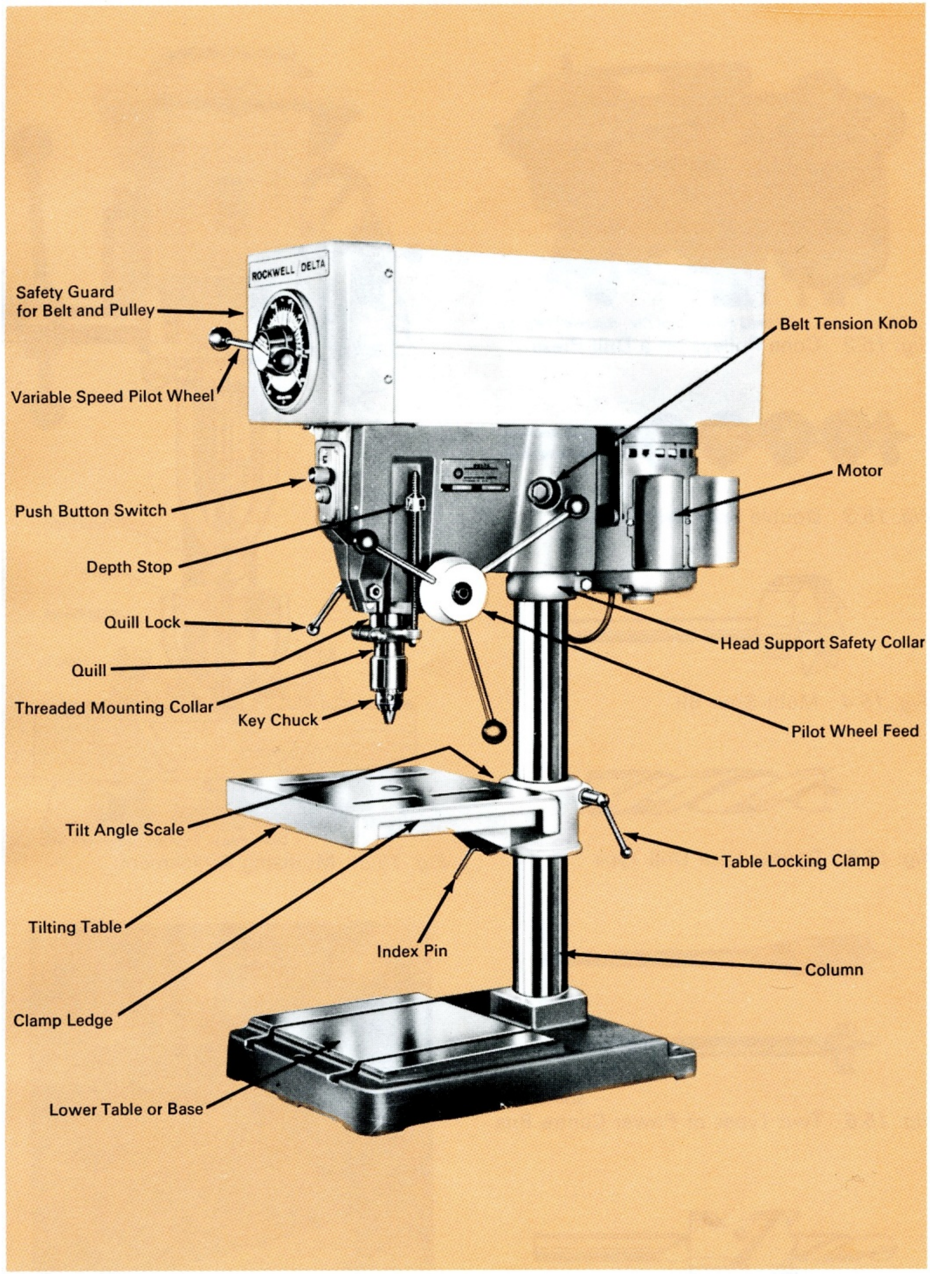

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Fig. 15:1 380 mm Drill Press

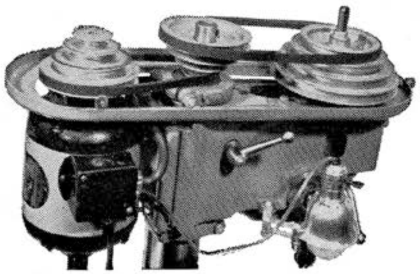

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Fig. 15:2 Cone Pulleys on a Drill Press

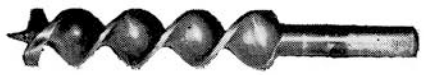

Fig. 15:3 Double Spur Drill Press Bit

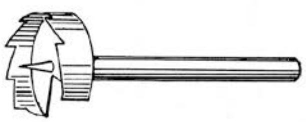

Fig. 15:4 Multi-Spur Bit

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

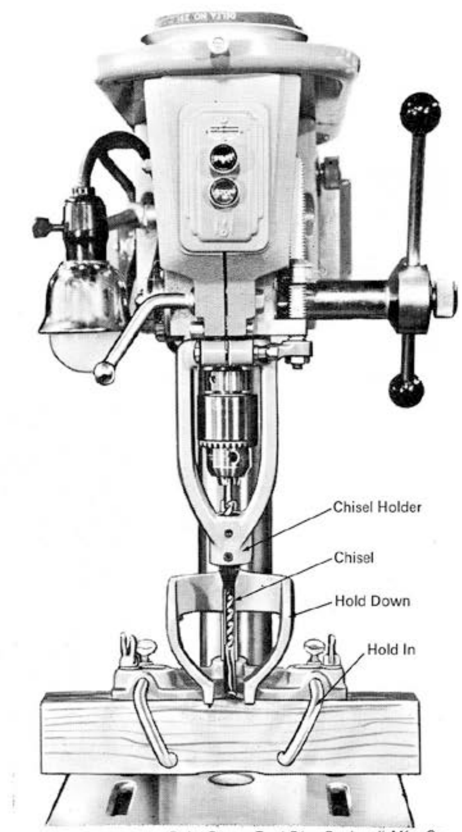

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Fig. 15:8 Mortising Attachment

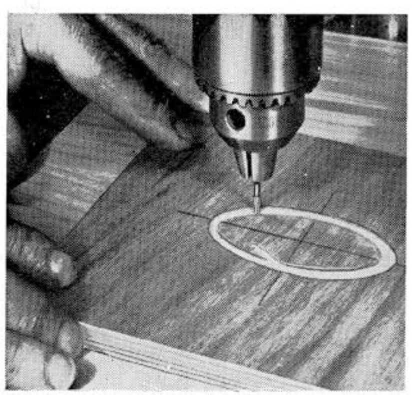

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Fig. 15:9 Cutting a Design with a Router Bit

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

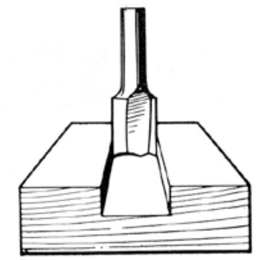


Fig. 15:11 Router Bit with Small Shank

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.

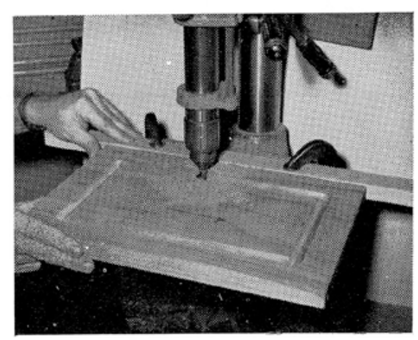


Fig. 15:12 Note the direction of the feed.

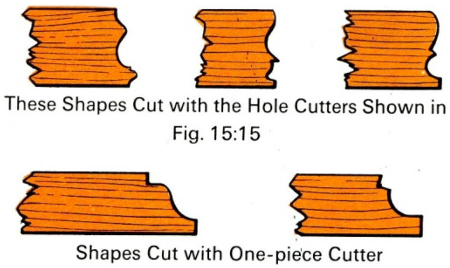


Fig. 15:13

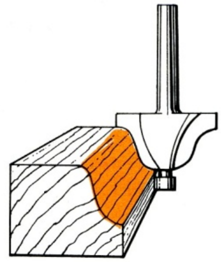


Fig. 15:14 Straight Cutter

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 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.

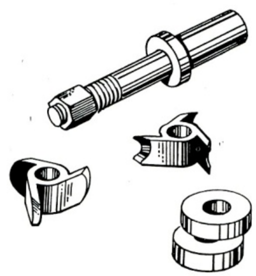
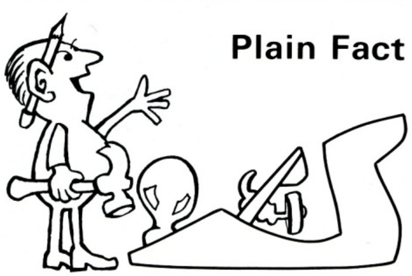


Fig. 15:15 Hole Cutters

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.



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.

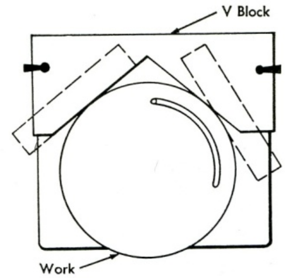


Fig. 15:16 Inlay Work on Curved Edges

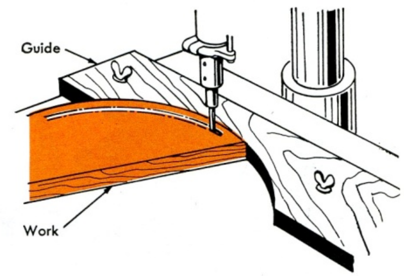


Fig. 15:17 Inlay Work on Curved Edges

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Fig. 15:18 Drum Sanders

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.

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.

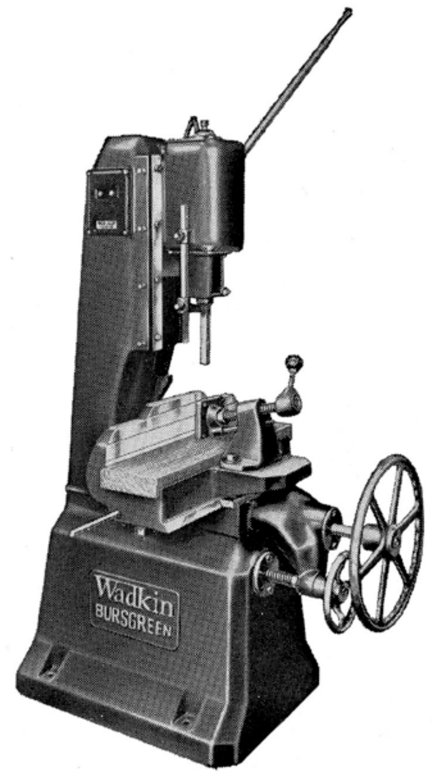
There are two general types of mortisers: (a) the *hollow chisel mortiser*, and (b) the *chain saw mortiser*, where the wood is removed from the mortise by an endless chain saw arrangement that rotates around two sprockets. The hollow chisel type is the most common and is the one that we will describe 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.

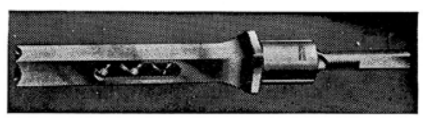
To set up and cut the mortise

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

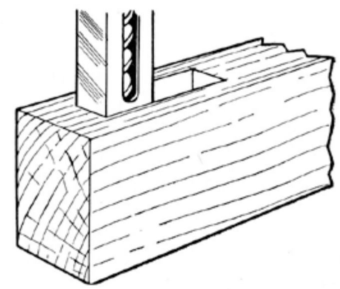


Fig. 15:21 Mortise Bit in the Work

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.

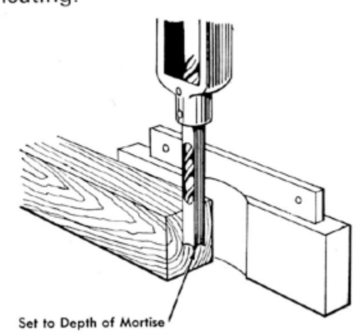


Fig. 15:22

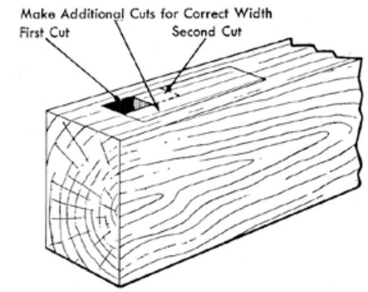


Fig. 15:23

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.

band saws and jig saws

Band saws

There have been many improvements in the design and operation of band saws since the first one was made and patented by William Newbery in 1808 in England. Several types of band saws are made, each designed for a different kind of work. The largest is the *band mill*, which is used in sawmills for cutting logs into planks. This saw has wheels up to 2100 mm in diameter and blades up to 400 mm wide. The *band resaw* is somewhat smaller and is used in mills and lumber yards for resawing thick lumber into thinner material. The type of saw used in small industrial shops, schools, and home workshops is the *band scroll saw*. This is a smaller general-purpose saw used for cutting curved and straight work, and is simply referred to as a *band saw*. This is the type shown in Figures 14:1 and 14:2 and described here.

All band saws operate in the same manner. The blade is a flexible strip of steel with teeth on the forward edge. The blade revolves round the two wheels as a belt round two pulleys (see Figure 14:1). One of the wheels is power-driven while the other is turned by the belt action of the blade. The parts of the band saw are shown in Figure 14:2. You should make yourself familiar with them.

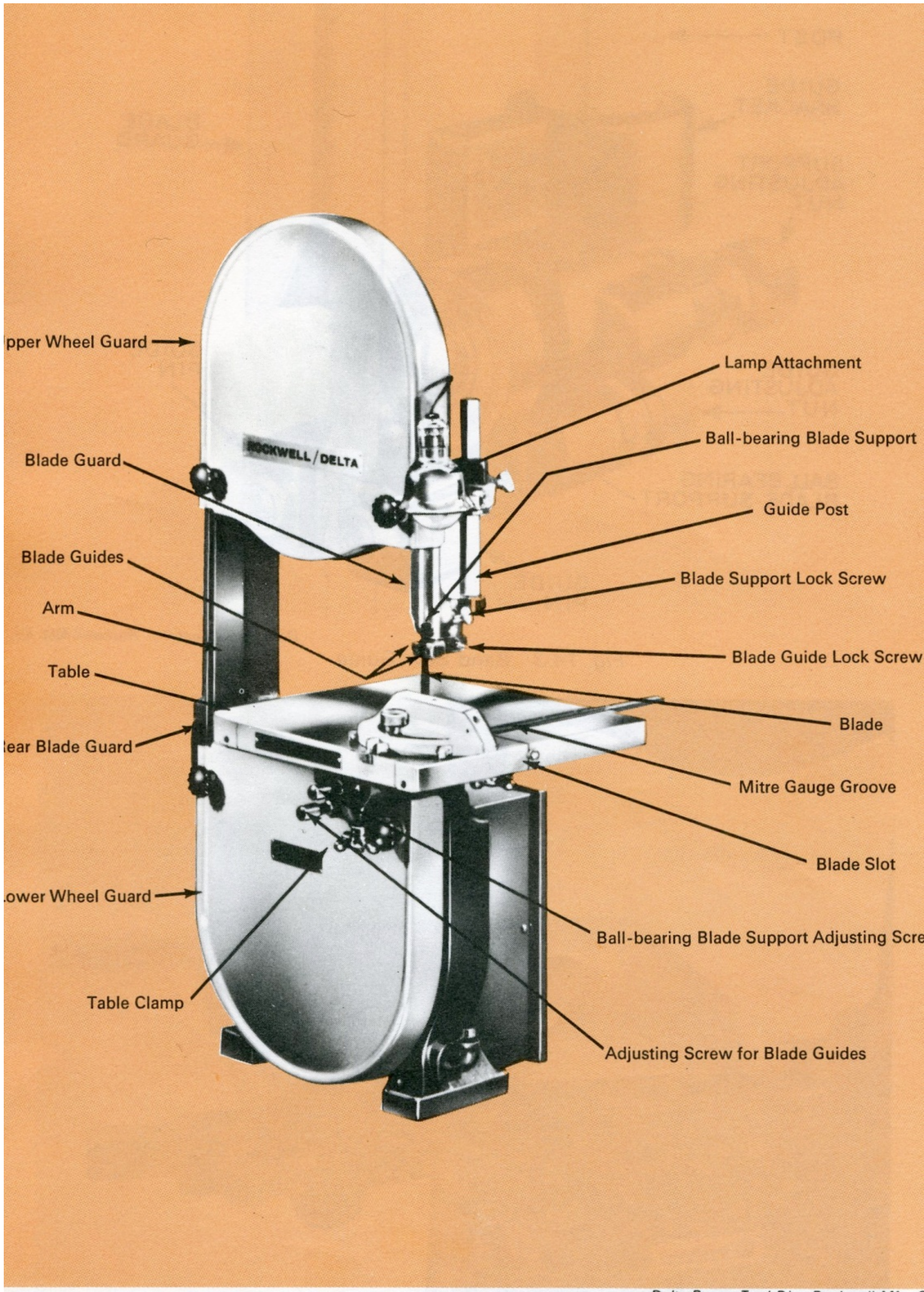
The size of a band saw is determined by the diameter of the wheels. The 350 mm, 500 mm, and 750 mm are popular sizes for general work.

A rubber band or tire is fitted on the rim of the wheels. The top wheel can be adjusted up or down for the correct blade tension. It can also be tilted sideways for centring the blade on the rim so that it will track properly.

Wadkin Bursgreen

Fig. 14:1 Band Saw with Guard Doors Open

To prevent the blade from twisting, the band saw is equipped with an adjustable saw guide above the table, which also serves as a safety device. This guide has two hardened metal blocks, one on either side of the blade, to keep it in line. The guide is vertically adjustable and should be kept not more than 12 mm above the surface of the work. This serves to steady the blade and may prevent serious acci-



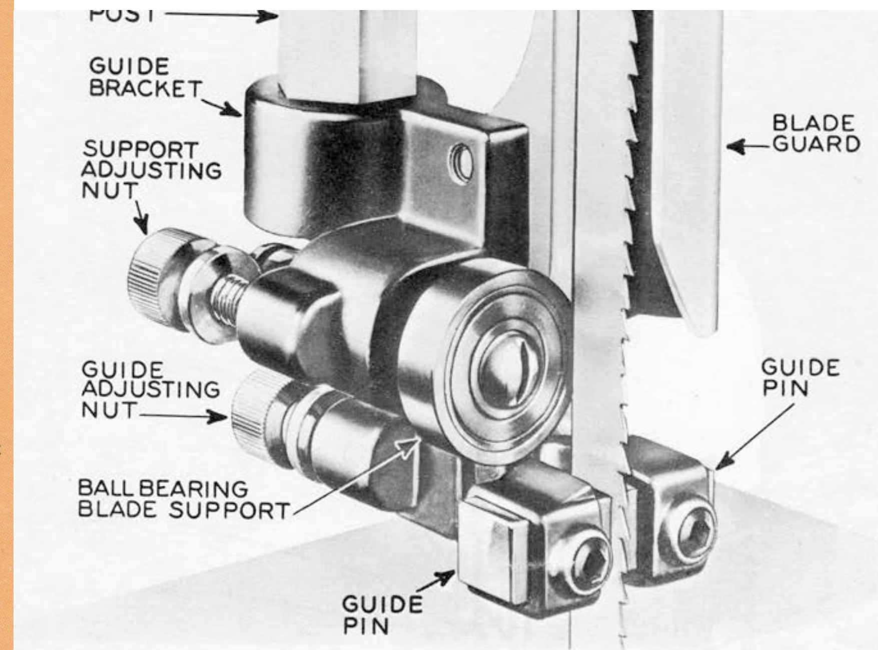


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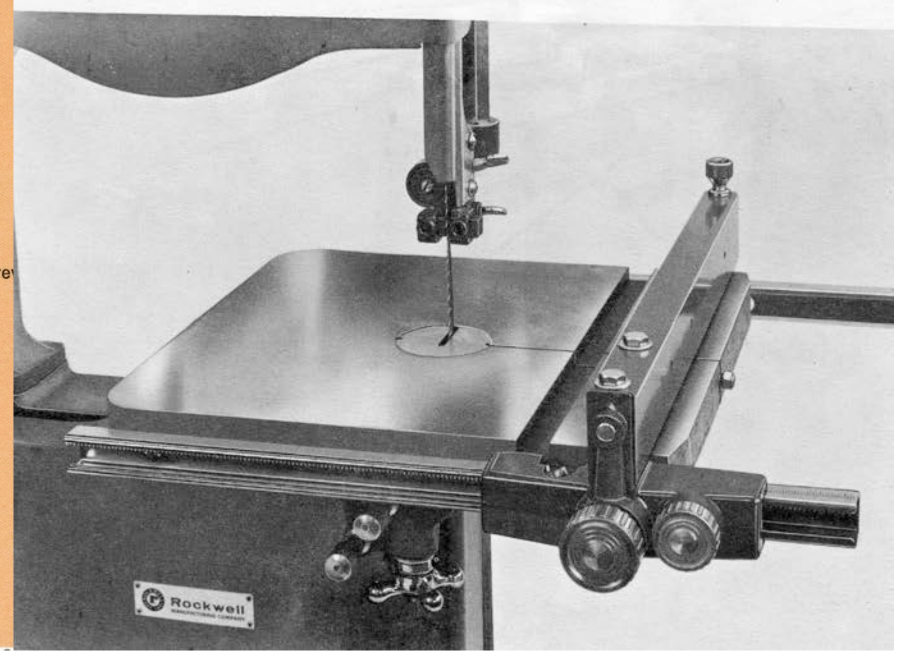
Fig. 14:3 Band Saw Guide



dents. If the operator's fingers should slip off the work into the path of the blade they would be stopped by the guide. A guide is also placed below the table, which can be adjusted but not raised or lowered. Both guides have idler wheels or ball-bearing blade supports, which prevent the blade from being pushed off the back of the wheels. The blade support wheel should either be stopped or be turned slowly during normal operation of the saw. A saw guide is shown in Figure 14:3.

Most band saws may be equipped with cross-cut fences for making straight cuts either with or against the grain of the wood. A rip saw fence is shown in Figure 14:4.

How to use a band saw

The band saw is not a difficult machine to operate; in fact, the beginner can do a fairly good job on his first or second attempt at using it. However, there are some techniques that will help you to do a still better job.

Stand behind the blade and a little to the left. Feed the work with the right hand, which is held at the end of or far back on the work. The left hand is usually used to guide the work and is held at the edge of the work opposite the blade. The position of the hands will necessarily depend to some extent on the size and shape of the piece to be cut.

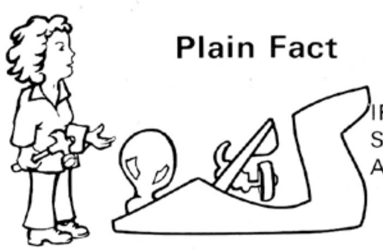
Always outline the shape you wish to cut so that you have a guide line to follow. Cut on the waste side of this line, leaving the line on the work.

Do not crowd the saw or push the work into the blade too rapidly. Some experimenting will show you the correct speed for smooth and easy cutting.

Guide the work evenly around the curved cuts. As the blade cannot turn, the work must be moved. The size of arc that can be cut is determined by the width of the blade; the narrower the blade the smaller the radius that may be cut. A table indicating the minimum radius that may be cut with the various blade widths is shown below.

Blade Width (millimetres)	*Minimum Radius (millimetres)*
3	6
5	12
6	19
9.5	25
12	32
19	44

Although the band saw is used mainly for cutting curves or irregular shapes, it can also be used for cross-cutting, ripping, or resawing. To resaw is to set the stock on edge and to saw the full



Plain Fact

IF THE BAND SAW IS USED WITH SAFETY AND CARE, YOU WILL BE ABLE TO MAKE ALL MANNER OF CURVED CUTS.

width of the piece, thus making two or more pieces of equal thickness. For these operations a wider blade should be used if a considerable amount of material is to be cut.

Before you begin to make the saw cut, study the design and decide where to start and which cut to make first. Long curves or combination cuts such as are shown in Figure 14:5 should be broken up by making short, straight cuts. The saw blade can be backed out of these quite easily. This will prevent the blade from being trapped in an internal corner, from which the blade must be backtracked out of a long and difficult curve, a manoeuvre likely to pull the blade off the wheel. Figure 14:5 shows examples of various designs that might be cut; the arrows indicate the cuts to be made first.

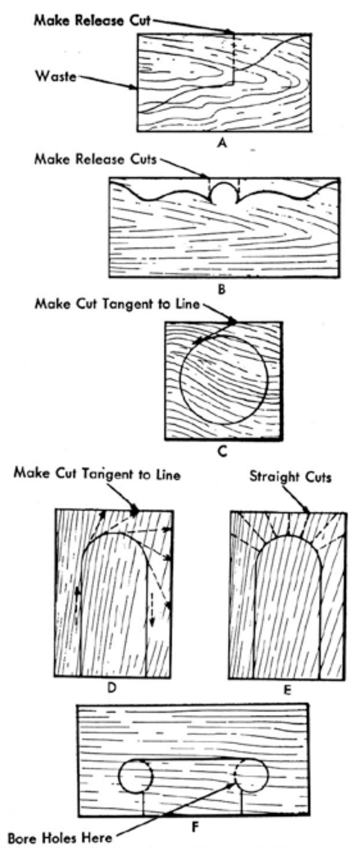


Fig. 14:5 Cutting Curved Shapes on the Band Saw

A little thought before you start will save time later in finishing your work and prevent you from getting into difficulties.

Although the band saw is a comparatively safe machine to operate, there are some safety precautions that *must* be observed:

1. Place the upper saw guide *not* more than 12 mm above the work.
2. Pay close attention to the operation of the machine. Do not be distracted by anything or anyone. The saw requires your undivided attention.
3. See that the wheel guards are in place.
4. Do not start to cut until the saw has reached full speed.
5. Keep your fingers as far away from the blade as the size of the work will permit.
6. Use a push stick to move scrap pieces of wood away from the blade.
7. Keep the floor area around the saw clean.
8. Do not hesitate to seek assistance if you are not certain how to proceed or if you get into difficulty.
9. Do not use a wide blade if you are cutting small arcs.
10. Never leave the saw running and unattended.
11. If the blade breaks, shut off the power and stand clear until the wheels have stopped turning.

The scroll saw

This machine is more often referred to as a *jig saw*, but its correct name is the *scroll saw*. The scroll saw is used mainly for cutting fine, intricate shapes from thin stock. It is equally useful for cutting external or internal shapes (cutting out the centre portion of a pattern). The blades used are narrow, a factor which makes it possible to cut very sharp angles for fine work.

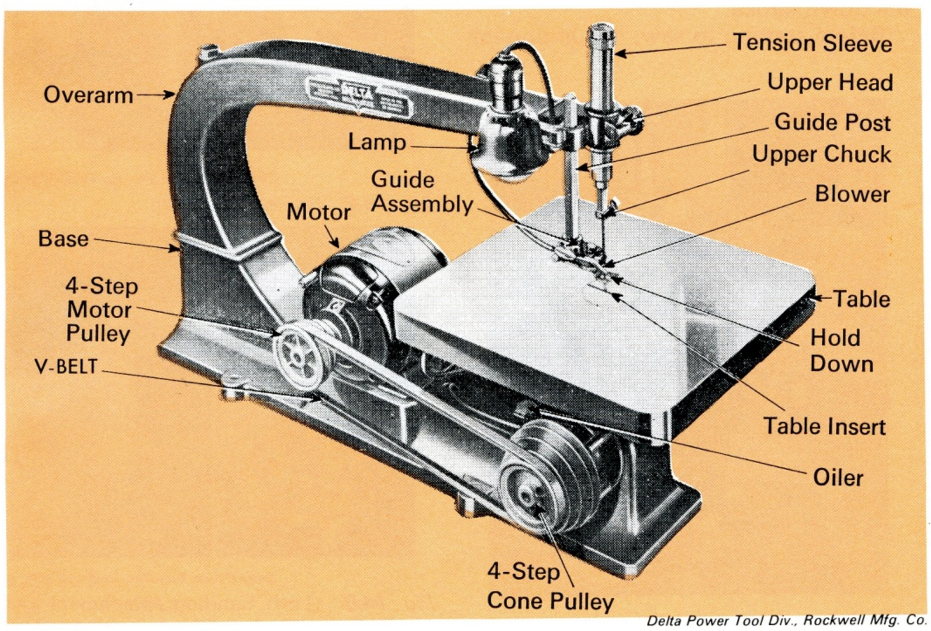
There is a considerable overlap in the jobs that can be performed on the band saw and the scroll saw. Many cutting operations can be done equally well on either machine. However, the band saw is restricted to cutting radii 6 mm or more. Even for the 6 mm radius a narrower blade is required than is used for general band saw work. The jig saw, on the other hand, is restricted as to the thickness of the work that can be cut. The maximum thickness should be 25 mm. It operates more efficiently with thin stock.

The principal mechanical part of the scroll saw is the cam shaft, a mechanical device that converts the circular motion of the belt-driven pully to the up-and-down motion required for the saw blade.

The size of a scroll saw is determined by the width of the throat, or the distance between the blade and the frame. The 600 mm size is the most popular.

The principal parts of a scroll saw are shown in Figure 14:6.

The table on most scroll saws can be tilted for bevel cutting. There are two types of blades that may be used. The first is the jeweller's blade, which is fine and must be held in place by two chucks, one attached to the lower plunger, and one above the table attached to the upper plunger. This blade is used for fine work. The sabre blade is heavier and is attached only to the lower chuck, with the top of the blade left free. This blade is fast-cutting and is used for heavier material when the



Delta Power Tool Div., Rockwell Mfg. Co.

Fig. 14:6 Scroll Saw or Jig Saw

curves are not too small. Figure 14:7 shows a jeweller's blade in place, and Figure 14:8 a sabre saw blade. A sanding attachment can be attached to the lower chuck, as shown in Figure 14:9.

The scroll saw is probably the simplest woodworking power tool to operate. However, there are a few rules that should be followed:

The spring hold-down should rest on the work, pressing it firmly on the table to prevent the work from bobbing up and down with the action of the blade.

When the blade must be threaded through a hole to make an inside cut, you should release the blade from the upper chuck, and raise the tension sleeve and guide post. This will provide enough space for the work to go over the blade. If a sabre blade is used, it is necessary only to raise the guide post and the hold-down assembly.

Always have the points of the teeth pointing down so that the blade cuts on the down stroke.

Before starting to saw, it is important

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Fig. 14:7 Jig Saw with Jeweller's Blade

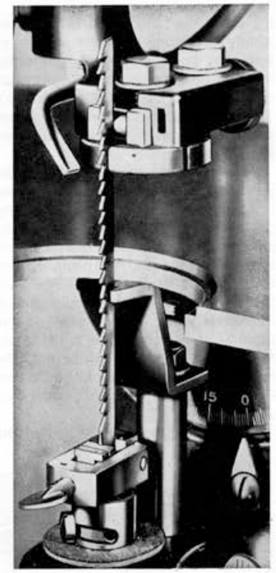

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Fig. 14:8 Sabre Saw Blade

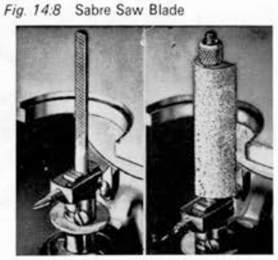

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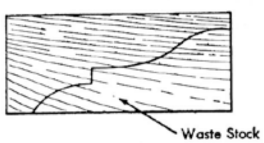
Fig. 14:9 (Left) Sanding Attachment on a Scroll Saw, (Right) File Attachment on a Scroll Saw that you have a clear pencilled outline to follow. The outline may be transferred from a pattern by carbon paper or it may be drawn or laid out directly on the wood.

ASSIGNMENT

Band saw

1. Explain the operating principle of a band saw.
2. Why is a rubber tire used on the rim of the wheel?
3. How is a band saw blade tracked?
4. Describe the two purposes served by the band saw guide.
5. What is the purpose of a small idler wheel on the saw guide?
6. What is the smallest-diameter circle that can be cut with a 5 mm blade? 6 mm blade? 9.5 mm blade?
7. Redraw the sketch shown here and indicate by numbered lines the order in which you would cut out this pattern.



8. List five safety precautions that must be observed while operating the band saw.

Jig saw

9. What is the main difference in the cutting action of the band saw and the scroll saw?
10. How is the size of a scroll saw determined? What is the most popular size?
11. What are the two types of blades used on scroll saws? How do they differ?
12. List the steps involved in setting up the jig saw for cutting an interior section of a pattern.

wood as a material

Wood has always been one of our most abundant and most valuable raw materials. To primitive people it meant shelter, utensils, fuel, and weapons, and people soon learned that wood could be shaped and that several pieces could be joined together to make all manner of useful things. With the advance of technology other materials have replaced wood for some purposes, but there has been, at the same time, a very large increase in the number and variety of new products manufactured from wood or wood fibres. We need only think of paper, plywood, plastics, veneer, wallboards, fabrics, and adhesives to see how our use of wood has grown. It would, in fact, be difficult to imagine our way of life without wood.

Some of the reasons for the usefulness and popularity of wood products are: the ease with which it can be worked with hand tools and machines to any desired shape or size; the strength of wood in proportion to its weight; the ability of wood to absorb shock from a suddenly applied load; the pleasing appearance of the colour, texture, and grain formation; the durability and performance of wood; and the high insulation value of wood with respect to heat, sound, and electrical current. Wood can easily be fastened together with nails, screws, dowels, or glue; it can easily be bent or twisted for various uses; it takes and holds paint well; and it can be salvaged and re-used several times. Because an adequate supply of wood is available in most parts of the world, wood is the most economical structural material. One of the principal advantages of wood is that forests are renewable like crops, so that, with care and conservation, a continuous supply of lumber remains available. This requires an efficient forest management policy to maintain these areas as a permanent source of raw materials for the forest-based industries that supply us with lumber and other wood products. Our forests should also be developed as a setting for a wide range of recreational activities.

Our forests are *not* unlimited. The world's demand for lumber has been so great that our once-abundant supply has already been sadly depleted. In order to meet the ever-increasing call on our forest resources, the following steps must be taken:

(a) Lumbering operations should be selective; only mature trees or stands should be cut.
(b) Seedlings should be planted immediately after an area has been cropped, or the area should be seeded in some other way.
(c) New crops must be tended in order to achieve maximum growth for the greatest possible quality and quantity of good trees.
(d) Adequate protection must be provided against forest fires and insects.
(e) New strains and species of trees must be developed that are suited to our soil and climate and will grow to maturity in a short time.

If our forests are not properly managed, the needs of future generations will not be met; it is as simple as that.

Lumber

When wood is cut into commercial sizes it is referred to as lumber. In Canada there are 170 different species of trees; 55 of these are used commercially; 23 are hardwood varieties. Of all the wood used in Canada today 20% is for fuel, 34% for pulp and paper, 42% for lumber, and 4% for miscellaneous uses. We are primarily concerned in this book with the 42% of the wood that is cut into lumber.

All Canadian lumber can be divided into two general classifications, *softwood* and *hardwood*.

Softwood is cut from those trees we commonly call evergreens, which keep their needle-like foliage all winter. Because most of these trees produce cones, they are also called conifers.

Hardwood is cut from broad-leafed trees that lose their leaves in the winter. They are referred to as deciduous trees. Some common species of hardwoods are ash, oak, birch, walnut, and elm.

Hardwoods and softwoods are fundamentally the same, being made of the same substance. All wood consists of millions of tiny, hollow cells packed tightly together in a honeycomb structure. Hardwoods, however, have a thicker cell wall, making the wood denser and heavier, thus increasing its strength. Softwoods, on the other hand, have thin cell walls, which makes them more porous and lighter in weight and therefore not as strong as hardwood. The woods that we use vary in density from 300 kg/m³ to 700 kg/m³ when dry and have a corresponding variation in strength. The terms *soft* and *hard* are only general ones, for there are the exceptional softwoods that are harder than some woods classed as hardwoods.

In general, softwoods are easier to work, more resistant to rot, and strong enough for general purposes. Because of these qualities and the fact that they are plentiful and relatively inexpensive, softwoods such as spruce, fir, helmock, and cedar are used extensively in the construction of homes and other buildings. Fortunately for us, 75% of the forests of the northern hemisphere are the softwood variety.

Hardwoods are extensively used for furniture because they are harder and stronger, have a more attractive grain formation, and in many cases are darker in colour. Hardwood is also used for many purposes in buildings where extra strength, greater wearing qualities, or a more attractive appearance is required, as in floors, trim, and stairs.

To transform a living tree into usable lumber involves many operations. The tree must be felled, the branches trimmed off, and the log transported to the sawmill. The bark sections, referred to as *slabs*, must be removed. The part of the log suitable for lumber is then sawed into boards generally 25 mm or 50 mm in thickness. The lumber must then be stacked for seasoning until it is dry enough for commercial use, or it may be artificially dried in kilns immediately after being cut. The latter method permits the lumber to be put on the market much sooner and also saves shipping weight. The lumber is generally dressed or planed smooth on two or all of its four surfaces before it is ready for the customer. The parts of the tree not used for lumber are often cut into chips to be pressed into wallboard or ground into pulp for paper.

The lumbering industry is now becoming highly mechanized. Heavy equipment can trim off all the limbs and top while the tree is still standing, cut it at ground level, and load the log onto a waiting truck.

Structure of wood

A general knowledge of the structure of wood and the various growth formations that make up the wood we use is essential in understanding how to use it. Wood reacts in certain ways under certain conditions because of its structure.

A quarter-section of a log is shown in Figure 5:1, illustrating some of these growth formations.

Bark

No two species of tree have identical bark, a factor that makes it easier to identify trees. The bark is the outer protective coating. If much of this bark is removed, the tree will die. The bark consists of a thick outer *cortex layer* and an inner *bast layer*.

Cambium layer

This is the very important fibrous layer of the tree where all the growth takes place. New cells of both sapwood and bark are constantly being formed in this layer. All the food for the growth of the tree, moving either up or down, is transported within the cambium layer.

Annual rings

The growth that takes place each year is evident from the formation of these rings of vertical cells. They are made up of a wide, light-coloured section, the *spring wood*, which is the growth that takes place in the spring. The other part is the narrow harder section, the *summer wood*, which is formed in the summer when the growth is relatively slow. The sizes of the rings vary according to the growing conditions in that particular year. The rings are much larger in those species of tree that grow quickly.

Medullary rays

These are rows of small wood cells that grow horizontally from the centre of the tree towards the bark. They bind the annual rings together, greatly strengthening the tree. The medullary rays are apparent in hardwoods, such as oak, but are not visible in most softwoods. They transport the flow of sap from the outer to the inner part of the sapwood sections of the tree.

Pith or medulla

This is the core of the log. In a healthy tree it is hard, but as the tree gets older it becomes soft and eventually begins to

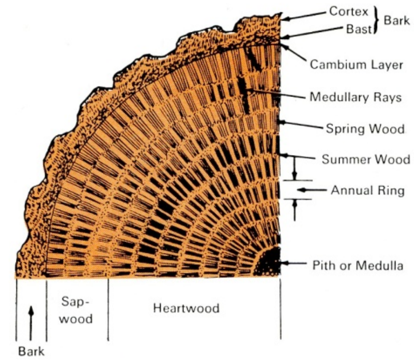
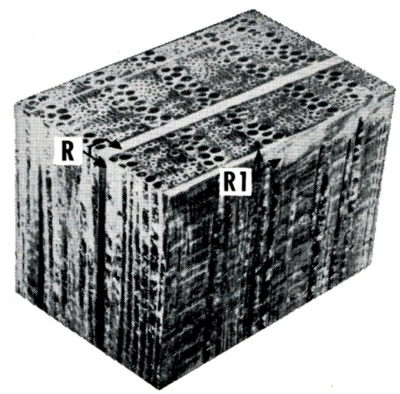


Fig. 5:1 Quarter-Section of a Log

decay. The decay spreads to the rest of the tree until a hollow log develops.

Sapwood

This wood is made up of the living cells of the tree. It is generally lighter in colour than the heartwood and has fewer knots.



Forest Products Research Branch, Dept. of Forestry

Fig. 5:2 Cell Structure—Enlarged View of an Oak Block Showing Four Annual Layers. Note the large, porous wood cells in the spring wood and the smaller cells in the summer wood. The medullary ray is shown at R and R1.

Heartwood
The cells in this section have ceased to function as part of the living tree. Yet, generally the wood is hard and sound, and darker in colour than the sapwood.

Lumber quality

There are almost as many qualities and grades of lumber as there are uses for it. Some wood is good only for firewood. Poor-quality lumber is used for crating or other rough work; the better lumber is used for furniture or trim.

Below is a list of some of the defects and blemishes found in lumber that make for poor quality. A lumber *defect* is a condition that affects the strength and appearance of a piece of stock. A *blemish* is a condition that affects only the appearance of the lumber.

Knots
These are not necessarily injurious to the lumber unless they are loose and likely to drop out. Too many knots, however, even when sound and tight, lower the grade of the lumber because they can affect its strength and appearance.

Wane
When bark appears on the edge of the lumber the result is an uneven edge and a low grade of lumber.

Pitch pockets
These are cavities in the lumber that are filled with pitch. If they are numerous, they are considered to be a serious defect. Pitch pockets occur most often in pine and fir.

Stain streaks
These are streaks of discolouration caused by minerals in the soil, seasoning, or slight decay. They should be considered as blemishes rather than defects and are not serious if the work is to be painted.

Dry rot
This is a fungus growth that forms on wood when it is placed in a dry, warm place with little ventilation. It seriously affects the strength of lumber.

Worm holes
These are caused by termites or other wood-eating insects that bore through the wood. They can make lumber very unsightly and sometimes affect its strength.

Wet rot
Rot is caused by a fungus growth when the wood is in constant contact with warm air and moisture. It is very injurious to lumber.

Shakes
Shakes, which are caused by frost or wind in living trees or by injury when a tree is felled, consist of a separation of the wood fibres. Three types of shakes exist: (a) *ring shakes*, a separation between the growth rings; (b) *transverse shakes*, a separation running across the wood fibres; and (c) *through shakes*, where the check or crack extends all the way through the log.

Wood shrinkage and warpage

One of the problems that we must face when using wood is that it is constantly changing in shape and volume. How much and at what rate wood will shrink or swell depends on how much moisture the wood contains. Freshly sawed wood contains a great deal of moisture; lumber that has been seasoned contains little. The moisture content of the air surrounding lumber will also determine the amount of shrinkage or swelling that takes place. Wood gives up moisture and shrinks under low humidity or dry conditions and takes in moisture and swells under high humidity or moist air conditions.

The moisture that causes these

changes is stored in the walls of the minute wood cells. Figure 5:3 shows three very much enlarged views of one of these cells. *A* is a cell from freshly cut green lumber. Both the cell wall and the cavity in the centre are saturated with moisture. *B* shows the same cell after some of the moisture has gone out of the lumber, leaving the centre of the cell empty. No change has yet taken place in the size of the cell. In *C* the wood has dried still further, and the moisture has left the wall as well as the centre of the cell, making it smaller. The drying out of the millions of individual cells causes the lumber to shrink in width and thickness but very little in length.

The moisture in the wood exists in two forms: (a) *free*, the water occupying the hollow space in the wood cell; and (b) *hygroscopic*, the moisture held in the material composing the cell wall. When the free water in the hollow area evaporates but the walls are still saturated, the wood is considered to be at its *fibre saturation point*. This generally occurs when the wood reaches a moisture content of 25%.

When wood is stored for some time in a place where the temperature and the relative humidity of the air are constant the wood will reach the same moisture content as the air surrounding it. When this condition is reached the wood is at its *equilibrium moisture content*, after which no shrinking or swelling should occur, unless the moisture content of the air surrounding it changes.

Some of this shrinkage can be minimized by the way the log is sawed into boards. The two methods generally used are *plain sawed* (flat grain) and *quarter sawed* (edge grain). These are illustrated in Figures 5:4 and 5:5. The largest amount of usable lumber can be obtained from plain sawed logs. Although this results in less wastage, the quality is not as high as for lumber cut from quarter sawed logs.

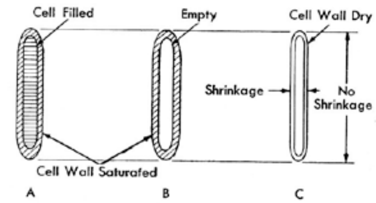


Fig. 5:3 Wood Cell Shrinkage

The medullary rays prevent the wood from shrinking at a right angle to the rings. Thus, if the lumber is cut with the rings running through the thickness of the piece, as shown in Figure 5:5 for quarter sawed lumber, warpage is reduced to a minimum. The board will shrink in thickness but very little in width. It should be noted here that the shrinking or swelling of the wood cells

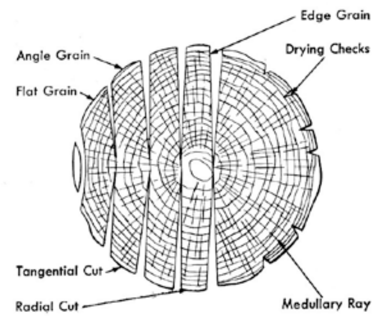


Fig. 5:4 Plank and Log Shrinkage

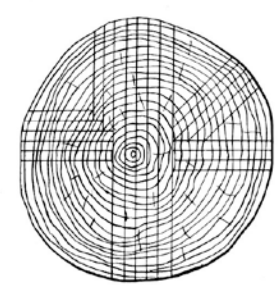


Fig. 5:5 Quarter Sawing

determines the amount of warping or cupping of a flat sawed board. This is due to the direction of the medullary rays. Because very little shrinkage takes place along these rays, the piece shrinks more on one face than on the other. Thus we often find warped boards with a hollow centre, as shown in Figure 5:6.

Flat-grained woods present an attractive wide grain formation but have the disadvantage of changing shape. Edge-grained woods on the other hand may not present as attractive an appearance, but they will stay flat. For this reason, they are used for such things as stair treads, where a permanent flat surface is essential.

All woods will check or crack a certain amount at the end of the log or board. The checking takes place along the medullary rays as the wood dries out. The moisture leaves through the end grain more rapidly, causing the board to shrink faster at this point and the end to split or check.

Definition of types of warpage
Figure 5:7 illustrates the following kinds of warping:

(a) cup — bending of a side across the grain,
(b) bow — bending of a side along the grain of wood,
(c) crook — bending of an edge along the grain of wood,
(d) twist or wind — bending of sides and edges of a piece of wood (propeller shape).

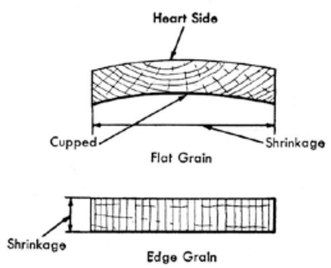


Fig. 5:6 Board Shrinkage

Seasoning of wood

Before lumber is used, it should be carefully dried to bring it to the correct moisture content. This will minimize any shrinkage or warping that might take place when it is used, and will also increase the strength and hardness of the lumber. This carefully controlled drying of lumber is referred to as seasoning.

There are two methods of seasoning lumber: air drying and kiln drying.

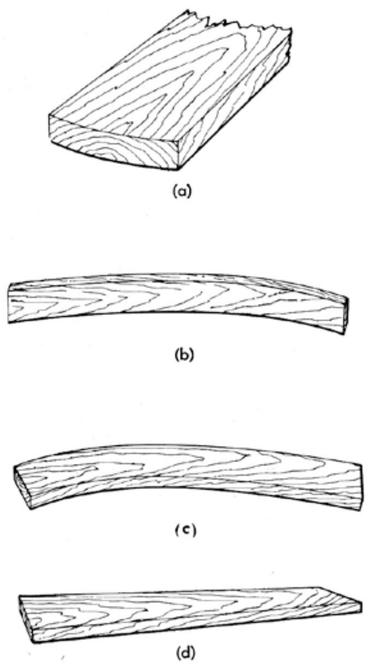


Fig. 5:7 Types of Warpage

Air drying
Lumber to be air dried is stacked in piles in the open air (see Figure 5:8). The boards must be placed so that there is a free circulation of air between the pieces and each layer of boards. The pile must be set on blocks or piers. Lumber is placed as a roof on the top of the pile at a slope to allow the rain to run off. The weight of the boards above prevents undue warpage in the pile. The length of time required to dry lumber in this manner depends on the temperature and the moisture content of the air, as well as on the use to which the lumber is to be put. Air-dried lumber is suitable for construction and general use.

Kiln drying
Lumber can also be dried in an enclosure called a *kiln*. There are many sizes and shapes of these. One type is shown in Figure 5:9 and illustrates the general principles of the process. Hot air is forced up through the centre of the pile, which has been carefully constructed to ensure a circulation of air, and the cool air is drawn off from around the outside of the pile. This circulation of warm air draws the moisture from the wood.

The humidity of the air must be controlled in order not to dry the wood too rapidly, thus causing it to check or become honeycombed. In a kiln the moisture content of lumber can be closely controlled so that it can be dried to suit any type of work from outside framework to fine furniture. The temperature of the kiln is kept at approximately 68°C. The length of drying time depends on the desired moisture content of the wood. The moisture content desirable for lumber used for furniture and cabinet work is 4% to 6%, for interior trim 6% to 8%, and for structural framework 10% to 20%. Most lumber mills use moisture meters to determine the percentage of moisture in their lumber.

The kiln shown in Figure 5:9 is a

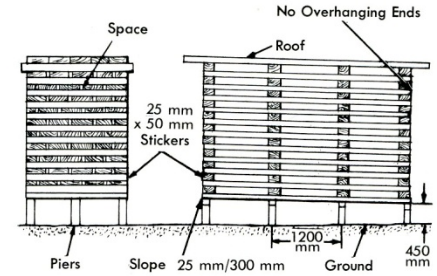


Fig. 5:8 Air Seasoning

simple compartment *charge kiln*. Larger kilns are also used, where the lumber is loaded on rolling cars that enter at one end of a long tunnel, and the lumber is dried as it passes through to the other end. Many carloads of lumber can be seasoned at the same time in this way. These are referred to as *progressive kilns*. The smaller type of charge kilns often use a natural flow of warm air, while the larger kilns use forced-air heating. There are other methods of artificially seasoning lumber, most of them still in the experimental stage. Some are used for small lots of lumber in the manufacture of special, expensive wood products. These methods may involve the use of chemical seasoning, high-

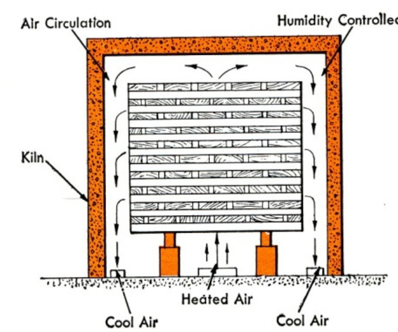


Fig. 5:9 Kiln Drying

frequency dielectric heating, infra-red radiation, solvent seasoning, vacuum drying, or vapour drying.

Wood identification

Because there are hundreds of different species of wood, it is impossible here to provide a sure-fire method of identifying individual woods. The ability to identify a large number of woods comes only after considerable study and experience. Everyone, however, should be able to identify our most common woods. Some of these are illustrated on the inside covers of this book. How many of these can you recognize without looking at the labels? If not many, it would be worth your while to study them until you are familiar with all of these much-used woods.

In general, the softwoods have a small closed cell structure with a fine grain, while most hardwoods have a larger open grain and a coarse, wavy grain structure.

You will note that some of the distinguishing features of wood are the weight, colour, odour, cell structure, and grain formation. Standing trees are distinguished by their bark, leaves, seeds, flowers, nuts, and to some extent their size and habitat.

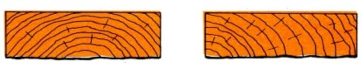
ASSIGNMENT

Wood as a material

1. Make a list of products that are made from wood pulp or wood fibres.
2. List five reasons for the popularity of wood as a material from which to make things.
3. State two ways in which you think we could conserve our forests.
4. (a) How many different species of tree grow in this country?
   (b) How many are commercially grown?
   (c) What percentage of the wood cut in our forests is used for lumber?
5. List four operations required to transform a living tree into lumber.
6. (a) Draw a cross-section of a log, showing the growth formation.
   (b) Write a sentence describing four of the growth formations just named.
7. (a) List three types of lumber defects, and state the cause of each.
   (b) List two types of blemishes found in lumber.
8. (a) Explain the difference between hard and soft wood.
   (b) State three uses for hardwood and three for softwood.
   (c) List three species of tree in each division.

Wood shrinkage and warpage

9. Show by means of a sketch how a wood cell in freshly cut lumber differs from one in well-seasoned lumber.
10. What is the difference between plain sawed lumber and quarter sawed lumber?
11. (a) Redraw the pieces of lumber illustrated below, showing how they might warp when they dry out.



    (b) Why will they warp in the manner you have shown?
12. Why is edge-grained stock used in preference to flat-grained stock for some purposes?

Seasoning of wood

13. What is meant by the "seasoning" of wood?
14. Write a paragraph describing each of the two methods of seasoning lumber.

15. What should be the moisture content of lumber used for (a) furniture? (b) interior trim? (c) framework?
16. List four species of softwood trees and four species of hardwood trees.
17. What are some of the distinguishing features of the various species of woods that will help you to identify them?
18. Bring sample pieces of two hardwoods and two softwoods to class.